Development and testing of a novel dimensional framework for understanding human attachment

By

Marcantonio Gagliardi

Supervised by

Prof. Tony Prescott (Department of Computer Science)

Dr. Luca Barlassina (Department of Philosophy)

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

The University of Sheffield

Faculty of Engineering

Department of Computer Science

November 2021

Abstract

Attachment is the deep emotional bond that every human being needs to create with another. In the prototypical case, the child attaches to their mother.

In this work, I present the Attachment-Personality Theory (APT), which proposes an enhancement of the Standard Attachment Theory (SAT) from a cognitive-clinical perspective. By focusing on the representational and dimensional nature of attachment, the APT suggests that attachment knowledge is based on seven dimensions, which constitute the core of personality. Accordingly, I outline an attachment module that functions as a seven-dimensional control system.

I empirically test the APT through (1) the Attachment-Caregiving Questionnaire (ACQ) – a clinical self-report that works as a personality inventory – and (2) the Attachment Computational Model (ACM) – an agent-based model of three attachment dimensions. The analysis of the ACQ administered on a small sample provides preliminary support to the APT and encourages using artificial pattern recognition for further analysis. The ACM generates results compliant with the theory.

Overall, this research suggests that the APT might contribute to bridging the gap between clinical psychology and engineering, favoring applications closer to psychological data. Moreover, independently of the APT, the developed clinical questionnaire and computational model can provide insights into attachment nature and novel methodological directions in synthetic psychology.

Acknowledgements

This research represents the concretization of a decade-long personal project that would have never been possible without the enlightening guidance and constant support of my supervisors Prof. Tony J. Prescott and Dr. Luca Barlassina, to whom I am extremely thankful.

I feel particularly in debt for the help and teachings of Dr. Barlassina that allowed the successful publication of the conceptual basis of my research. But besides the theoretical effort, a great deal of experimental work was involved in the making of this thesis. In this regard, my deep gratitude goes to Dr. Sara Billai and Dr. Marina Bonadeni for their precious clinical advice, and to Prof. Prescott and Dr. Alejandro Jimenez-Rodriguez for patiently and wisely assisting me in the development of the presented computational model.

Table of Contents

List of Figures

List of Tables

List of Most Used Acronyms

SAT	Standard attachment Theory
APT	Attachment-Personality Theory
ACQ	Attachment-Caregiving Questionnaire
ACM	Attachment Computational Model
(f-)IWM	(firmware) Internal Working Model
ABM	Agent-Based Model
SSP	Strange Situation Procedure
AAI	Adult Attachment Interview
PCA	Principal Component Analysis
AI	Artificial Intelligence

Declaration

I, Marcantonio Gagliardi, confirm that the Thesis is my own work. I am aware of the University's Guidance on the Use of Unfair Means (www.sheffield.ac.uk/ssid/unfair-means). This work has not been previously been presented for an award at this, or any other, university.

Chapter 1 is based on: Gagliardi, M. (2021). *How Our Caregivers Shape Who We Are: The Seven Dimensions of Attachment at the Core of Personality*. 12(2656). doi: *10.3389/fpsyg.2021.657628*.

Introduction

Nowadays, psychological wellbeing and coexistence with intelligent machines are becoming issues of always increasing prominence. Behind them, lays the critical question of what the essential human qualities are and to what extent they can be artificially reproduced. With this research, I investigate some essential aspects of human nature, aiming also to support their reproduction on a non-human agent. In this perspective, this study hopes to contribute to the future creation of a synthetic equivalent of a human being (Braitenberg, 1984; Dawson, 2004; Prescott, 2015; Prescott and Camilleri, 2018).

More specifically, I first outline an innovative clinical-psychological theory, which concerns a characterizing human feature: attachment. I present then its testing through both clinical and computational means. Therefore, although it touches on multiple fields, this research is located between psychology and engineering. It adopts a cognitive-clinical approach and uses the elaboration on the theoretical foundation of its subject – attachment – to tackle its modeling.

1. Theory and empirical testing

This work addresses the problem of the conceptualization and empirical testing of attachment: the evolutionary mechanism that encourages each of us to seek care from another – a caregiver or attachment figure – as a child typically does from their mother (Bowlby, 1969/1982; Ainsworth and Bell, 1970; Main and Solomon, 1990) (Figure 1).

Figure 1. Attachment and caregiving.
The child forms an attachment relationship with their mother based on interactions driven by the child's motivation to ask for care and the mother's motivation to provide it.

The theory is tested both clinically and computationally, and a distinctive feature of the proposed theoretical framework is to be particularly suitable for computational

modeling. The review of the related literature (Likhachev and Arkin, 2000; Buono et al., 2006; Petters, 2006; Amengual, 2009; Stevens and Zhang, 2009; Petters and Waters, 2015; Cittern, 2016; Petters and Beaudoin, 2017; Talevich, 2017) suggests that the – not many – existing computational models of attachment mostly refer to an early and inconvenient approach that conceptualizes it as behavioral and categorical. In contrast, attachment is essentially representational and dimensional in nature, and focusing on such aspects leads to the formulation of an enhanced attachment theory that facilitates its computational modeling by clarifying the central features of the phenomenon.

1.1. A clinical-psychological theory and its computational modeling

The psychological theory that I present here is meant to have direct clinical application by giving a contribution to the understanding of how the human mind is structured and works, especially in dysfunctional conditions. However, despite the clinical-psychological applicability of its theoretical foundation, a specific purpose of this work is to test the theory through the development of a computational model. Such a model will consequently be primarily informed by the theory itself rather than by a consolidated mathematical formulation.

The constitutional elements of attachment relevant at the personality level – in particular, its core beliefs – are investigated and used to reconstruct the functioning of the system, thereby adopting what can be called an engineering approach to clinical psychology. By taking a cognitive-clinical perspective and considering the crucial influence of the layered organization of knowledge in the mind, attachment is seen as a representational mechanism whose information concerns several evolutionarily established dimensions. There is reason to believe – and this research reinforces this belief – that this more technical-formal approach can significantly enhance our comprehension of clinical matters and, at the same time, help computational modelers realize a more realistic reproduction of human mind and behavior. Formalization is critical when facing complex socio-psychological phenomena – such as attachment – whose literature can adopt considerably diverse perspectives (Fitton, 2012; Sutton, 2019) often very far from that of a computational modeler. The outlined theory tries to make a step in this direction by offering a framework that is also more systematic and quantifiable than those usually presented by clinical-psychological theories. This not only makes it easier to explain clinical phenomena but – more importantly here – helps identify key aspects of them. In particular, it will facilitate recognizing the role of attachment as the socio-psychological firmware of our mind. In this perspective, the considerable effort put into clarifying a theoretical framework for attachment can be considered an essential part of its computational modeling. This

point will be further elaborated on shortly but, before doing that, it is important to specify the role of representation in this work, which is central with respect to both theory and modeling.

1.2. Representation and its levels

A representation is an entity that stands for another, thereby, indeed, representing it. Representations can assume numerous forms – such as verbal or visual – and computations can be performed on them to create new representations. Cognitive science, the interdisciplinary study of the mind (Thagard, 2007; Friedenberg and Silverman, 2016), broadly embraces a computational theory of mind that conceptualizes the mind as working by performing computations on mental representations, both of which – computations and representations – can be of various kinds (Thagard, 2019; Pitt, 2020). For example, mental representations can be words manipulated according to grammatical rules or images that can be moved or composed. Given that the brain implements the mind, this conception corresponds to a brain-computer analogy.

My research pertains to the vast area of cognitive science and is based on computation and representation. With respect to attachment phenomena, representations can be identified at three different levels, stemming from the physical context of attachment interactions (Figure 2). (1) Mental level. Attachment theory considers attachment as a representational mechanism, recognizing that the child, from their exchanges with the caregiver, forms mental representations (termed internal working models) that have an active role in their interactions (Bowlby, 1973; Main et al., 1985; Waters and Waters, 2006; Sherman et al., 2015). (2) Theoretical level. The enhancement of the theory presented here expands this concept by considering attachment representations as belonging to several domains – the attachment dimensions. Each dimension is regarded as encoding a specific piece of information in the brain, which exerts a certain degree of influence on attachment exchanges. (3) Modeling level. Finally, such theorized pieces of information are taken into computational modeling through single variables or parameters whose values correspond to their degree of influence. In brief, (1) attachment is considered to consist of mental representations of different kinds (such as cognitive, emotional, and sensorimotor) that are (2) theoretically expressed by information over several dimensions and (3) by numeric values in a computational model.

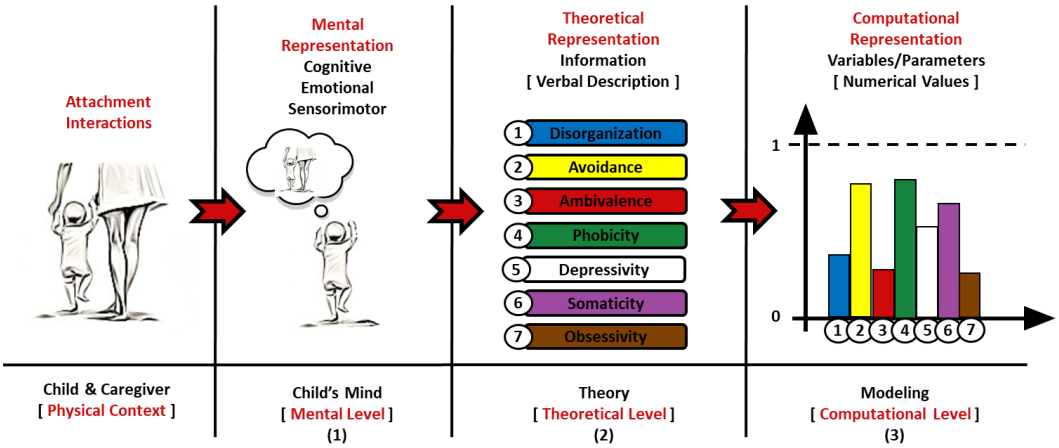


Figure 2. Representation and its levels.
Attachment representations can be considered at different levels. (1) Mental Level. From attachment interactions, the child generates mental representations, which can assume cognitive, emotional, and sensorimotor forms. (2) Theoretical Level. In the presented theory, these representations are assumed to be information encoded over seven dimensions and verbally describable. (3) Computational Level. Finally, these theorized representations are brought into computational modeling through variables and parameters, which take values between zero and one.

It is worth noting that, although (in accordance with attachment theory) this work adopts the computational-representational perspective on cognition, important complementary or alternative explanations of mental functioning have been proposed. The dynamical systems theory, for instance, explains cognition as state-changes in time, with no computation on representations in the process (van Gelder and Port, 1995; Bechtel, 1998). Interestingly, the computational model presented here can also be interpreted and expanded from a dynamical standpoint, thereby possibly gaining insights into the nature of attachment dynamics. Such a study represents an exciting extension of this research.

2. The goals of this project

As mentioned above, this research touches on multiple disciplines. However, it especially involves clinical psychology and engineering, trying to bridge the large gap that traditionally separates them. With this respect, the aim is to help build a deep and lasting connection between them.

2.1. Theoretical goal: An enhanced attachment theory

Attachment is the subject of a specific theory – attachment theory indeed – that has been first developed by John Bowlby, especially through his trilogy on attachment and loss (Bowlby, 1969/1982; 1973; 1980). The theory has soon gained a significant

empirical relevance thanks to the work of Mary Ainsworth and Mary Main, who developed powerful assessment tools – respectively, the Strange Situation Procedure (SSP) (Ainsworth et al., 1978; Main and Solomon, 1990) and the Adult Attachment Interview (AAI) (George et al., 1985; Main and Hesse, 1990; Hesse, 2016), the first meant to measure attachment in infants and the latter in adults. Over the last fifty years, the theory has grown enormous proportions and has become one of the most influential theories in psychology. In fact, it critically involves clinical, developmental, social, personality, and evolutionary psychology. A glimpse of the breadth and relevance of attachment theory can be taken from its handbook, which is at the moment at its third edition (Cassidy and Shaver, 1999; 2008; 2016). Although the corpus of the theory is so vast and important aspects of it remain controversial, most researchers share a common view on a number of fundamental issues, thereby substantiating what can be called a **Standard Attachment Theory** (SAT). According to this version of the theory, attachment is characterized by three dimensions – avoidance, ambivalence, and disorganization.

By elaborating on existing data adopting a cognitive-clinical perspective, I developed a novel theoretical formulation of human attachment that considers attachment and its relation to personality, thereby representing an **Attachment-Personality Theory** (APT) (Gagliardi, 2021)[1]. The first part of my PhD has been dedicated to outlining this framework and a corresponding attachment module as a preliminary goal (cf. Chapter 1 and 2). Many years of development have resulted in an extension of the standard view of attachment that maintains its achievements, making the APT an enhanced attachment theory. The designed attachment module represents an intermediate step toward its computational implementation.

The particular perspective taken by the APT to conceptualize attachment shines a light on its representational and dimensional nature. Arguments supported by a considerable amount of data – from clinical, developmental, evolutionary psychology, and neuroscience – are presented that overall endorse the central hypothesis according to which attachment is a multidimensional phenomenon. More precisely, it is proposed to be characterized by seven dimensions – four more than the ones recognized by the SAT, the additional dimensions being termed phobicity, depressivity, somaticity, and obsessivity. Attachment is a representational mechanism over these dimensions, on which our most intimate socio-psychological interactions rely. In our first years of life, through attachment interactions, we build our fundamental seven-dimensional representation of the other and the self. According

[1] The APT has been termed APM – Attachment-Personality Model – in Gagliardi (2021) to suggest the empirical nature and practical applicability of the theory.

to the APT proposal, these pieces of information correspond each to a specific caregiving feature that we are evolutionarily preordained to detect and measure in order to adapt to both our early and later environment. In other words, what a mother does when she takes care of her child covers several caregiving features – such as emotional warmth or ethical guidance, for example. The child detects and measures these features, thereby acquiring for each feature a value on a corresponding dimension. For simplicity, this will usually be expressed by saying that each feature induces a specific dimension. For example, the emotional warmth expressed by the caregiver will induce the child's acquisition of a tendency to engage in attachment interactions, and the ethical guidance provided by the caregiver will induce the child's acquisition of a tendency to respect certain rules. The strength of such tendencies corresponds to the acquired dimensional level.

This idea challenges the standard perspective of attachment, which emphasizes the multiple determining factors involved in attachment phenomena. Many factors have been proposed, both internal to the attachment relationship (Whipple et al., 2011; Bernier et al., 2014; van Ijzendoorn and Bakermans-Kranenburg, 2019) – such as maternal sensitivity or autonomy support – and external (Fraley, 2002; Pinquart et al., 2013) – such as social support or socio-economical condition. However, considering a principal inducing factor does not exclude the existence of many others that can possibly intervene and, at the same time, allows focusing on what is expected to be primarily involved. The SAT propensity to consider multiple factors stemmed from the disconfirmation of maternal sensitivity as the only one responsible for the fundamental attachment characteristics: (1) Avoidance – expressed by a child that appears not emotionally involved in the relationship with the mother; and (2) Ambivalence – expressed by a child that appears preoccupied about the mother's availability. According to this early hypothesis, a different degree of maternal sensitivity could induce in the child a different degree of both avoidance and ambivalence, which were conceptualized as different categories (Ainsworth et al., 1978). In contrast, according to the theoretical work presented here, attachment is induced by multiple caregiving features – not only sensitivity – over corresponding multiple dimensions (Gagliardi, 2021). In the case of avoidance and ambivalence, the first is induced by the caregiver's insensitivity and the latter by the caregiver's unresponsiveness. Overall, the theory suggests that a limited number of measurable caregiving variables can be conveniently isolated, and their influence mapped to corresponding attachment ones. Compared to a scenario of multiple and not clearly specified factors, the modeling advantage is evident.

It is essential to stress that the theoretical formulation taken as a reference can significantly influence the outcome of a practical application. In particular, given the

essentially qualitative nature of attachment, the related concepts are usually formulated in a way that results significantly far from a possible computational implementation. Moreover, the complexity of the phenomenon under study and the broadness of the theory have made it very difficult for computational modelers to identify the most relevant aspects of attachment, gain the most convenient perspective on them, and therefore effectively model them. In this regard, the enhanced attachment theory presented here results being particularly suitable for computational implementation.

In general, the connection between information and motivation is key to computational modeling. The outline of the APT (cf. Chapter 1) allows for the design of an attachment module (cf. Chapter 2) that represents attachment primarily as a representational and dimensional device, which is governed by the independent motivation to seek care. In this perspective, information drives action, and the possible available actions determine behavioral dynamics. An agent-child that is allowed to either approach an agent-caregiver or explore the environment will generate an approach-exploration pattern by selecting an action after comparing the current psychological representation of the relationship with the one they hold as a set-goal. A behavioral (as opposed to representational) and categorical (as opposed to dimensional) perspective would lead the same agent to act following a completely different logic. The particular theoretical perspective adopted can dramatically affect the actual behavior of the agent. Importantly, the designed attachment module derived from the APT leads to the realization of an agent-based model (ABM) of the interactions between child and caregiver that, as it will be shown (cf. Chapter 4), produces a realistic simulation of avoidant and ambivalent interactions.

By removing the limitations set by the behavioral and categorical approach to attachment endorsed by most previous models (Buono et al., 2006; Stevens and Zhang, 2009; Cittern, 2016; Petters and Beaudoin, 2017; Talevich, 2017), this more elaborated theory opens a new horizon in terms of computational implementation. In particular, the categorical view of attachment has led to conceptualizing avoidance and ambivalence as depending on the same caregiving feature, which has been demonstrated not to be the case. The ABM presented here overcomes this problem by considering the two dimensions as related to two different caregiving features.

There is more to it. In general, personality can be considered as the set of relatively stable psychological characteristics of an individual – what are often referred to as traits. The APT offers an additional advantage to the modeler of human behavior by connecting attachment to personality. In fact, attachment is presented as the core of personality, as far as personality is considered from a representational perspective.

More specifically, although personality is a complex concept, in which innate and acquired aspects have a role, a crucial part of it is constituted by acquired information, especially of attachment origin. The APT models precisely this part – the fundamental knowledge that constitutes personality. Therefore, the possibility to model attachment interactions can lead to that of providing a non-human agent with the basic elements of a human personality. Indeed, the rudiments of a personality will be recognizable in the behavior of the agents.

2.1.1. A challenge to some common assumptions about attachment

Although the proposed theoretical framework broadly relies on the classical theory, it is worth stressing that the APT also poses some considerable challenges to the SAT. The main one concerns the understanding of the relationship between attachment and personality. In fact, studying the phenomenon from different perspectives can suggest different conclusions on this crucial aspect. In particular, social and clinical psychology tend to diverge on this point. Social psychologists usually focus on the possibility of change and, therefore, to consider attachment loosely connected to personality. By contrast, in agreement with most clinical psychologists, this work hypothesizes (and supports the idea) that attachment is a fundamental part of personality. The APT is clinically oriented.

This point is related to another distinctive feature of the presented framework. Consistently with assuming attachment as loosely related to personality, numerous theorists consider attachment patterns more open to change than personality. This work proposes instead – on the basis of the multiple arguments laid out in chapter 1 – that attachment tends to be stable.

Finally, the fact – often assumed as a sign of a weak connection between attachment and personality – that an individual can change attachment pattern depending on the caregiver (or context) is also compliant with the proposed framework. Following the APT, a person can activate a different dimension depending on the caregiver (or context) and, therefore, show a different attachment pattern while maintaining a stable personality.

2.2. Empirical goal: Validation and implementation

The theoretical effort needs to be supported by an empirical testbed, which can be provided by multiple means. Validation has been the main concern of the second part of my PhD (cf. Chapter 3, 4, and 5), and it can be considered its principal goal since the theory itself has been conceived to progress by testing.

Since the proposed theoretical framework connects attachment to personality and clinical phenomena – in particular, mental disorders (Beck et al., 2015; Levy et al., 2015; DeKlyen and Greenberg, 2016; Stovall-McClough and Dozier, 2016; Gordon-King et al., 2019) – besides being computationally tested, the APT was also clinically tested.

2.2.1. Validation through questionnaire

The clinical testing of the APT was pursued through the development of an **Attachment-Caregiving Questionnaire** (ACQ). The instrument is meant to investigate the current attachment representation of the subject over its theorized seven dimensions and the corresponding caregiving features experienced by the subject as a child with their main maternal and paternal figures.

The ACQ is composed of three main sections. A preliminary section – Q_D (56 items) – collects general personal data (such as sex, age, education, etc.) and general clinical information (such as psychological wellbeing, level of stress, etc.). Then, the attachment section – Q_A (125 items) – assesses the current attachment state of the subject as a product of their overall attachment experiences. Finally, the caregiving section consists of three subsections. The first brief section – Q_{Fy} (17 items) – collects information about the family of origin. The following two sections – Q_{CM} and Q_{CF} (83 items each) – assess the attachment experience of the subject in childhood with their mother and father respectively.

The ACQ required a long developmental process that involved the collaboration of external expert clinicians. Each item has been carefully elaborated on multiple times until reaching mutual agreement, usually taking advantage of its mediated presentation in clinical settings. The ACQ has been finally judged as a clinically valuable instrument and considered ready for the first administration – which has been ethically approved by The University of Sheffield.

Overall, the ACQ allows for the testing of three key APT hypotheses:

1. H_A: the seven-dimensionality of attachment as measured by the items of Q_A;
2. H_C: the seven-dimensionality of caregiving as measured by the items of Q_{CM} and Q_{CF};
3. H_{CA}: the correspondence between the caregiving features experienced as a child and the attachment dimensions expressed as an adult.

These hypotheses can be tested through at least two different methods. The first one is commonly used for questionnaire validation. It consists of a statistical analysis that exploits factor extraction to obtain the dimensionality to which the items can be reduced. This is typically done by means of Principal Component Analysis (PCA). The

second method is much less common for questionnaire validation. It utilizes artificial intelligence (AI) to recognize the patterns underlying subject responses. Both methods require a large sample. In particular, according to an old rule of thumb, PCA requires a minimum sample size 5 to 10 times larger than the number of items. For Q_A, this rule suggests at least 625 subjects. More recent studies indicate more complex and favorable rules, but a quite optimistic prediction could be not less than 500 subjects (Bandalos and Boehm-Kaufman, 2009; Rouquette and Falissard, 2011).

However, these analyses were deemed too demanding for this doctorate, and the goal was decided to be the realization of the questionnaire and a preliminary study (cf. Chapter 3). For the attachment and caregiving sub-questionnaires – Q_A, Q_{CM}, and Q_{CF} – items have been grouped according to theoretical considerations, and a useful PCA on a sample of 51 subjects has been carried out. The results of this study provide a first confirmation of the presented theoretical framework, which – like the one given by the presented computational implementation – can be considered a proof of concept. Moreover, the development of the questionnaire and the performed statistical analysis both suggest that information concerning the implicit knowledge acquired in attachment relationships is embedded in flexible patterns of answers – i.e. patterns that cannot be reduced to rigid scales and remain undetected by a usual correlation analysis such as the PCA. Therefore, pattern recognition performed by AI is suggested to be a preferable validation method.

2.2.2. Validation through computational implementation

The computational testing of the APT was pursued through the development of an **Attachment Computational Model** (ACM), which represents an empirical test both of the operationalizability/implementability and validity of the theory. The ACM consists of a multidimensional Agent-Based Model (ABM) of attachment that implements key features of the outlined theoretical framework. It has been designed to be the structurally simplest model that can allow for the simulation of avoidant and ambivalent interactions between a child and their caregiver (cf. Chapter 4). The model has been then extended to simulate an additional dimension theorized by the APT – phobicity (cf. Chapter 5).

The ACM creates a squared surface on which two dots can move autonomously – a scenario that is meant to represent the interactions of child and caregiver in a large room and resembles an SSP setting (Figure 3).

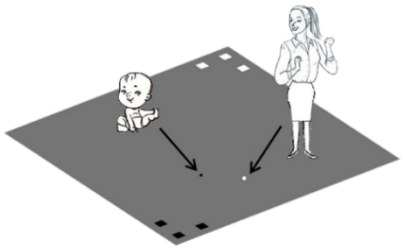


Figure 3. A dyad of 'humanoid dots'.
The presented agent-based model represents child and caregiver as dots free to move on a square.

The model is meant to simulate the interactions shown by the dyad following the attachment learning process. In other words, the child is assumed to have acquired their attachment dimensions from the caregiver and interact with them accordingly. The resulting behavioral patterns are observed.

The two agents are free to explore the environment, approach the other agent, or take no action according to rules that directly translate the enhanced attachment theory presented here. Therefore, the behavioral patterns shown by the two agents can be taken as the attachment-caregiving patterns corresponding to the theory. As a result, the comparison between these patterns and those shown by humans can serve as a validation of the theory.

As it will be shown, the simulated patterns bear similarities to those reported in attachment literature that suggest the validity of the proposed theoretical framework. However, given the preliminary nature of this test – like in the case of the presented questionnaire – the confirmation obtained can be considered a proof of concept. In particular, the computational model simulates the interactions of the agents for different values of avoidance and ambivalence. The highly avoidant dyad shows the expected independent and explorative patterns, while the highly ambivalent one shows the expected entangled patterns with a child preoccupied for the availability of their caregiver. Moreover, the additional theorized attachment dimension – phobicity – also leads to simulations coherent with real phobic patterns where a hyper-protective caregiver limits the child's autonomous exploration. In all cases – the avoidant, ambivalent, and phobic one – a caregiving feature is modeled as a measure of an observable caregiver behavior, thereby confirming that an attachment dimension can be induced by a specific caregiving feature. For example, the caregiver's emotional coldness – that is assumed to be related to the child's avoidance – depends on a measure of the caregiver's exploration, while the caregiver's physical availability – that is assumed to be related to the child's ambivalence – depends on a measure of the distance from the child maintained by the caregiver.

Of course, a 'humanoid dot' is significantly different from a humanoid robot (Figure 4). By endowing a robot with sensors and actuators, a modeler can exploit the multiple channels through which attachment-caregiving relationships are realized. A child can signal their needs in a variety of ways – such as crying, expressing facial emotions, speaking, approaching, etc. – all behaviors that can much more directly be simulated by a robot than a dot. Nonetheless, the basic setting realized by an ABM can offer remarkable possibilities (Petters and Waters, 2015) and even the advantage of focusing on few essential variables.

Figure 4. A humanoid robot.
An important objective of this work is to favor the reproduction of human attachment and personality on a humanoid robot.

Finally, a further advantage offered by the APT and its representational-dimensional perspective is the possibility of studying attachment both as the product of single identifiable major determinants and considering their possible interactions. The ACM considers here the effect of single causes, but it can be further extended to study their interaction. Therefore, it can be used to practice synthetic psychology (Braitenberg, 1984; Dawson, 2004; Prescott, 2015; Prescott and Camilleri, 2018) and learn about features of attachment that are hardly observable in real settings.

2.2.3. Engineering applications beyond theory

The ACQ and ACM suggest that the APT might contribute to bridging the gap between clinical psychology and engineering. The ACQ is designed to allow for the application of artificial intelligence to the gathered data, while the ACM relies on a high-level psychological representation of the attachment-caregiving context to simulate child-mother interactions.

Despite the objective of the ACQ and ACM being testing the APT, these tools can provide contributions to knowledge through engineering applications regardless of the validity of the theory they are meant to test. They implement an original design and novel methodological solutions that can provide insights into attachment nature through synthetic psychology – independently of the APT. More specifically, the application of artificial intelligence to a clinical questionnaire would lead to the creation of an artificial clinician able to help human decision-making by providing an expert automatic profile. The realization of a computational model that implements

high-level psychological phenomena can not only provide an artificial agent with a module more compliant with psychological data but also contribute to the future creation of a synthetic equivalent of a human being.

2.3. Summary

Summarizing, the objective of this research is twofold:

1. **Theoretical.** The research first aims to present an enhanced attachment theory (the APT), which – by connecting attachment to personality – has particular clinical relevance.
2. **Empirical.** The research aims then to test the presented theory through the development of a clinical questionnaire (the ACQ) – that also works as a personality inventory – and a computational model (the ACM).

3. Thesis organization

In accordance with its objectives, this work is organized into five chapters, which develop two subsequent parts, a theoretical (Chapter 1-2) and an empirical (Chapter 3-5) one. The first part concerns the presentation of the APT and the outline of a corresponding attachment module, which will work as a basis for the computational modeling. The second concerns the testing of the APT through the ACQ (a clinical questionnaire) and the ACM (a computational model). An overview of each chapter follows.

Chapter 1. Standard view of attachment and its enhancement

In this chapter, an overview of the **Standard Attachment Theory** (SAT) is first presented, focusing on the central aspects of the phenomenon. Attachment is an evolutionary mechanism that works both as an intrinsic motivation and a knowledge base, which serves to direct such motivation. Then, the **Attachment-Personality Theory** (APT) (Gagliardi, 2021) is presented, according to which attachment is primarily about building an internal representation over seven dimensions, which are acquired through a specific mechanism: imprinting. This way, the seven theorized dimensions of attachment constitute the knowledge core of our personality. Through its representational and dimensional approach, the APT clarifies the relationship not only between attachment and personality but also between attachment and psychopathology. The outlined motivational and knowledge characteristics will be at the center of the realized computational implementation. Overall, the chapter shows how the proposed theory enhances the standard version from both a clinical and a computational standpoint.

Chapter 2. Attachment as a multidimensional control system

This chapter shows how the modeling problem has been tackled by the previous – SAT-based – works and takes a further step toward a concrete realization of an APT-informed model. Some of the most relevant attachment models present in the literature are reviewed, aiming at both taking inspiration from them and identifying possible causes of the difficulties they encountered. The most significant limitations of most previous works may derive from their reference to a behavioral (as opposed to representational) and categorical (as opposed to dimensional) perspective on attachment. In contrast, the APT leads to building an attachment module – outlined here – that is based on the acquisition, maintenance, and employment of information over seven dimensions. The module connects motivation to knowledge and generates a final internal state and behavior. The seven dimensions of attachment theorized by the APT set the goals for the module and direct attachment, making it a – representation-driven – multidimensional control system.

Chapter 3. The Attachment-Caregiving Questionnaire (ACQ)

The main object of this chapter is the presentation of the **Attachment-Caregiving Questionnaire** (ACQ), which I developed to test the APT and is, indeed, informed by such a theoretical framework. After illustrating the conceptualization and realization of the ACQ, the preliminary study carried out to test the theory is presented. Development started with considering the problem of adult attachment assessment, focusing on the available questionnaires. The first steps were taken considering them carefully, but since they proved not to be APT-compliant, an independent path was taken. The ACQ is a complex clinical questionnaire consisting of 380 items and multiple parts, and details of these parts and the process that led to their layout are given. By virtue of the APT connection between attachment, personality, and psychopathology, the instrument works as both a clinical tool and a personality inventory. It allows for the testing of multiple hypotheses, the main of which are attachment and caregiving dimensionality and the correspondence between adult expression of attachment and caregiving experienced in childhood. The complete test of these hypotheses would require the administration to a large sample – most probably, at least 500 subjects – which would call for a dedicated work. Here, once the questionnaire was laid out, the goal was to perform a preliminary statistical analysis on a small sample. Such analysis was possible through grouping the items into scales as theorized by the APT. This work produced data that provides a first confirmation of fundamental theoretical assumptions regarding attachment dimensions and caregiving features. A large-scale administration is proposed as future work, and two methods of data analysis are discussed.

Chapter 4. An Attachment Computational Model (ACM) of avoidance and ambivalence

This chapter illustrates the main features of the **Attachment Computational Model** (ACM) – the first model that directly derives from the APT. Consistently, it implements the APT representational and dimensional perspective on attachment, which is modeled as a – representation-driven – multidimensional control system. Its dimensions provide the representations that set the goals of the system. The ACM is an agent-based model that represents a large room – termed lab – as a squared surface and a child-caregiver dyad as two dots on it. The agents are free to either explore the lab or express their characterizing motivation: attachment for the child and caregiving for the caregiver. The model presented in this chapter considers the two basic dimensions avoidance and ambivalence, assuming that they are induced by the two features insensitivity and unresponsiveness respectively. Dimensions and features are all considered stored information, and corresponding interactions are simulated. The attachment patterns generated by the model for different dimensional levels are compared to those described in the literature, showing that simulated patterns reflect the expected ones, thereby supporting the implemented theory. On the one hand, avoidant dyads feel a low need (to attach and give care) and are highly explorative. On the other, ambivalent dyads feel contrasting needs and show opposite behaviors: the ambivalent child often wants to attach and approach the caregiver, while the unresponsive caregiver rarely wants to offer care and often explores.

Chapter 5. Extension of the ACM to phobicity

In this last chapter, the two-dimensional **Attachment Computational Model** (ACM) that simulates avoidance and ambivalence is extended to a third dimension: phobicity. Phobicity was chosen because it appeared to be the only dimension that the current basic ACM setting can adequately support. According to the APT, it is induced by a limiting caregiver – namely, a caregiver that hinders the child's natural tendency to explore. For its simulation, the limiting caregiver is assumed to be hyper-protective and the corresponding phobic child to feel vulnerable without their protection. The caregiver's distance from the child is taken to signal the degree of protection offered. More precisely, the caregiver is assumed to be more protective if they are closer to the child and, symmetrically, the child to feel less vulnerable. When phobicity is high, child and caregiver want to stay close to each other – the child to be protected, the caregiver to protect – and, therefore, they keep short distances. Again, the simulated patterns reflect the expected ones, thereby further supporting the APT and its representational and dimensional perspective on attachment.

Chapter 1[*]

Standard view of attachment and its enhancement

Introduction

In this chapter, I outline the main features of the **Standard Attachment Theory** (SAT), with an emphasis on the central aspects of attachment: motivation and knowledge. The main problems this formulation poses will offer the basis for the presentation of the enhanced version of it that provides the foundation for the rest of this work.

According to the SAT, evolution provided us with a powerful mechanism to adapt to our early environment – attachment, which motivates us to attach, indeed, to our caregiver (Bowlby, 1969/1982; 1973; 1980). This way, we are warranted not only the care that is necessary to survive but also the chance to gather indispensable socio-psychological information. With the help of our caregiver – who as such is motivated to care for us – we soon learn how to explore the environment (Bowlby, 1969/1982; Ainsworth and Bell, 1970) and gradually enrich the relationship through many other motivations (Liotti and Ardovini, 2008; Liotti et al., 2017). Attachment maintains its key role throughout the entire course of our life (Bowlby, 1969/1982; Mikulincer and Shaver, 2016), both as a motivation and a knowledge base. The latter serves, in fact, to direct the former. The standard theory assumes that attachment is underpinned by representations – termed Internal Working Models – that refer to the attachment dyad and their relationship (Bowlby, 1973; Waters and Waters, 2006; Bretherton and

[*] Based on Gagliardi, M. (2021). *How Our Caregivers Shape Who We Are: The Seven Dimensions of Attachment at the Core of Personality*. 12(2656). doi: *10.3389/fpsyg.2021.657628*.

Munholland, 2008; Sherman et al., 2015; Marvin et al., 2016; Petters, 2019). However, their precise content and use remain unclarified, as well as the mechanism of their acquisition. In fact, the SAT, despite its continuous attempts, has not been able to shine a light on three major controversial aspects that concern attachment – in relation to (1) intergenerational transmission, (2) stability, and (3) psychopathology.

I present here the **Attachment-Personality Theory** (APT) (Gagliardi, 2021)[2], an enhanced version of the SAT, which proposes novel hypotheses about attachment knowledge and its origin. An Internal Working Model (IWM) is formally defined as consisting of seven attachment dimensions, which correspond each to an elementary piece of information about the other or the self with adaptive value. According to this hypothesis, in the early years of life, the caregiver induces – in the child – the imprinting of this information through seven specific caregiving features. Each dimension can be acquired by the child at a different level, thereby determining the quality of their attachment patterns. Since this socio-psychological knowledge occupies a foundational position, it becomes the core of our personality: our core beliefs. Imprinting confers on it the necessary resistance to change. Imprinted values that go beyond a given threshold make us particularly sensitive to related psychological discomfort and mental conditions. Thus, the proposed representational and dimensional perspective on attachment helps clarify its relationship with personality and psychopathology – also suggesting a solution to the above-mentioned three major problems from which the SAT suffers. This enhanced version of attachment theory offers significant advantages from both a clinical and a computational perspective. As we will see (cf. Chapter 4 and 5), the presented computational model – by implementing this conceptualization – overcomes some crucial theoretical issues encountered by its predecessors.

Below, the APT is illustrated in detail, proceeding as follows. As a preliminary step, the cognitive-clinical approach to personality of the theory is better clarified (cf. 1.1). Then, the SAT and its view of personality are presented (cf. 1.2). The three major problems that beset the SAT (concerning stability, intergenerational transmission, and psychopathology) and their relation to personality are discussed in the next section (cf. 1.3). At this point, the APT is outlined, showing how it helps solve the three crucial issues that lock the standard theory in a stalemate. According to the APT, attachment knowledge is composed of seven dimensions that are acquired by detecting seven corresponding caregiving features (cf. 1.4). Finally, the APT implications and limitations are discussed (cf. 1.5). The proposed hypotheses are supported by indirect evidence, but how to test them directly is suggested. The questionnaire and

[2] The APT has been termed APM – Attachment-Personality Model – in Gagliardi (2021) to suggest the empirical nature and practical applicability of the theory.

computational model that are presented in the second part of this work provide the first instances of such direct testing.

1.1. A cognitive-clinical approach to personality

Psychologists usually recognize the significant explanatory power of attachment theory (Cassidy and Shaver, 1999; 2008; 2016) and the clinical effectiveness of cognitive psychotherapy (Beck, 2011; Beck and Haigh, 2014). The APT is situated in this context, and two general features define its aim and scope:

(1) The APT draws on the achievements of the SAT, developing them in a cognitive-clinical perspective – which makes its considerations also entirely compatible with psychoanalysis and most other clinical approaches. It introduces some hypotheses that have not been considered yet by attachment theory and proposes their direct empirical testing, supporting such a proposal through evidence gathered from a variety of fields. Therefore, the APT is a purely theoretical framework, which is, however, grounded in previous well-established, evidence-based research. The knowledge aspects of personality and their developmental underpinnings are outlined, following the principles of cognitive science (Thagard, 2007; 2019). Accordingly, concrete ways to test the proposed hypotheses are suggested – some of which are later implemented (cf. Chapter 3, 4, and 5).

(2) The APT only considers the part of personality related to (implicit) knowledge acquisition, although multiple factors play a fundamental role in its constitution (temperament in particular)[3]. The phenomenon is complex and can be studied from a variety of perspectives (such as biological, environmental, social, and cultural), as the many authors who try to encompass in their analyses as many variables as possible demonstrate. Here, only one of the major factors involved is considered, aiming at a better understanding of its effect. The focus is set on (implicitly acquired) information to help clarify its role in the overall makeup of personality. Therefore, a standard healthy biological substrate should be considered as a reference.

Personality can be defined as the fairly stable psychological characteristics of an individual (McCrae and Costa, 2003; Corr and Matthews, 2009; Engler, 2013; Beck et

[3] Multiple studies have found personality has significant heritability. Bouchard (2004, p.150) reported a mean heritability of 50% for the Big Five traits (Extraversion .54, Agreeableness .42, Conscientiousness .49, Neuroticism .48, Openness .57). More recently, an accurate meta-analysis from Vukasović and Bratko (2015, p.778) – considering three different personality measures (Eysenck, Tellegen, Big Five) – found a mean heritability of 40%. For the Big Five the mean heritability was 36% (Neuroticism .37, Extraversion .36, Openness .41, Agreeableness .35, Conscientiousness .31). The mean 40% heritability for personality was confirmed by Plomin (2018, p.6).

al., 2015; Friedman and Schustack, 2015) and, according to the cognitive approach, one's personality is critically determined by their core knowledge – a set of core beliefs (Young, 2002; Dweck, 2008; Perdighe and Mancini, 2010; Beck et al., 2015; Osmo et al., 2018). This raises the two questions: (1) What are these core beliefs? (2) How are they acquired? Here, it is argued that an adequate enhancement of the SAT offers a persuasive answer to these questions.

According to (a significant part of) the SAT, an individual forms the core knowledge of their personality through the relationship with their caregiver, and such knowledge concerns three fundamental dimensions – disorganization, avoidance, and ambivalence (Bowlby, 1969/1982; 1973; 1980; Liotti, 2009; Paetzold et al., 2015; Feeney, 2016; Mikulincer and Shaver, 2016; Thompson, 2016). These core beliefs are first determined by the particular kind of care experienced in childhood (Main et al., 1985; Platts et al., 2002; Sherman et al., 2015; Hesse, 2016; Marvin et al., 2016). For example, considering avoidance, the child who has a relationship with a cold caregiver develops the belief of being an unlovable person, while the child who has a relationship with a warm caregiver develops the belief of being a lovable person. Such beliefs correspond to different concretizations of this dimension.

The APT embraces this idea and elaborates on it, arguing the following.

1. The nature of two of the three attachment dimensions described by the SAT – avoidance and ambivalence – needs to be better specified, and four additional dimensions – phobicity, depressivity, somaticity, and obsessivity – are required to explain personality. The APT suggests the existence of seven dimensions.
2. The caregiving features that induce the acquisition of the attachment dimensions need to be identified. The APT suggests that each dimension is induced by a specific feature.
3. The specific mechanism through which attachment information is acquired needs to be considered. The APT final suggestion is that imprinting gives attachment dimensions the quality of stable personality traits.

Thus, the APT proposal is that (the knowledge core of) personality is made up of seven pieces of information imprinted through attachment relationships. The presented framework is, therefore, a seven-dimensional Attachment-Personality Theory.

Given that personality is a complex and controversial concept (Engler, 2013; Friedman and Schustack, 2015), it is important to point out again that the APT is limited to the knowledge part of personality. Accordingly, this part is simply referred to as personality, and the focus is set on the core of it – the core beliefs indeed.

Before analyzing the relationship between attachment and personality from the particular cognitive-clinical perspective adopted, it is important to offer a broader view of the SAT considering different angles, different proposed analyses, and some severe criticisms.

1.1.1. A broader view on standard attachment theory

As mentioned above (cf. Introduction 1.1), attachment theory has been hugely developing for several decades from its initial Bowlbyan formulations. It is not surprising then that a diversity of approaches have been adopted so far (Fitton, 2012; Sutton, 2019). At least five different ones can be identified, each of which inherits a specific angle and investigation methodology from its more general area of research: (1) Developmental psychology; (2) Social Psychology; (3) Clinical Psychology; (4) Evolutionary psychology; (5) Computational psychiatry.

(1) Developmental psychology. The developmental approach was the first to be adopted and flourished thanks to the Strange Situation Procedure (SSP) (Ainsworth et al., 1978; Main and Solomon, 1990) – a lab technique that allows the measurement of infant attachment patterns. Many other techniques for analogous assessments at each developmental age followed. This approach focuses on the attachment figure's role as a safe base that favors the child's exploration and felt security. Its success was consolidated by the Adult Attachment Interview (AAI) (George et al., 1985; Main and Hesse, 1990; Hesse, 2016), which provides an assessment of attachment in adulthood that matches the one given by the SSP in childhood. Both instruments – the SSP and AAI – distinguish between four categories of attachment patterns.

(2) Social psychology. The socio-psychological approach to the study of attachment can be considered an extension of the developmental one. Patterns similar to those observed between caregiver and infant were identified between romantic partners (Hazan and Shaver, 1987), and many questionnaires were developed to measure them. For example, the Relationship Questionnaire (RQ) (Bartholomew, 1990; Bartholomew and Horowitz, 1991), the Adult Attachment Scale (AAS) (Collins and Read, 1990), the Revised AAS (RAAS) (Collins, 1996), the Adult Attachment Questionnaire (AAQ) (Simpson et al., 1992; Simpson et al., 1996), the Experiences in Close Relationships (ECR) (Brennan et al., 1998), the ECR Revised (ECR-R) (Fraley et al., 2000), and the ECR Relationship Structures (ECR-RS) (Fraley et al., 2011), which will be discussed in Chapter 3. A fundamental feature of this approach is relying on statistical methods for data analysis. In particular, questionnaires were generally developed through factorization, which supported the underlying dimensional nature of attachment. Self-report measures can considerably vary over time and, consistently,

social researchers generally focus on the multiple factors that can affect attachment and determine its change. As a result, in this perspective, attachment is usually seen as more loosely related to personality.

(3) Clinical psychology. Clinical psychologists and psychotherapists often focus on the profound relationship between mother and child in the early years of life, considering it a key factor in the building of the child's later psychological characteristics (Berne, 1972; Bowlby, 1980; Guidano, 1991; Blatt and Levy, 2003; Liotti and Farina, 2011; Yakeley, 2018; Karterud and Kongerslev, 2019). This approach draws on the Bowlbyan psychoanalytic interest in investigating how early attachment relationships affect the formation of the self and how such relationships can be used to modify dysfunctional acquisitions. In this perspective – which is the one adopted in this work – attachment is strictly related to personality. Different clinical schools elaborate on different related concepts – such as cognitive organizations or mentalization for example – but they generally focus on close emotional experiences to understand later outcomes and design bespoke interventions.

(4) Evolutionary psychology. The evolutionary approach has the potential to further enhance the original view of attachment as a survival mechanism. According to this perspective, attachment dimensions must have originated in our ancestral typical environment and be related to typical caregiving features (Chisholm, 1996; Chisholm and Sieff, 2014). Moreover, they must have offered not only a survival advantage – as the early Bowlbyan theory suggested – but also a reproductive one since an adaptive mechanism is selected when it favors gene propagation (Hamilton, 1964; Simpson and Belsky, 2016). In other words, besides childhood survival, the dimensions also favor adult reproduction and should, therefore, be considered for their roles in both childhood and adulthood.

(5) Computational psychiatry. The computational approach is the most recent one, but it seems very promising in offering key contributions to the study of attachment (Montague et al., 2012; Petters and Beaudoin, 2017). Through different engineering methods, models of attachment phenomena are not only built and tested against psychological data but also used to produce new insights (cf. 2.1). Moreover, mathematical models of physiological phenomena in non-human animals – such as the thermoregulation involved in rat huddling (Glancy et al., 2015; Wilson, 2017) – may shed light on the evolutionary precursors of human attachment. Importantly, the development of cognitive architectures that allow the implementation of human motivational and emotional phenomena can reveal the underpinnings of the complex mechanisms underlying our attachment interactions (Petters and Waters, 2015; Petters, 2019).

As this brief overview shows, attachment theorists come from multiple disciplines and adopt a number of approaches and related methodologies. This work primarily embraces the clinical and engineering ones.

1.1.2. Current discussion in attachment theory

Despite its consolidation over the years, attachment theory is still open to discussion on multiple key points. Notably, researchers with different approaches tend to focus on some of such points more than others. As an example, two relevant comprehensive analyses of the theory are proposed below. And finally, some radical criticisms are also considered.

Analysis 1. Cowan and Cowan (2007) examined the status of attachment research across the lifespan, focusing on parental and romantic attachment. In doing so, they identified the following seven fundamental questions:

1. Should attachment be conceptualized as categorical or dimensional?
2. Is attachment underpinned by a single or multiple working models?
3. Are early specific attachments the basis of subsequent attachments in life?
4. Does attachment develop over time?
5. Is attachment a culturally specific or a universal phenomenon?
6. Can intergenerational attachment phenomena be conveniently studied by considering the family as a system?
7. Can attachment theory help inform parental and therapeutic practices?

In summarizing the answers indicated by the authors, the corresponding APT position will be reported, noting how – as expected – some answers differ significantly from what this work proposes. (1) In accordance with the APT, by relying on the studies from Fraley and Spieker (2003) and Roisman et al. (2007a), the authors stress that the dimensional model fits attachment data better than the categorical one (Cowan and Cowan, 2007, p.187). On the other hand, they also underline – still in accordance with the APT – the validity of both continuous and categorical attachment measures (Cowan and Cowan, 2007, p.187). In fact, having a dimensional nature does not preclude the utility of a categorical measure – especially in the case of the dimensions avoidance and ambivalence, which are not expressed simultaneously given the opposite activation they imply (cf. 4.2.1). (2) In regard to attachment working models, the authors point out that one can attach to multiple figures and in different ways – i.e. showing different patterns or states of mind (Fox et al., 1991; Furman and Simon, 2006) – and show different strategies with the same figure (Alexandrov et al., 2005). They conclude that an individual must have a different model for each attachment figure or type of attachment figure and, consistently, that attachment is not a

personality trait. More simply, the APT suggests instead the existence of a single multidimensional working model and that different patterns and states of mind can be the result of a different dimensional elicitation. (3) While examining the stability of attachment over time, the authors note that the AAI and adult attachment questionnaires have no or low correlation (Crowell et al., 1999) and infer that there is no reason to think that parental and romantic models of attachment should be consistent. In contrast, the APT proposes the singularity of the attachment working model and its fundamental stability based on imprinting. (4) Following the Bowlbyan proposal of a developmental attachment maturation (Bowlby, 1979) and consistently with their view of relatively easily mutable attachment working models, the authors lean toward the possibility of a developmental change of attachment. Conversely, the APT suggests multiple sensitive periods as the basis of subsequent general stability. (5) The authors stress the universal value of attachment despite important cultural differences in its manifestation, such as the different proportions of children belonging to each SSP category in different countries (van Ijzendoorn and Sagi, 1999). The APT fully agrees on this point. (6) Consistently with their conception of multiple attachment working models, the authors propose to see attachment from a family systems perspective. Accordingly, they suggest considering how the dynamics inherent to the family and all its subsystems influence the models of each member. As discussed above, the APT disagrees on this point, given the proposed singularity of the attachment working model. (7) Finally, the authors acknowledge the possible benefits of attachment-theory-informed parental and therapeutic interventions. This idea resonates with the APT clinical inclination, notwithstanding the important differences discussed above.

Analysis 2. In an attempt of summarizing and reorganizing attachment theory, Mercer (2011) considered 11 fundamental tenets from its early formulations. He divided them into four categories, consisting of ideas that have been generally: (1) Accepted with no criticism; (2) Accepted although criticized; (3) Questioned (partially rejected); (4) Rejected and/or reformulated. The tenets are summarized and discussed below, where they are labeled with a number in squared brackets referring to the list given by the author. Again, the APT position will be reported and compared to the one proposed by the author.

(1) Accepted with no criticism. The author lists three notions as the basis of attachment theory: [1] Attachment is an emotional bond, [2] which is formed in infancy with a caregiver who is not necessarily the biological mother. [3] Separation from the caregiver first generates protest and then grief – with the possibility of finally attaching to a different caregiver. The APT fully agrees.

(2) Accepted although criticized. According to the author, despite some criticism, there is good evidence that: [4] Attachment is the product of child-caregiver interaction, with the determining effect of caregiving quality (Roisman and Fraley, 2006). [8] Early attachment experiences have a strong influence on later behavioral outcomes. [10] The child builds an internal working model representing their attachment experiences, which mediates later behavioral outcomes. The APT still fully agrees with these general statements.

(3) Questioned (partially rejected). The author considers the following two early hypotheses of attachment theory: [5] Attachment is grounded in evolutionary mechanisms for social response – similar to those present in other species (e.g. imprinting). [11] Disruptions in early attachment experiences can cause later pathological outcomes. The first hypothesis is considered of little use, the second one difficult to prove. In contrast, the APT values these ideas and further elaborates on them.

(4) Rejected and/or reformulated (not proven). The author considers the following as a hypothesis of attachment theory: [6] Attachment can occur only in an early sensitive period (6 months – 3-4 years). He then lists: [7] Attachment is formed with a single caregiver. [9] Attachment phenomena are generated by an attachment control system influenced by the environment. According to the author, the first hypothesis has been rejected, the second has been reformulated considering the possibility of multiple caregivers, and the third is in abeyance and requires deeper analysis. The APT does not support the first two ideas (which seem hard to collocate into any formulation of attachment theory). On the other hand, the attachment control system is a fundamental APT concept.

Radical criticisms. Finally, it is worth noting that some authors question the general validity and prominence of attachment theory (Bolen, 2000; Berghaus, 2011).

The high relevance of genetic factors in determining psychological characteristics – and, in particular, personality (Bouchard, 2004; Vukasović and Bratko, 2015; Plomin, 2018) – is often considered to undermine the relevance of attachment. The APT recognizes the importance of both elements – the genetic and attachment ones – focusing on the latter.

Another crucial point is maternal sensitivity, seen as a not sufficiently concrete and defined concept to describe caregiving behavior (van den Boom, 1995) or as a factor having only a minor effect on social relationships (Rutter et al., 2009). Consistently, some authors suggest downsizing the influence of early relationships on later outcomes and consider a number of additional possible factors (Berghaus, 2011; van

Ijzendoorn and Bakermans-Kranenburg, 2019). The APT proposes that a broader range of caregiving features and the mechanism of their influence – i.e. imprinting – can explain the acquisition of attachment dimensions and their enduring effects.

Finally, the involvement of attachment phenomena in developmental psychological disorders has been particularly criticized, to the point of proposing the elimination of the Reactive Attachment Disorder as a diagnostic category (Allen, 2016; Fitzgerald, 2019). The APT suggests how attachment is connected to a broad range of mental disorders in conditions that do not imply attachment disruption and the possible development of a reactive attachment disorder. The considered disorders are, in fact, common in adulthood.

1.1.3. Further contextualizing this work

The above discussion provides a glimpse of the numerous and sometimes contradicting facets of attachment theory, which – for convenience – is here referred to as a whole through the term Standard Attachment Theory (SAT). Given the multiple perspectives adopted by the SAT and the ongoing controversies, it is important to further contextualize the presented theoretical framework. The analyses from Cowan and Cowan (2007) and Mercer (2011) also confirm that the APT differs in crucial aspects from the SAT. Two points are particularly relevant.

First, it must be stressed again that the APT adopts a particular cognitive-clinical standpoint. It focuses on the knowledge acquired in attachment relationships and connects such knowledge to the building of personality, which provides us with individual sensitivities and tendencies to develop mental disorders. In particular, the conception of the internal working model and the suggested acquisition mechanism – imprinting – challenge the current theory and justify the central APT proposal: attachment as a foundational part of personality. As evident from the above analyses and criticisms, numerous attachment theorists see attachment and personality as two weakly connected entities, and some do not see any connection at all.

Second, the reviewed analyses also report several questions that are proposed to be – or have been – central in the SAT. Interestingly, the authors focus on different aspects of attachment and do not seem always to have the same view (e.g. concerning the effect of early experiences on later outcomes). In this respect, it is important to note that the three problems examined by the APT – intergenerational transmission, stability, and psychopathology – are considered major ones given the particular cognitive-clinical perspective adopted and the focus on personality. As the above analyses show, other issues in attachment theory can be considered crucial given other perspectives and interests.

1.2. The standard conceptualization of attachment and its relation to personality

In this section, the main features of the standard version of attachment theory – as it is currently broadly accepted – along with its view of personality are outlined.

Bowlby (1969/1982; 1973; 1980), father of attachment theory, maintained that attachment is the fundamental evolutionary mechanism that every human being adopts – *"from the cradle to the grave"* (Bowlby, 1969/1982, p.208) – to obtain protection and care from a conspecific – a caregiver. For several years after birth, children need to be protected and cared for to survive and develop, and the first caregiver – most often the mother – plays this fundamental role. However, despite the primacy of this early relationship, attachment remains prominent throughout life, and new attachment bonds with similar characteristics can be created at any age (Bowlby, 1969/1982; Allen, 2008; Kerns and Brumariu, 2016; Marvin et al., 2016; Mikulincer and Shaver, 2016; Fraley and Roisman, 2019). For example, when feeling vulnerable, an adult will look for protection and care from their partner as a child does from their caregiver, although usually in a different form. While the child cries and clings, the adult might call their loved one and relate a difficult day at work, looking for sympathy.

According to attachment theorists, the two fundamental aspects related to the formation of attachment bonds are the innate motivation to attach and the knowledge acquired through such bonds. Indeed, as discussed below, human behavior is: (1) driven by motivational systems – and attachment is one of them; (2) strongly influenced by knowledge – especially that related to attachment. Let us consider these two points in turn.

1.2.1. Attachment as an innate motivation

Bowlby (1969/1982; 1973; 1980), inspired by ethological studies and control theory, conceptualizes human behavior as driven by behavioral systems. Attachment – he says – is the system that the child activates to regulate their distance from the caregiver, aiming to obtain protection and care from them, who accordingly activates the caregiving system to protect and take care of their child. In this perspective, the caregiver works as a secure base for the child's exploration. Of course, other behavioral systems are necessary to perform the full range of human activities. Following a clinical perspective, these devices are here referred to as 'motivational systems' (Bowlby, 1969/1982; Lichtenberg et al., 2010; Panksepp and Biven, 2012; Liotti et al., 2017; Schaller et al., 2017). Their main characteristics are being innate

(genetically predefined) and universal (present in every human being). A number of such systems can be identified, and different authors have focused on different intrinsic motivations. A particularly useful conceptualization is the one presented by Liotti (Liotti and Monticelli, 2008; 2014; Liotti et al., 2017), who proposes a set of fifteen motivations divided into three levels according to both a psychological and evolutionary criterion (Table 1.1). According to his conceptualization, (1) the most ancient – less evolved – level is the 'reptilian' one, which drives individual activities, such as those concerning physiological regulation, exploration, and the defense of one's own integrity. (2) Social activities are regulated by the 'mammalian' level. The systems most relevant to our psychological dynamics – such as attachment, caregiving, and ranking – belong to this level. Finally, (3) the most recent – and evolved – level is the exclusively human one, which underpins our cultural endeavors. According to this evolutionary theory of motivation, every human behavior arises from the activation of (at least) one of these motivational systems. Whatever we do is motivated, and any of our actions can be traced back to (at least) one of these systems.

	Motivational System	Level
1	Physiological Regulation (e.g. nutrition, respiration)	Individual Level: systems regulating non-social behaviors
2	Defense (Freeze, Fight, Fly, Faint)	
3	Exploration	
4	Territoriality	
5	Predation	
6	Sexuality (without building a relationship)	
1	Attachment	Social Level: systems regulating social behaviors (social interaction based on mutual recognition between conspecifics)
2	Caregiving	
3	Ranking (competition)	
4	Sexuality (building a relationship)	
5	Cooperation	
6	Affiliation (to a group)	
7	Play (social)	
1	Intersubjectivity (sharing of subjective states)	Cultural Level: systems needed for cultural development
2	Construction of Meanings	

Table 1.1. Liotti's Motivational Systems.
Liotti (Liotti and Monticelli, 2008; 2014; Liotti et al., 2017) developed an evolutionary theory of motivation for clinical purposes. The theory identifies 15 innate and universal motivational systems and divides them into 3 levels, from the less to the more evolved: (1) Individual level: Systems for non-social behaviors (typical of reptiles); (2) Social level: Systems for social behaviors (typical of mammals); (3)

Cultural level: Systems that allowed humans to develop culture (exclusively human). According to this theory, behavior is underpinned by the interplay of all these intrinsic motivations.

Importantly, a system can be either active or inactive, multiple systems can be simultaneously active, and different kinds of activations are possible. The activation is cyclic when the system activates periodically, such as nutrition, for example. It is phasic when the system is activated by detected events. This is the case of attachment. Finally, activation is tonic when the system is always activated but at different levels, such as exploration, for example.

1.2.2. Attachment as acquired knowledge

The fundamental aspects related to attachment knowledge have been described through the concepts of Internal Working Model (IWM) of attachment and attachment dimensions. They both correspond to representations – or core beliefs – built in attachment interactions.

1.2.2.1. The internal working model of attachment

According to the SAT, attachment interactions are the context in which specific representations of the caregiver and the self, called Internal Working Models of attachment, are generated (Bowlby, 1973; Waters and Waters, 2006; Bretherton and Munholland, 2008; Sherman et al., 2015; Marvin et al., 2016; Petters, 2019). For simplicity, these multiple representations are here referred to as a whole, using the singular form of the term: Internal Working Model. Since the origin of the attachment relationship, the IWM represents the caregiver and the self and, hence, implicitly characterizes such a relationship. It has a very pragmatic function: guiding the individual's attachment behavior by influencing both their expectation and interpretation of events. For example, a child who experiences an unloving mother will build an IWM that predicts that they will not be loved and suggests avoiding, as much as possible, asking her for comfort.

1.2.2.2. Attachment dimensions

Attachment representations correspond to typical observable behavioral patterns. These patterns have been measured for the first time in infants of about one year of age through the Strange Situation Procedure (SSP) (Ainsworth et al., 1978; Main and Solomon, 1990). The SSP is realized in a room where the child is the protagonist of eight three-minute episodes in which attachment behaviors are measured. Attachment is elicited by creating adequate situations that involve the child, their caregiver, and a stranger. Since the child's feeling of safety depends on the caregiver's attitude and location, the episodes where the caregiver leaves and then reenters the

room are key to assessing the quality of the relationship. Attachment has then been assessed in adults through the Adult Attachment Interview (AAI) (George et al., 1985; Main and Hesse, 1990; Hesse, 2016). The AAI is a semi-structured interview that measures the so-called state of mind of the subject with respect to attachment, in particular, referred to their maternal and paternal figures. These tools identified four attachment categories, which correspond to each other – and can be termed Avoidant (A), Secure (B), Ambivalent (C), and Disorganized (D) following the SSP nomenclature. Indeed, they persist across the lifespan (Ammaniti et al., 2000; Target et al., 2003; Stievenart et al., 2012).

Initially, attachment was conceived as categorical, but later research demonstrated it rather has a dimensional nature. Fraley and Spieker (2003, p.399) reported how their "*analyses indicate[d] that the data are most consistent with a dimensional view of individual differences*" and "*propose[d] a two-dimensional model of individual differences in attachment*". The authors went on stating that "*disorganization […], according to [their] analyses, […] should be represented as a third domain that is for all intents and purposes orthogonal to the other two domains*" (Fraley and Spieker, 2003, p.403). Cowan and Cowan (2007, p.187), considering what "*Fraley and Spieker found, as did Roisman, Fraley, and Belsky (2007)"*, remarked that *"dimensional constructs rather than categorical constructs fit the data better*". The measured attachment categories are now recognized to be underpinned by three dimensions – disorganization, avoidance, and ambivalence (Bartholomew and Horowitz, 1991; Brennan et al., 1998; Fraley and Spieker, 2003; Liotti and Farina, 2011; Fraley et al., 2015; Paetzold et al., 2015; Mikulincer and Shaver, 2016). However, although the SSP and AAI were first developed to detect categories and then found to better identify dimensions (Fraley and Spieker, 2003; Roisman et al., 2007a), these categorical instruments remain "*the gold standard in the field*", as suggested by (Roisman et al., 2007a, p.675). In fact, as mentioned above, the dimensional model is perfectly consistent with a categorial assessment.

The three dimensions are generally considered reciprocally (statistically) independent, although some correlation between avoidance and ambivalence has been found when measuring adult attachment (Cameron et al., 2012; Fraley et al., 2015). An individual who is neither avoidant nor ambivalent is defined as secure. In other words, avoidance and/or ambivalence determine an insecure attachment. Like the IWM, the dimensions express attachment knowledge.

The APT refers to these three basic dimensions – disorganization, avoidance, and ambivalence – as α-dimensions, in order to easily distinguish them from the four additional ones – phobicity, depressivity, somaticity, and obsessivity – that are

introduced later and referred to as β-dimensions. Below, each α-dimension is described according to standard attachment theory.

Disorganization. This dimension of attachment has been recognized as coming from a frightening caregiver (Main and Solomon, 1990; Lyons-Ruth and Jacobvitz, 2016). Therefore, it can be defined as the subjective measure of the caregiver's frightfulness. The phenomenon can be fully understood by considering the underlying motivational dynamics (Liotti, 2004; Ogden et al., 2006; van der Hart et al., 2006; Liotti, 2011; Liotti and Farina, 2011). In this case, the caregiver, who is by definition a source of protection and care for the child, is also a threat. Therefore, the child activates both the attachment and the defense system. Since the two systems are incompatible, the child is driven by inconsistent behaviors, disorganized indeed, which might express a simultaneous attempt to approach and avoid, for example. The clinical consequence of disorganization is the manifestation of dissociative symptoms (Liotti, 2004; Ogden et al., 2006; van der Hart et al., 2006; Liotti, 2011; Liotti and Farina, 2011).

Avoidance and ambivalence. These two dimensions are thought to be strongly related to the caregiver's sensitivity – how adequately and promptly the caregiver detects and satisfies the child's needs (Ainsworth et al., 1978; De Wolff and van Ijzendoorn, 1997). Attachment researchers agree on the main characteristics of avoidance and ambivalence, which can be synthesized in terms of attachment activation (Shaver and Mikulincer, 2002; Mikulincer et al., 2003; Mikulincer and Shaver, 2016) and corresponding observable characteristics across the lifespan (Ainsworth et al., 1978; Parkes et al., 1993; Green et al., 2000; Fraley and Shaver, 2008; Mikulincer and Shaver, 2016) as follows.

1. Avoidance is characterized by deactivation of the attachment system and corresponding inhibition of attachment behaviors and emotions.
2. Ambivalence is characterized by hyper-activation of the attachment system and corresponding over-expression of attachment behaviors and emotions.

Indeed, the avoidant is detached and cold in the relationship, while the ambivalent is hyper-involved in the relationship and over-emotional. In particular, the ambivalent is concerned about being taken care of and protest for not being taken care of when needed.

What differentiates these dimensions. Disorganization, avoidance, and ambivalence have been recognized by the SAT to be different dimensions, but this acknowledgment is not completely clear for at least two reasons. The first is that disorganization is still often considered as the product of the rapidly alternating expression of avoidance and ambivalence (Crittenden, 1995; Fraley and Shaver, 2008; Lyons-Ruth and Jacobvitz,

2008; Farnfield et al., 2010; Mikulincer and Shaver, 2016). However, although avoidance and ambivalence can be simultaneously present and can correspond to opposite behaviors, they do not imply a frightening caregiver and the activation of the defense system as disorganization does. Therefore, they have nothing to do with it. The second is that avoidance and ambivalence are still often considered opposite expressions of the same underlying dimension – as suggested by the early categorical approaches to attachment (Ainsworth et al., 1978; George et al., 1985; Green et al., 2000; Target et al., 2003). In particular, avoidance and ambivalence have been conceptualized as both deriving from the same caregiving feature of 'sensitive-responsiveness' and, therefore, as belonging to the same dimension of 'security-anxiety' (Ainsworth et al., 1978, p.152). This view has been more recently disconfirmed by the SAT itself, which has proposed many other caregiving features as responsible for the generation of avoidance and ambivalence (Whipple et al., 2011; Bernier et al., 2014; van Ijzendoorn and Bakermans-Kranenburg, 2019). Both these conceptions reduce the dimensionality of attachment and produce considerable effects on its modeling. As will be discussed in the next chapter, most previous models of attachment have adopted an early theoretical formulation that may well have limited their simulation capability.

Attachment style. Attachment theory is complex, and researchers in different areas tend to use different terms to denote attachment characteristics related to different categories or dimensions. In particular, attachment 'pattern' and 'state of mind' traditionally belong to the developmental area and 'style' to the social one. Here, the term 'style' will be used, but in a proprietary way, focusing on the representational and dimensional nature of attachment.

1.2.3. Attachment knowledge and personality

According to (a significant part of) the SAT, the IWM constitutes our primary other-self representation and can, therefore, be considered our fundamental socio-psychological knowledge. In fact, attachment has been recognized as a major constituent of personality (Bowlby, 1969/1982; 1973; 1980; Guidano, 1987; 1991; Noftle and Shaver, 2006; Guidano, 2007; Chopik et al., 2013; Levy et al., 2015; Mikulincer and Shaver, 2016; Karterud and Kongerslev, 2019; Rosa-Mendes et al., 2019; Young et al., 2019).

The connection between attachment and personality is particularly clear in the TAM (Temperament-Attachment-Mentalizing) model of personality elaborated by Karterud and Kongerslev (2019). These authors effectively synthesize the complexity of personality by identifying in Temperament (T), Attachment (A), and Mentalizing (M)

the three major components of personality. T is the innate biological basis of personality, A is what is learned since the early stages of life in the attachment relationship, and M is a higher-level cognitive ability grounded in A and developed throughout life. Therefore, according to the TAM model – as well as to the APT – attachment knowledge can be considered the fundamental acquired part of personality. The concept of metacognition – the ability to consider and reason about mental states and processes (Semerari et al., 2003; Semerari et al., 2007; Dimaggio and Lysaker, 2010; Carcione et al., 2011; Carcione et al., 2019) – widely overlaps with that of mentalizing (Bo et al., 2014; Semerari et al., 2014; Dimaggio and Lysaker, 2015; Fonagy and Bateman, 2016). As a consequence, as discussed below, the APT is also compatible with the well-established metacognitive interpersonal therapy (Dimaggio et al., 2015; Dimaggio and Lysaker, 2018).

1.2.3.1. Imprinting in attachment

Bowlby (1969/1982) first studied the phases through which attachment develops in the child (Table 1.2). He suggested that the attachment of a child to a specific caregiver is realized through imprinting: a mechanism that has the key property of producing a durable acquisition. Such an acquisition, he further suggests, occurs in an early sensitive period, which usually ends within the sixth month. After the child attaches to this specific figure, they need to acquire the information to build their IWM and dimensions. Such information – that allows the child to best adapt to their caregiver – needs to be acquired within the first 24 months, otherwise, the child will suffer from terrible psychological dysfunctions (Marvin et al., 2016; Troller-Renfree and Fox, 2017). Therefore, although the SAT does not usually explicitly consider any specific attachment acquisition method, these elements already indicate imprinting as such a method and the period between 6 and 24 months as sensitive for the acquisition of the α-dimensions – disorganization, avoidance, and ambivalence. In section 1.4.3, imprinting is extensively discussed as being the specific acquisition method of attachment knowledge and, from now on, this assumption is made.

A remark on the term imprinting. Bowlby (1969/1982) used this word to designate the attachment to a specific person, taking it from ethology. The term had been first used with a very narrow sense for birds, considering it a rigid, irreversible process occurring soon after hatching. The phenomenon was then studied in numerous other animals, finding similar, but not identical, characteristics. Drawing on the available studies, Bowlby suggested using the term for human attachment with a broader sense compared to other species. In his words: "*the way in which attachment behaviour develops in the human infant and becomes focused on a discriminated figure is sufficiently like the way in which it develops in other mammals, and in birds, for it to be included, legitimately, under the heading of imprinting*" (Bowlby, 1969/1982,

p.223). Notwithstanding the evident similarities, for humans, imprinting appeared much more flexible than for birds. Unfortunately, after introducing the concept, Bowlby did not elaborate on it further. This work takes on this challenge. Following Bowlby's intuition, the idea is elaborated on, extending its application from the acquisition of the caregiver's identity to the acquisition of the information pertaining to the domains of interaction with them – the attachment dimensions. As discussed below, the term is used in multiple fields to indicate phenomena having the same characteristics proposed here for attachment (Knudsen, 2004; 2013).

	Period	Characteristics
1	0-2 months	"Orientation and signals with limited discrimination of figure"
2	2-6 months	"Orientation and signals directed towards one (or more) discriminated figure(s)"
3	6-24 months	"Maintenance of proximity to a discriminated figure by means of locomotion as well as signals"
4	After 24 months	"Formation of a goal-corrected partnership"

Table 1.2. Phases of early attachment development.
The development of attachment has been deeply studied by Bowlby, who identified the four stages illustrated here (Bowlby, 1969/1982, pp.265-268).

The APT central ideas in a nutshell. The above discussion suggests a formal definition of IWM. Given that (1) attachment knowledge is (unconsciously) acquired through imprinting and (2) the IWM and dimensions of attachment both represent such knowledge (as generally recognized by the SAT), the APT defines the IWM as the imprinted knowledge consisting of all the attachment dimensions. According to the SAT, there are three such dimensions. The APT argues that four additional ones need to be taken into account. Moreover, given the primacy of the early attachment relationship over any other relationship and the persistence of the related acquisitions, it proposes that the attachment dimensions are the central socio-psychological knowledge of the mind. Therefore, it defines the core of personality precisely as these dimensions. For brevity, this core will often be referred to simply as personality. These ideas can now be developed in detail.

1.3. Three major problems concerning personality

In this section, it is shown that the SAT encounters three major problems when trying to account for the relationship between attachment and personality. Then, in the following section, it is demonstrated how these problems can be solved by the APT.

The three key areas of investigation in attachment theory related to personality are:

1. The intergenerational transmission of attachment, which relates to the acquisition of personality.
2. The stability of attachment over life, which relates to the stability of personality.
3. The influence of attachment on psychopathology, which relates to the link between personality and psychopathology.

Below, each of them and the problems they raise are examined.

1.3.1. Problem P1: Intergenerational transmission

A central issue in attachment theory is the intergenerational transmission of attachment styles. Both attachment and clinical sources support the style transmission from a generation to the next (Bowlby, 1969/1982; 1973; 1980; Guidano and Liotti, 1983; Guidano, 1987; 1991; Bretherton, 1993; van Ijzendoorn, 1995; Bernier et al., 2014; Sette et al., 2015; Verhage et al., 2016; van Ijzendoorn and Bakermans-Kranenburg, 2019). According to this phenomenon, a child will most likely acquire the style of their main caregiver. When measuring a child's style through the SSP and their caregiver's style through the AAI, the most probable outcome is to have: (A) An avoidant child from an avoidant caregiver; (B) A secure child from a secure caregiver; and (C) An ambivalent child from an ambivalent caregiver. However, the identification of the caregiving features responsible for bringing about each attachment dimension remains an open problem. An extensive statistical analysis indicates caregiver's sensitivity as not being the only cause of avoidance and ambivalence (van Ijzendoorn, 1995; Verhage et al., 2016; van Ijzendoorn and Bakermans-Kranenburg, 2019), and other caregiving features have been proposed to fill this so-called transmission gap (Whipple et al., 2011; Bernier et al., 2014; van Ijzendoorn and Bakermans-Kranenburg, 2019). In other words, although sensitivity is the feature that is supposed to be involved in fostering attachment security, being sensitive seems not to be enough to raise a secure child. The standard theory has proven unable to fill this gap with the conceptual means available.

1.3.2. Problem P2: Stability

Personality is (fairly) stable by definition. Therefore, if attachment is – as proposed by many attachment theorists – a fundamental part of personality, then attachment should also be (fairly) stable. This means that an individual's attachment style over time should – in general – stay the same. According to this view, an avoidant child, for example, is expected to become an avoidant adult. However, this crucial aspect of

attachment remains controversial: The studies that investigated attachment consistency across the lifespan found different results and, often, only modest stability (Waters et al., 2000; Fraley, 2002; McConnell and Moss, 2011; Pinquart et al., 2013; Kobak et al., 2016). In other words, according to the standard view, there is a contradiction: attachment is supposed to be, at the same time, a central part of personality and not really stable – while personality is. The standard theory seems to be caught in an unsolvable dilemma.

1.3.3. Problem P3: Psychopathology

Finally, the link between attachment and psychopathology is unanimously recognized. In particular, disorganization has been identified as a cause of dissociative pathologies (Liotti, 1992; 2004; Liotti and Farina, 2011; DeKlyen and Greenberg, 2016; Lyons-Ruth and Jacobvitz, 2016; Mikulincer and Shaver, 2016; Stovall-McClough and Dozier, 2016), and avoidance and ambivalence as generally correlated to most mental disorders (DeKlyen and Greenberg, 2016; Stovall-McClough and Dozier, 2016). A frightening caregiver favors the development of dissociative symptoms – such as depersonalization and derealization (i.e., an alteration of the individual's perception of themselves and the world around respectively) – while an insensitive caregiver characterizes the childhood of most people who suffer, in adulthood, from a common mental disorder – such as mood, anxiety, eating, obsessive disorders – suggesting a profound and durable effect of early attachment on the individual. Given its implications on a personal and social level, this problem is the most critical one. In fact, it has been accurately taken into account, and many clinicians believe that attachment should play a primary role in the therapeutic process (Obegi and Berant, 2010; Berry and Danquah, 2016). However, the underlying factors that connect insecure attachment to psychopathology remain unidentified. Again, the standard theory is stuck. It could only prove the implication of attachment in psychopathology with no further specification.

1.3.4. Attachment theory is in trouble: What should be done?

The SAT identifies attachment as a fundamental part of personality. However, the theory confronts three critical problems that challenge the validity of this claim. (1) Sensitivity – the caregiving feature indicated as involved in the early attachment relationship – is not sufficient to explain the acquisition of the attachment knowledge by the child. (2) Attachment cannot be simultaneously a central part of personality and relatively unstable over life because personality is stable. (3) Psychopathology is deeply affected by attachment, but the theory is unable to specify how exactly.

These problems suggest two possibilities: (1) Attachment is not really a central part of personality; or (2) Attachment is a central part of personality, but the theory needs to be enhanced to fully account for this centrality. In the following sections, it is shown how such an enhancement can be realized, and its remarkable implications are illustrated.

1.4. Attachment dimensions and the imprinted personality

This section is dedicated to outlining the APT enhancement of standard attachment theory to account for the relationship between attachment and personality. The argumentation starts by assuming (in sections 1.4.1 and 1.4.2) imprinting as the specific mechanism of attachment knowledge acquisition. Although the standard theory implicitly accepts imprinting as such a mechanism, it has never elaborated on the concept, and imprinting and its implications have never been adequately considered. Therefore, detailed arguments in favor of imprinting are then provided (in section 1.4.3). Overall, the APT suggests that seven dimensions are first imprinted over two consecutive early sensitive periods:

1. Three α-dimensions – disorganization, avoidance, and ambivalence – over an α-period (between 6 and 24 months). As mentioned above, this has already been found by the standard theory.

2. Four β-dimensions – phobicity, depressivity, somaticity, and obsessivity – over a β-period (between 2 and 6 years). This is an APT proposal.

Although the focus is here on the dimensions, the attachment to a specific caregiver is also realized through imprinting and is usually already accomplished within the first six months of life (Bowlby, 1969/1982; Marvin et al., 2016) (c.f. 1.2.3.1) (Figure 1.1).

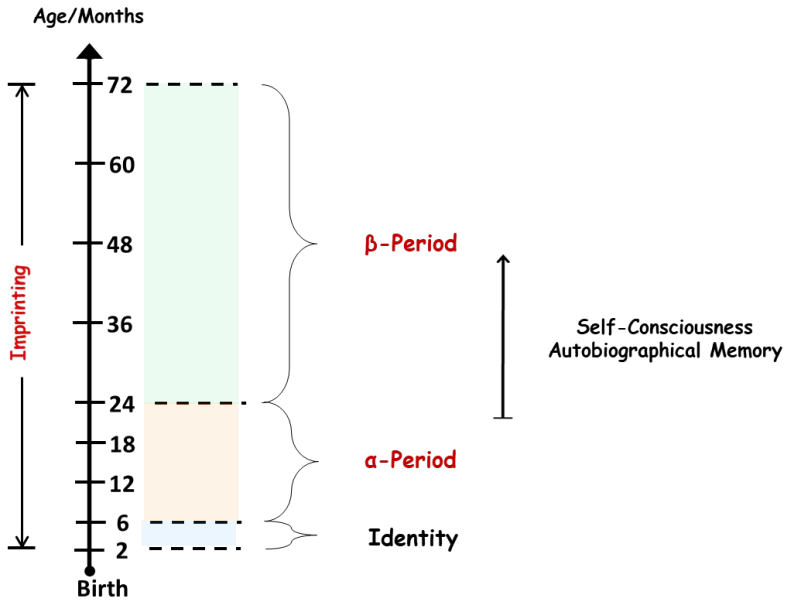


Figure 1.1. Sensitive Periods and Imprinting.
Three consecutive sensitive periods for attachment are indicated. (1) Between 2 and 6 months, the identity of the caregiver is usually already acquired, but the sensitive period extends to 24 months. (2) The α-Period (6-24 months) is the sensitive period for the α-dimensions – disorganization, avoidance, ambivalence. Currently, 24 months is considered to be the maximum extension of the attachment sensitive period (Bowlby, 1969/1982; Marvin et al., 2016; Troller-Renfree and Fox, 2017). (3) The β-Period (2-6 years) is the sensitive period for the β-dimensions – phobicity, depressivity, somaticity, and obsessivity. This additional period is proposed by the APT. The beginning and end of each period are approximate, and clear-cut demarcations are indicated for simplicity.

According to the APT proposal, seven imprinted dimensions fully account for the centrality of attachment in personality. In particular, the APT argues that: (1) A redefinition of avoidance and ambivalence solves the intergenerational transmission gap (solution to problem P1, section 1.4.1); (2) The introduction of four additional dimensions fully explains the causal relationship between attachment and psychopathology (solution to problem P3, section 1.4.2); (3) Imprinting accounts for the stability of attachment and, therefore, personality (solution to problem P2, section 1.4.3). Importantly, this mechanism, although ensuring general stability, also allows for change at any age.

1.4.1. α-Dimensions: The Three Basic Attachment Dimensions

According to the SAT, the three α-dimensions – disorganization, avoidance, and ambivalence – are first acquired during the α-period, which corresponds to most infancy (6-24 months). Disorganization has been precisely linked to a frightening caregiver, but the connection of avoidance and ambivalence to caregiving features is still controversial, with a transmission gap that remains to be filled.

1.4.1.1. A new definition of avoidance and ambivalence

The APT proposes that the α-dimensions derive each from one corresponding caregiving feature (Table 1.4), which it terms α-features. To account for such a causal link, it suggests the following – more specific – definition of avoidance and ambivalence starting from a precise definition of the corresponding α-features – that are referred to as sensitivity and responsiveness respectively:

- **Sensitivity**: the emotional connection offered by the caregiver. Sensitivity is the feature of love, the 'emotional warmth', which is communicated by the caregiver to the child.
  Responsiveness: the physical availability offered by the caregiver. Responsiveness is the feature of 'being physically there when needed'.

- **Avoidance**: the subjective measure of the caregiver's insensitivity. The more the caregiver is (perceived as) unloving, the higher is avoidance.
  Ambivalence: the subjective measure of the caregiver's unresponsiveness. The more the caregiver is (perceived as) physically unavailable when needed, the higher is ambivalence (for the child, the caregiver should and could be there but is not).

These definitions entail a two-channel hypothesis – i.e., that two main (relatively) independent communication channels, one emotional and the other physical, are first relevant in the attachment relationship – with a one-to-one causal link between caregiving features and attachment dimensions:

1. Emotional-Channel. Sensitivity affects avoidance, and only avoidance: sensitivity is the emotional α-feature and avoidance the emotional α-dimension.

2. Physical-Channel. Responsiveness affects ambivalence, and only ambivalence: responsiveness is the physical α-feature and ambivalence the physical α-dimension.

The insensitive caregiver does not engage emotionally and encourages the child to deactivate attachment. As a result, the child tends to avoid interactions based on attachment. The unresponsive caregiver does not engage physically and encourages the child to hyper-activate attachment. As a result, the child tends to be worried about the caregiver's availability (with evident emotional display).

Importantly, these definitions provide a clear correspondence between caregiving features and attachment dimensions. Insensitivity and avoidance match with each

other by virtue of their emotional nature. The avoidant avoids the intolerable experience of facing a cold caregiver by deactivating attachment and focusing on other activities (Ainsworth et al., 1978; George et al., 1985; Hesse, 2008; Mikulincer and Shaver, 2016). A child will typically explore the environment or play. When the insensitive caregiver is present, they do not connect emotionally and, as a result, asking comfort from them makes no sense. Unresponsiveness and ambivalence match with each other by virtue of their physical nature. The ambivalent hyper-activates attachment and worries whether their caregiver will be physically there for them (Ainsworth et al., 1978; George et al., 1985; Hesse, 2008; Mikulincer and Shaver, 2016). The unresponsive caregiver is unpredictably available but connects emotionally when present and, as a result, an emotional signal demanding their presence makes perfect sense. Interestingly, an insensitive-unresponsive caregiver will correspond to an avoidant-ambivalent child, but the two dimensions cannot be expressed simultaneously (since deactivation and hyper-activation are incompatible).

Hence, the provided definitions perfectly illustrate the basic characteristics of the attachment relationship. Their adequacy is further supported by the following four arguments.

(1) **Statistical-independence argument.** As discussed above, avoidance and ambivalence as defined in the standard literature are generally considered mutually (relatively) independent. The APT defines avoidance and ambivalence more specifically – referring to the caregiver's sensitivity and responsiveness – but still maintains that they are (relatively) independent. In fact, if they are, there must be two mutually (relatively) independent caregiving features, each of which induces one of them, and they also need to be identified.

The definitions given above support independence both between insensitivity and unresponsiveness and between avoidance and ambivalence. Indeed:

1. One is an emotional variable (insensitivity/avoidance) and the other a physical one (unresponsiveness/ambivalence).

2. Any combination of the emotional and physical variables is possible. In particular, a caregiver can independently provide any degree of emotional and physical care. For example, as emerges from a broad range of research (Bowlby, 1969/1982; 1973; Ainsworth et al., 1978; 1980; Guidano and Liotti, 1983; Guidano, 1987; 1991; Schore, 1994; Sroufe, 1995; Guidano, 2007; Hesse, 2008; Mikulincer and Shaver, 2016), a caregiver can be physically there but emotionally disconnected and, conversely, they can usually be not physically there but emotionally connected when present.

The given definitions meet the requirement of reciprocal (relative) independence. By contrast, the literature has not focused on the mutual independence of caregiving features. Distinguishing between a purely emotional channel and a purely physical one guarantees such independence.

(2) **Developmental argument.** Two points are considered. (A) In order to develop adequately, for the child, both emotional connection and physical care are essential (Bowlby, 1969/1982; 1973; 1980; Stern, 1985; Schore, 1994; Sroufe, 1995; Leerkes and Wong, 2012; Marvin et al., 2016; Feldman, 2017). (B) As mentioned above, some caregiving features have been suggested as inducing avoidance and ambivalence. In particular, Bernier et al. (2014) found that sensitivity and autonomy support as defined by Whipple et al. (2011, p.397), although not reciprocally independent, fully explain the generation of avoidance and ambivalence. This entails that it is possible to find two caregiving features on which avoidance and ambivalence entirely depend.

These data suggest that the cause of avoidance and ambivalence should be sought by considering (A) the emotional and physical aspects of development and (B) two caregiving features. This is, indeed, the content of the APT proposal.

(3) **Evolutionary argument.** There is reason to believe that in the Environment of Evolutionary Adaptedness (EEA), the context of human evolution (Bowlby, 1969/1982), avoidance and ambivalence have been transmitted through two mutually independent channels – one emotional and the other physical. More precisely, according to an evolutionary argument, avoidance derives from the unwillingness to invest and ambivalence from the inability to invest in the offspring (Chisholm, 1996; Chisholm and Sieff, 2014).

On the one hand, unwillingness is an emotional feature that expresses intentional rejection. Evolutionarily, this is due to a harsh environment that makes the caregiver opt for investing in mating (as opposed to parenting) in order to maximize their reproductive success. In this condition, the child finds the best fit by ignoring their caregiver and boosting their autonomy (avoidance).

On the other, inability is a physical feature that expresses the impossibility of being physically there. Evolutionarily, this is due to an unpredictable environment that occasionally forces the caregiver to attend to essential survival activities, thereby abdicating their role. In this condition, the child finds the best fit by amplifying their need signals (ambivalence).

The evolutionary argument is supported by developmental evidence. Indeed, caregiver willingness and ability seem to be crucial information for young children, as

proved by the ability of nine-month-old infants to distinguish between the unwillingness and inability of an adult to hand them a toy (Behne et al., 2005).

(4) **Neuroscientific argument.** The APT has defined: (A) Insensitivity and avoidance as socio-emotional properties. As such, they primarily rely on gaze direction and facial expressions (relevant to emotional connection). (B) Unresponsiveness and ambivalence as socio-physical properties. As such, they primarily rely on reciprocal position (relevant to physical attendance).

Two quite independent brain networks can be identified as underpinning these emotional and physical aspects. (A) On the one hand, the superior temporal sulcus, which is essential to detect gaze direction (Pelphrey et al., 2005; Hoehl et al., 2009; Itier and Batty, 2009; Carlin and Calder, 2013), is connected to the amygdala, which is key to reading facial emotions (Loughead et al., 2008; Whalen et al., 2013; Gothard, 2014; Wang et al., 2017). (B) On the other, the precuneus region is essential to deem the reciprocal position (Peer et al., 2015).

These neuroscientific data are consistent with two (relatively) independent channels, one emotional and the other physical, that underpin insensitivity/avoidance and unresponsiveness/ambivalence respectively.

Concluding this section, it is important to stress that the focus on these two basic channels is proposed to help further understand and differentiate the complex nature of the two fundamental dimensions of avoidance and ambivalence and not to reduce it to such channels. In other words, the two channels are suggested to catch a fundamental distinction between the two dimensions and not to describe them exhaustively.

1.4.1.2. Solution to the 'intergenerational transmission problem' (P1)

Overall, the above arguments converge to strongly support the two-channel hypothesis. With these definitions, three attachment dimensions and three corresponding caregiving features are revealed to be clearly causally related: (1) a frightening caregiver induces disorganization, (2) an insensitive caregiver induces avoidance, and (3) an unresponsive caregiver induces ambivalence. Accordingly, each α-dimension can be thought of as corresponding to a core belief: "My caregiver is frightening," "My caregiver is insensitive," and "My caregiver is unresponsive" respectively. This framework will be completed by the β-dimensions (Table 1.3). Therefore, the APT indicates how attachment – and the related aspects of personality – are transmitted from a generation to the next, thereby solving the intergenerational transmission problem (P1).

		Dimension	Core Belief	Definition: Subjective measure of how much the caregiver is
α-Dimensions	1	**Disorganization**	"My caregiver is frightening"	Frightening
	2	**Avoidance**	"My caregiver is not going to love me"	Insensitive
	3	**Ambivalence**	"My caregiver is usually not available"	Unresponsive
β-Dimensions	4	**Phobicity**	"I am in danger if my caregiver is not with me" / "My caregiver won't let me go"	Limiting
	5	**Depressivity**	"I won't be able to reach my caregiver emotionally"	Unreachable
	6	**Somaticity**	"I need my caregiver to tell me about myself" / "My caregiver will intrude on me"	Defining
	7	**Obsessivity**	"I am wicked"	Judgmental

Table 1.3. Attachment dimensions as core beliefs.
According to the APT, the IWM of attachment consists of seven dimensions that are first imprinted in sensitive periods early in life. Each dimension (1) corresponds to a core belief – a very simple but evolutionarily valuable piece of information – and (2) is defined as the subjective measure of the caregiving feature by which it is induced.

As repeatedly stressed, three dimensions are still insufficient to account for the relationship between attachment, personality, and especially psychopathology. The APT suggests these dimensions to be seven, and the additional four are now introduced.

1.4.2. β-Dimensions: The Four Additional Attachment Dimensions

Analogously to the α-case, the APT proposes a β-period corresponding to the preschool years (2-6 years) as sensitive for the imprinting of four β-dimensions – phobicity, depressivity, somaticity, and obsessivity (Figure 1.1) – and that these dimensions also derive each from one corresponding caregiving feature, termed β-feature (Table 1.4). Indeed, as discussed below, the caregiver can be:

1. **Limiting:** The caregiver regulates the child's balance between attachment and exploration. When the caregiver is exploration-limiting, they induce a sense of vulnerability and constriction in the child. The attachment consequence is **phobicity**.

2. **Unreachable:** The caregiver should be emotionally reachable for the child. When the caregiver is emotionally unreachable, they induce a sense of defeat/ loss in the child. The attachment consequence is **depressivity**.

3. **Defining:** The caregiver regulates the child's internal states, in particular sensations and emotions, and supports the child's own definition of them. When the caregiver imposes their own definitions on the child, they induce a sense of somatic uncertainty and intrusion in the child. The attachment consequence is **somaticity**.

4. **Judgmental:** The caregiver provides an ethical reference to the child. When the caregiver is judgmental to the child, they induce a sense of being wicked in the child. The attachment consequence is **obsessivity**.

	α-feature		α-dimension
1	**Frightening** caregiver	→	**Disorganized** child
2	**Insensitive** caregiver	→	**Avoidant** child
3	**Unresponsive** caregiver	→	**Ambivalent** child
	β-feature		**β-dimension**
4	**Limiting** caregiver	→	**Phobic** child
5	**Unreachable** caregiver	→	**Depressive** child
6	**Defining** caregiver	→	**Somatic** child
7	**Judgmental** caregiver	→	**Obsessive** child

Table 1.4. Caregiving features and corresponding attachment dimensions.
The APT proposes seven attachment dimensions that derive each from a specific caregiving feature. Three α-features induce the three α-dimensions, and four β-features induce the four β-dimensions. For example, an insensitive caregiver induces avoidance in their child, a defining caregiver induces somaticity in their child.

Importantly, these features are indicated as the principal causes of the corresponding dimensions, without excluding other possible influences on them. Moreover, it is suggested that the β-dimensions are the typical cause of specific mental disorders. Indeed, analyzing vast clinical samples of patients suffering from the most common mental disorders – such as anxiety, mood, eating, and obsessive disorders – Guidano and Liotti found that these patients organized their pathological knowledge following four patterns. They called these patterns 'cognitive organizations' (CO), which then became 'personal meaning organizations' in Guidano's post-rationalist theory (Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007) (Table 1.5).

	β-Dimension	Corresponding Cognitive Organization (CO)	References
1	**Phobicity**	**Phobic CO**	Guidano and Liotti (1983, pp.221-227); Guidano (1987, pp.139-154; 1991, pp.41-45; 2007, pp.79-88)
2	**Depressivity**	**Depressive CO**	Guidano and Liotti (1983, pp.190-193); Guidano (1987, pp.124-138; 1991, pp.35-40; 2007, pp.62-78)
3	**Somaticity**	**Eating disorder CO**	Guidano and Liotti (1983, pp.291-294); Guidano (1987, pp.155-171; 1991, pp.45-50; 2007, pp.88-103)
4	**Obsessivity**	**Obsessive-Compulsive CO**	Guidano and Liotti (1983, pp.261-266); Guidano (1987, pp.172-187; 1991, pp.50-56; 2007, pp.103-114)

Table 1.5. β-Dimensions and corresponding cognitive organizations.
The β-dimensions correspond each to a 'cognitive organization' (also referred to as 'personal meaning organization') described by Guidano and Liotti (1983), Guidano (1987; 1991; 2007), and Guidano's followers (Nardi and Bellantuono, 2008; Nardi et al., 2010).

According to their studies, such COs favor the onset and maintenance of specific disorders – and, therefore, can be considered their cause. This research has been then confirmed by Guidano's followers and extensively tested in clinical practice (Nardi and Bellantuono, 2008; Arciero and Bondolfi, 2009; Nardi et al., 2010). Furthermore, tools have been conceived to assess the four COs both in healthy and pathological conditions (Picardi et al., 2003; Nardi et al., 2012). Essentially, the organizations of knowledge identified by Guidano and Liotti can be considered higher-level descriptions of personality traits, and their careful analysis allows for the extraction of characterizing core beliefs that evidently correspond to those implied by the β-dimensions (Table 1.3). In other words, the β-dimensions can be considered the foundation of the COs (Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007; Nardi et al., 2010), and, therefore, such dimensions result to be causally related to psychopathology (Table 1.6).

	Dimension	Main Causally Related Mental Disorders
1	**Disorganization**	**Dissociative Disorders**
2	**Phobicity**	**Separation Anxiety, Agoraphobia, and Panic Disorder**
3	**Depressivity**	**Depression**
4	**Somaticity**	**Eating disorders**
5	**Obsessivity**	**Obsessive-Compulsive Disorder**

Table 1.6. Attachment dimensions that can be a cause of a mental disorder.
Given their characteristics, five of the seven attachment dimensions – disorganization, phobicity, depressivity, somaticity, and obsessivity – are causally related to psychopathology. Standard

attachment theory recognizes the role of disorganization (Liotti, 1992; 2004; Liotti and Farina, 2011; DeKlyen and Greenberg, 2016; Lyons-Ruth and Jacobvitz, 2016; Mikulincer and Shaver, 2016; Stovall-McClough and Dozier, 2016), while the studies of Bowlby, Liotti, and Guidano and his followers prove the role of phobicity, depressivity, somaticity, and obsessivity (Bowlby, 1973; 1980; Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007; Nardi et al., 2010). These dimensions can cause the onset and maintenance of a specific mental disorder by making the subject more sensitive to conditions that favor it. For example, a phobic is more sensitive to some situations that favor panic, a depressive to others that favor depression. The table shows the link between the dimensions and the most obvious related disorders. Importantly, none of these disorders corresponds exclusively to a specific attachment dimension. A panic attack, for example, can be developed by a somatic subject (or any other), or depression can be developed by an obsessive one (or any other).

Finally, it must be stressed that the β-dimensions belong to every personality and, although they are connected to mental disorders, a high level of such dimensions does not entail psychopathology. They can be considered personality traits, whose excessive presence can facilitate a related disorder. Therefore, being phobic, depressive, somatic, or obsessive does not imply any pathology (and can actually favor adaptation). Similarly, a mental disorder typically related to these dimensions can have an etiology that is not related to them.

In this section, the β-dimensions are outlined, showing that (1) each of them primarily provides adaptation to a specific β-feature and (2) the four fundamental adaptation problems they address are particularly salient in the β-period. Further evidence of such a period is presented in the next section.

1.4.2.1. Phobicity and the limiting caregiver

The APT defines phobicity as the subjective measure of how much the caregiver is limiting (in terms of the child's exploration)[4]. The child needs to get their tendencies to attach and explore regulated by the caregiver, and the phobic child experiences a limitation of their exploration. In other words, the caregiver somehow forces the child to be closer to them than the child feels necessary. For example, the caregiver may be hyper-protective and tend to keep the child under their strict control. In this case, the child will tend to feel restricted and, when confronted with the task of autonomously exploring the environment, particularly in danger.

As a result, the APT proposes, the preschool child gets imprinted an implicit knowledge that can be expressed by the core belief "I am in danger if my caregiver is not with me" and "My caregiver won't let me go" (Table 1.3). This knowledge characterizes phobicity, making the phobic particularly sensitive to the balance attachment-exploration and inclined to suffer from (1) separation anxiety when too far from the

[4] For simplicity, this corresponding caregiving feature is often referred to as 'limitation'.

caregiver and (2) a sense of constriction when too close. In practice, phobicity is revealed by such sensitivity.

The APT definition and proposal are supported by the following evidence.

(1) **Caregiving-Attachment.** The balance between protection and autonomy support is a fundamental caregiving task (Bowlby, 1973; Skinner et al., 2005; Bernier et al., 2014), and autonomy support has been found to be especially important in the preschool years for the following socio-emotional development (Matte-Gagné et al., 2015). The parental styles that induce phobicity have been found to be of two kinds, both of which result in limiting child exploration (Bowlby, 1973; Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007): (A) Direct limitation: the caregiver is over-protective; (B) Indirect limitation: the caregiver makes the child fear to lose them if they do not stay close – for example, by complaining about a serious illness.

(2) **Clinical.** The caregiver limitation of exploration, in any of its forms, is causally related to the main clinical manifestations of phobicity – separation anxiety, agoraphobia, and panic disorder (Bowlby, 1973; Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007; Nardi et al., 2010). Indeed, despite the many intervening variables, the limitation of exploration suffered in childhood has been found correlated to adult panic disorder (Faravelli et al., 1991; Faravelli et al., 2010), and separation anxiety as a child to agoraphobia and panic attacks as an adult (Ayuso et al., 1989; Silove et al., 1995; Kossowsky et al., 2013).

(3) **Evolutionary.** In a difficult EEA, clearly, the child that gets imprinted to stay close to the caregiver enhances their chances to survive, especially when they develop the ability of autonomous exploration (β-period, 2-6 years). Later, the phobic adult will tend to ensure they have their caregivers at hand, thereby improving their survival and reproductive chances in a harsh environment.

1.4.2.2. Depressivity and the unreachable caregiver

The APT defines depressivity as the subjective measure of how much the caregiver is emotionally unreachable[5]. The child needs to be able to reach the caregiver for emotional care, and the depressive child experiences a failure of their attempts to do so. In other words, the caregiver is, for some reason, emotionally unavailable to the child when the child tries to reach them. For example, the caregiver may be usually away from home. In this case, the child will tend to see their desire for emotional care frustrated and, therefore, to feel hopeless, defeated (Seligman, 1975; Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007).

[5] For simplicity, this corresponding caregiving feature is often referred to as 'unreachability'.

As a result, the APT proposes, the preschool child gets imprinted an implicit knowledge that can be expressed by the core belief "I won't be able to reach my caregiver" (Table 1.3). This knowledge characterizes depressivity, making the depressive particularly sensitive to the loss of the caregiver and inclined to suffer from (1) a sense of defeat and (2) depression when a loss is perceived. In practice, depressivity is revealed by such sensitivity.

The APT definition and proposal are supported by the following evidence.

(1) **Caregiving-Attachment.** Ensuring emotional availability to the child is a fundamental caregiving task (Bowlby, 1980; Skinner et al., 2005). The emotional reachability of the caregiver has been found to be especially important in childhood (Kendler et al., 2000; Otowa et al., 2013), and particularly in the preschool years (Belden et al., 2007), for the following socio-emotional development. A cold and demanding parental style (affectionless control) has been identified as connected to the development of future depression (Guidano and Liotti, 1983; Parker, 1983; Guidano, 1987; 1991; 2007). Moreover, the most evident depressive parental characteristic is their long physical absence, especially their loss, which clearly entails emotional unreachability (Beck, 1967; Brown and Harris, 1978; Bowlby, 1980; Guidano and Liotti, 1983; Slavich et al., 2011; Otowa et al., 2014). Neuroscientific research confirms the connection between early loss and future depression (Panksepp, 1998) and the preschool years as a sensitive period for it (Panksepp and Biven, 2012).

(2) **Clinical.** The caregiver emotional unreachability is causally related to the main clinical manifestation of depressivity – depression (Bowlby, 1980; Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007; Nardi et al., 2010). Accordingly, the lack of emotional reciprocity is considered to be a primary cause of the onset of depression in preschool children (Belden et al., 2007), and suffering early long separation or loss significantly increases the sensitivity to future loss as an antecedent to depression (Slavich et al., 2011).

(3) **Evolutionary.** In a difficult EEA, clearly, the child that gets imprinted to give up attempting to reach an emotionally unavailable caregiver enhances their chances to survive by becoming self-reliant (Bowlby, 1980). A tendency to self-reliance starts to be feasible when the child begins to develop some independence (β-period, 2-6 years). Later, the depressive adult will have the advantage to be used to relying on themselves, thereby improving their survival and reproductive chances in a harsh competitive environment.

1.4.2.3. Somaticity and the defining caregiver

The APT defines somaticity as the subjective measure of how much the caregiver is defining (in terms of the child's internal states)[6]. The child needs to learn to recognize their internal states – primarily, the most somatic ones: sensations and emotions – from the caregiver, and the somatic child experiences, instead, an external definition. In other words, the caregiver somehow forces the child to adopt an internal state that does not match the child's actual one. For example, the child might be suggested they feel pain when they do not (like in the case of Brenda, Guidano, 1987). In this case, the child will tend to feel confused about their own state and intruded upon by the caregiver. Somaticity is, therefore, an anomaly of the fundamental caregiving regulation of the child's internal states, where the caregiver's state does not correspond to the child's state. This way, the child does not learn how to recognize their own internal states and becomes uncertain of them.

As a result, the APT proposes, the preschool child gets imprinted an implicit knowledge that can be expressed by the core belief "I need my caregiver to tell me about myself" and "My caregiver will intrude on me" (Table 1.3). This knowledge characterizes somaticity, making the somatic particularly sensitive to the definition of their own internal states and inclined to suffer from (1) uncertainty when not sufficiently defined and (2) a sense of intrusion when being excessively defined by the caregiver. In practice, somaticity is revealed by such sensitivity.

The APT definition and proposal are supported by the following evidence.

(1) **Caregiving-Attachment.** The regulation of the child's internal states is a fundamental caregiving task performed through behavioral and biological synchronicity between caregiver and child (Stern, 1985; Sroufe, 1995; Harrist and Waugh, 2002; Schore, 2005; Feldman, 2017; Hollenstein et al., 2017; Reindl et al., 2018). The specific socio-emotional task of the preschool years is to go from dyadic to self-regulation (Sroufe, 1995). In this period, synchronicity supports the acquisition of social skills (Harrist and Waugh, 2002) accompanied by the development of complex social emotions, such as shame and guilt, that signal the understanding of social standards and rules (Lewis, 2011; Botto and Rochat, 2018). The parental style that induces somaticity is intrusively defining-misattunement, which does not allow the child to reach proper security in self-definition (Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007). As a result, the child tends to remain uncertain of their own internal states and in need for definition from a caregiver. Sensations and emotions – the most somatic states – are the first to be involved, but gradually the caregiver's attitude extends to more abstract ones such as preferences and opinions. Typically,

[6] For simplicity, this corresponding caregiving feature is often referred to as 'definition'.

the caregiver adheres to conventional standards, and the child strives to comply with them. Somaticity can lead to an enmeshed family, where members have very undefined self-borders and tend to have common emotions and opinions (Minuchin et al., 1978).

(2) **Clinical.** The caregiver intrusively defining-misattunement is causally related to the main clinical manifestations of somaticity – eating disorders (Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007; Nardi et al., 2010). These disorders have been found (A) significantly correlated to attachment insecurity (Tasca and Balfour, 2014; Faber et al., 2018) and, in accordance with the somatic uncertainty about self-definition and tendency to compliance, (B) characterized by alexithymia (Schmidt et al., 1993; Westwood et al., 2017) and unassertiveness (Behar A et al., 2006; Hartmann et al., 2010).

(3) **Evolutionary.** In a difficult EEA, clearly, the child that gets imprinted to comply with the caregiver's standards enhances their chances to survive by adopting a view of the situation that already proved functional instead of trying a new one. This becomes salient when the child develops the ability of autonomous exploration and starts to have broader social interactions (β-period, 2-6 years). The somatic adult will keep tending to comply with social standards, thereby improving their survival and reproductive chances in a harsh environment, where social compliance can make a key difference.

1.4.2.4. Obsessivity and the judgmental caregiver

The APT defines obsessivity as the subjective measure of how much the caregiver is judgmental[7]. The child needs to learn ethics – namely, what is considered right or wrong – from the caregiver, and the obsessive child experiences the imposition of the caregiver's code of conduct and being significantly blamed for not abiding by it. In other words, the caregiver enforces a strict and arbitrary set of rules by systematically blaming the child for disobedience. The blame is always justified by claiming to cause terrible harm to someone and conveys the implicit message of the caregiver's rejection of the child. It can assume different forms, such as verbal scold or physical punishment. For example, the child might be severely reproached for wearing wrinkled clothes (like in the case of Alison, Guidano, 1987). In this case, the child will tend to feel anguished by the possibility of misbehaving – even involuntarily – and to focus on acting correctly.

As a result, the APT proposes, the preschool child gets imprinted an implicit knowledge that can be expressed by the core belief "I am wicked" (Table 1.3). This knowledge

[7] For simplicity, this corresponding caregiving feature is often referred to as 'blame'.

characterizes obsessivity, making the obsessive particularly sensitive to ethical matters and inclined to suffer from (1) obsessions focused on their responsibility for causing harm and (2) compulsions to get rid of such intrusive ideas. In practice, obsessivity is revealed by such sensitivity.

The APT definition and proposal are supported by the following evidence.

(1) **Caregiving-Attachment.** The moral guidance of the child is a fundamental caregiving task that has been widely studied, identifying three main related parenting styles: authoritative, authoritarian, and permissive (Baumrind, 1971; Robinson et al., 1995; Skinner et al., 2005; Baumrind, 2013). The acquisition of a code of conduct, accompanied by the emergence of guilt, is accomplished in the preschool years (Sroufe, 1995; Aksan and Kochanska, 2005; Lewis, 2011; Nicolais et al., 2017; Botto and Rochat, 2018) and has been found to have a significant impact on the next development of the child (Baumrind et al., 2010; Kochanska et al., 2010). The parental style that induces obsessivity is cold and severe authoritarianism (Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007; Lennertz et al., 2010; Timpano et al., 2010). Typically, one of the two parents is very active in imposing the rules, and the other is a passive accomplice.

(2) **Clinical.** The caregiver aloof and strict moral guidance is causally related to the main clinical manifestation of obsessivity – the obsessive-compulsive disorder (Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007; Nardi et al., 2010; Basile et al., 2018). This disorder has been found (A) significantly correlated to attachment insecurity (Myhr et al., 2004; Doron et al., 2009; Ivarsson et al., 2010; Rezvan et al., 2012; Boysan and Çam, 2016) and, in accordance with the obsessive ethical focus, (B) characterized by guilt related to the violation of a moral rule (Shafran et al., 1996; Basile et al., 2013; Mancini and Gangemi, 2015).

(3) **Evolutionary.** In a difficult EEA, clearly, the child that gets imprinted to respect the caregiver's rules enhances their chances to survive by adopting a stricter and safer behavior. This becomes noticeable when the child develops locomotion and widens their social interactions, being both more cautious and a more reliable partner with a better reputation (β-period, 2-6 years). The obsessive adult, through conscientious application of their code, will reach relevant competencies (Hertler, 2015a; b), thereby improving their survival and reproductive chances in a harsh competitive environment.

1.4.2.5. Solution to the 'psychopathology problem' (P3)

The above arguments strongly suggest that: (A) The caregiver has four fundamental tasks: (1) regulating the child's balance between attachment and exploration; (2)

being emotionally reachable for the child; (3) regulating the child's internal states and supporting the child's own definition of them; (4) providing an ethical reference to the child. (B) These tasks become relevant during the preschool years. (C) The child needs to adapt to their caregiver's particular way of accomplishing these tasks. (D) An optimal solution to this adaptation problem is to detect the caregiver's attitude with respect to each of these tasks and rapidly and stably acquire such vital information – in other words, to imprint some core beliefs. Given their origin in the attachment relationship, these beliefs correspond to attachment dimensions and, given their fundamental socio-psychological role, they constitute the core of personality. (E) Particular kinds of accomplishments of these caregiving tasks induce the acquisition of core beliefs that can more easily lead to later dysfunctional states and behaviors – i.e., to psychopathology. (F) In particular, using the proposed definitions: (1) A limiting caregiver induces phobicity, (2) an unreachable caregiver induces depressivity, (3) a defining caregiver induces somaticity, and (4) a judgmental caregiver induces obsessivity. Four caregiving features result to be causally related to four attachment dimensions. Overall, each of us gets all the seven dimensions imprinted at a different level – which determines a different sensitivity to the corresponding aspect of the attachment relationship. These levels generate our particular personality profile. Values beyond a given threshold make us more inclined to suffer from psychological discomfort or mental disorders linked to the affected dimensions. Disorganization and the β-dimensions are related to specific conditions.

Attachment theory could not find a specific connection between attachment and most psychopathologies because it investigated only the α-dimensions. In contrast, by considering the β-dimensions, the APT can indicate the specific causal relationship between attachment – and, therefore, personality – and the most common mental disorders (Table 1.6), thereby solving the problem (P1) of fully relating attachment to psychopathology.

1.4.3. Imprinting and sensitive periods

As discussed below, imprinting is an evolutionarily preordained unconscious learning process, whose main characteristics are: (1) Taking place for the first time in sensitive periods during the early stages of life; (2) Being particularly resistant to change. In the previous sections, it is argued that attachment is characterized by seven dimensions and assumed that they are first acquired through imprinting over two early sensitive periods: (1) The α-period (6-24 months), in which the α-dimensions – disorganization, avoidance, and ambivalence – are imprinted; and (2) The β-period (2-6 years, the preschool age), in which the β-dimensions – phobicity, depressivity, somaticity, and obsessivity – are imprinted. In this section, a case is made for imprinting as the specific

attachment acquisition mechanism by drawing on five different areas: (1) Ethological; (2) Developmental-Attachment; (3) Clinical; (4) Evolutionary; and (5) Neuroscientific.

1.4.3.1. Ethological argument

Imprinting and sensitive periods have been documented in various species of birds and mammals (Lorenz, 1937; Harlow, 1959; Hess, 1959; Shipley, 1963; Salzen, 1967; Lorenz, 1981) (Table 1.7).

Species	Approximate Sensitive Period	Imprinting	References
Ducks	birth – 32 hours	Identity	Hess (1959)
Geese	birth – 48 hours	Identity	Lorenz (1937); Troller-Renfree and Fox (2017)
Rats	birth – 10 days	Identity	Opendak and Sullivan (2016); Opendak et al. (2017)
Rhesus Monkeys	2 weeks – 6 months	Identity	Harlow and Zimmermann (1959); Harlow and Harlow (1962); Harlow and Suomi (1970); Suomi et al. (1974)
Humans	2 months – 6 months	Identity	Marvin et al. (2016); Troller-Renfree and Fox (2017)
	6 months – 2 years	α-Dimensions	
	2 years – 6 years	β-Dimensions	APT Proposal

Table 1.7. Sensitive periods in different species.
Researchers have observed and studied sensitive periods and imprinting in many species of birds and mammals. Animals that are simpler in evolutionary terms – and more developed at birth – seem to show a more rudimentary form of imprinting – with a sensitive period that is closer to birth and more clear-cut. The APT proposes that humans, the most complex animals on earth, have multiple attachment imprintings with overlapping sensitive periods. The imprinting of the caregiver's identity is followed by that of the α- and β-dimensions.

Goslings, for example, attach to their mother during a well-defined brief sensitive period shortly after hatching. Lorenz demonstrated that, when they catch some cues from the environment at the right time, they follow whoever matches the expected features. Famously, they attached to Lorenz himself. Through this – clearly evolutionarily preordained – process, the animal fixes in their mind the identity of their caregiver. Reasonably, given our psycho-social complexity, we-humans might have evolved a more elaborated version of imprinting compared to other animals. The APT argues that we are not only preordained to fix in our mind the identity of specific caregivers, but also the most evolutionarily relevant attachment characteristics – the seven attachment dimensions.

1.4.3.2. Developmental and attachment argument

Bowlby (1969/1982) suggested the existence of imprinting and sensitive periods in humans, noticing the striking similarities between our attachment and that of other animals, such as the geese studied by Lorenz (1937) or the rhesus monkeys studied by Harlow (1959). Since then, these concepts have been generally maintained by developmental-attachment research (Marvin et al., 2016), but the multiple intervening factors that can contribute to change seem to have caught much more attention than them. However, the α-period is unequivocally confirmed as sensitive for attachment by studies concerning early child-institutionalization that prove the long-term effect of attachment experiences that occur within the first two years of life (Varin et al., 1996; Nelson et al., 2007; Zeanah et al., 2011; Fox, 2014; Troller-Renfree and Fox, 2017) (Figure 1.1) (Table 1.7). The effect of such experiences can be actually irreversible.

Regarding the β-period (preschool age), the following can be considered:

1. Attachment develops beyond the second year of life (Bowlby, 1969/1982).

2. Although the child's social context opens up to new interactions – in particular, with peers (Nelson, 2007; Coplan and Arbeau, 2009; Marvin et al., 2016) – the attachment relationship is still primary in the preschool years – since the child yet entirely depends on the caregiver for their survival (Crittenden, 2008; Marvin et al., 2016).

3. In the preschool years, caregiving is characterized by the four fundamental tasks provided by the caregiver's β-features (cf. 1.4.2.1-1.4.2.4): (1) Protecting and supporting autonomy; (2) Being emotionally reachable; (3) Favoring self-definition; (4) Providing moral guidelines. These features represent four developmentally standard care-conditions to which the child needs to adapt.

All this is consistent with the imprinting of the four β-dimensions, which provides the child with vital information to adapt to the four human-specific attachment situations that become relevant during the β-period. As discussed above, the APT suggests that (Table 1.4):

1. The child adapts to an exploration-limiting caregiver by becoming phobic.
2. The child adapts to an emotionally unreachable caregiver by becoming depressive.
3. The child adapts to a state-defining caregiver by becoming somatic.
4. The child adapts to a judgmental caregiver by becoming obsessive.

1.4.3.3. Clinical argument

Clinical research strongly supports the persistence of personality characteristics from childhood to adulthood and the correspondence between caregiving features and acquired attachment characteristics (Berne, 1972; Bowlby, 1973; 1980; Guidano and Liotti, 1983; Guidano, 1987; 1991; Blatt and Levy, 2003; Guidano, 2007; Levy et al., 2015; Yakeley, 2018). The resistance to change is evident in psychopathology. In cognitive psychotherapy, the phenomenon is called the 'neurotic paradox' (Perdighe and Mancini, 2010), which refers to the apparently inexplicable persistence of mental disorders despite the patients being aware of their self-damaging behaviors. The phenomenon is consistent with dysfunctional knowledge that is imprinted and can hardly be modified. This is exactly the characteristic of the seven attachment dimensions and, in fact, all major psychopathologies can regularly be linked to information acquired in attachment relationships, as shown by clinical accounts that report early attachment information (e.g. Bowlby, 1973; 1980; Guidano and Liotti, 1983; Guidano, 1987; 1991; Oltmanns et al., 2012).

More specifically for the preschool age, as discussed above (cf. 1.4.2.1-1.4.2.4): (1) the β-dimensions are causally related to specific mental disorders; (2) The β-period is the earliest timeframe for the onset of such disorders; (3) These disorders tend to last throughout life; and (4) Parenting has been recognized as one of the major causes of their onset (Hopkins et al., 2013; Whalen et al., 2017). Since imprinting is the mechanism that underpins the long preservation of information, these data strongly suggest the imprinting of the β-dimensions in the preschool years.

1.4.3.4. Evolutionary argument

Attachment has been designed by evolution as a fundamental adaptation mechanism. Bowlby (1969/1982; 1973; 1980) has first underlined the survival function of attachment for the child and, later, other authors (Chisholm, 1996; Chisholm and Sieff, 2014; Simpson and Belsky, 2016; Szepsenwol and Simpson, 2019; Young et al., 2019) have stressed the reproduction function of it for the adult. Indeed, the ultimate evolutionary goal of the individual is inclusive fitness (Hamilton, 1964), i.e., passing one's gene to the following generations. These authors argue that the early attachment relationship provides cues of environmental characteristics – such as harshness and unpredictability (Ellis et al., 2009) – and the child unconsciously gathers these cues from the caregiver to set up an adequate strategy for later reproduction. This consideration suggests that attachment information acquired as a child is meant to be durable. Otherwise, it would lose its value for reproductive purposes. This is precisely what an imprinted IWM with its seven attachment dimensions is meant to provide.

In fact, this line of reasoning fits the preschool age. As discussed above (cf. 1.4.2.1-1.4.2.4), beyond that in childhood, the β-dimensions have an adaptive function in adulthood: (1) Phobicity promotes protection through maintaining physical closeness; (2) Depressivity promotes the ability to be self-reliant; (3) Somaticity promotes familial cohesiveness through uniformity of thought and feeling; (4) Obsessivity promotes conscientiousness and competence through strict moral conduct. All these characteristics provide the adult with an advantage in a harsh and possibly unpredictable environment, thereby justifying imprinting the corresponding information from when it is available – the β-period indeed – to adulthood.

1.4.3.5. Neuroscientific argument

The neural processes underlying attachment during sensitive periods have been identified and studied in different birds and non-human mammals (Knudsen, 2004; Sullivan and Holman, 2010; Landers and Sullivan, 2012; Knudsen, 2013; Nakamori et al., 2013; Roth et al., 2016; Feldman, 2017; Opendak et al., 2017; Opendak and Sullivan, 2019). These studies suggest the possible neural underpinnings of imprinting in the human brain. In particular, Knudsen (2004; 2013) describes how imprinting in sensitive periods corresponds to a shaping of neural networks that is durable but still admits of a later change through a particular interaction with the environment, which is exactly what is here hypothesized for the IWM. In accordance with Bowlby, it has also been established that, during a sensitive period, attachment to a caregiver occurs regardless of the care received, even when the caregiver is abusive (Sullivan and Holman, 2010; Landers and Sullivan, 2012; Opendak et al., 2017; Opendak and Sullivan, 2019), which further confirms the evolutionary programming of the process. Finally, lines of research across neuroscience and clinical psychology (Schore, 1994; Turnbull and Solms, 2003; Schore, 2009) identify the human brain areas involved in imprinting, with a sensitive period within the first 24 months (Figure 1.1) (Table 1.7). In accordance with Bowlby, they stress the life-long durability of the phenomenon and its influence on personality.

Although neuroscience only recently has begun to address the attachment relationship directly in humans, some evidence has already been provided for a sensitive β-period. The studies of Rao et al. (2010) and Luby et al. (2016) found that maternal support in the preschool years is significantly correlated with hippocampal growth until adolescence, while maternal support in the following school years does not correlate with it. As a result, these authors explicitly propose that the preschool years are an attachment-related sensitive period. Moreover, Luby et al. (2016) found that preschool maternal support is correlated with emotional regulation in adolescence, with positive support linked to greater regulation ability. These data confirm the hypothesis of the preschool years as a sensitive period for attachment,

with caregiving having a role in psychopathology. This is precisely what the APT proposes for the β-period and β-dimensions.

1.4.3.6. Solution to the 'stability problem' (P2)

The above five arguments converge to provide compelling support for imprinting as the specific attachment acquisition mechanism. According to this view, attachment is characterized by imprinting – a learning process evolutionarily preordained to be performed in early sensitive periods. The α-dimensions are acquired in a sensitive α-period (6-24 months), and the β-dimensions are acquired in a sensitive β-period (2-6 years, the preschool age).

Therefore, the APT solves the dilemma of stability (P2) by clarifying that attachment – as it is expected of anything related to personality – is fundamentally stable.

1.4.4. A formal definition of Internal Working Model

Given the above discussion, the IWM – as a data structure – can be formally defined as consisting of the seven dimensions of attachment. At this point, its content and properties have been clarified. These seven pieces of information represent our fundamental socio-psychological knowledge unconsciously acquired through imprinting. They are not (directly) accessible to conscious thought and exert such an influence on our psychological state and behavior that they can be considered the core of our personality. Adopting a brain-computer analogy, they can be thought of as the firmware of our mind – data that is written at a very low level, very resistant to change, and very influential. To highlight this feature, the corresponding data structure will be referred to as firmware Internal Working Model (f-IWM). From such foundational knowledge, higher-level software will be built – attachment-related information less resistant to change and less influential.

1.5. An enhanced attachment theory: discussion

Focusing on its information component, personality can be seen as the set of stable traits that are critically determined by one's core beliefs. According to this perspective, to determine personality, its core beliefs and their origin need to be identified. Standard attachment theory offers a privileged starting point to solve this issue by connecting personality to the core knowledge that each of us acquires in early attachment relationships. However, the theory encounters three major problems concerning the link between attachment and personality: (P1) Intergenerational transmission; (P2) Stability, and (P3) Psychopathology.

By adequately enhancing the standard theory, the outlined APT proposes a solution to these problems that leads to the full account for the relationship between attachment and personality. Essentially, the enhancement implies considering a total of seven attachment dimensions – disorganization, avoidance, ambivalence, phobicity, depressivity, somaticity, and obsessivity – and the mechanism of their acquisition – imprinting. In particular, the following solutions to the above problems are suggested: (P1) A specific caregiving feature realizes the intergenerational transmission of each attachment dimension (Table 1.4); (P2) Imprinting provides attachment with fundamental stability (Figure 1.1); (P3) Psychopathology is causally related to specific attachment dimensions (Table 1.6).

These solutions clarify the general stability and fundamental socio-psychological value of the seven attachment dimensions, suggesting them to be the knowledge core of personality (Table 1.3).

1.5.1. Implications

Overall, the APT entails significant consequences for attachment and personality theories and for the conception, assessment, and treatment of the most common mental disorders.

1.5.1.1. Implications for attachment theory

The APT proposes a revision of the SAT that is fully compatible with its achievements but, at the same time, can significantly enhance its explanatory power. In particular, the theory suggests the relationship between caregiving features and attachment dimensions (P1), the basic stability of attachment due to imprinting (P2), and its connection to psychopathology (P3). This result is reached by focusing on the knowledge aspect of attachment and relying particularly on clinical research to explain the available data. This allows a reduction of complexity that leads to the identification of key elements and their causal links. In contrast, the SAT has usually been trying to take into account as many variables as possible, mostly relying on statistical studies that cannot identify causal links. As a result, many variables have been considered, but the relationship between them has often appeared unclear.

In particular, the APT considers an f-IWM consisting of seven dimensions: 3 α-dimensions – disorganization, avoidance, and ambivalence – first imprinted in an α-period and four β-dimensions – phobicity, depressivity, somaticity, and obsessivity – first imprinted in a β-period (Figure 1.1). It specifies the definition of avoidance and ambivalence so that avoidance is transmitted via an emotional channel and ambivalence is transmitted via a physical channel. As a result, the α-dimensions are

each induced by a specific caregiving feature. Furthermore, the theory introduces the four β-dimensions as each also induced by a specific caregiving feature. Consequently, it provides a complete mapping between caregiving and attachment (Table 1.4). According to the APT, the caregiving features correspond to fundamental tasks, among which the caregiver normally switches according to the situation, thereby inducing the acquisition or the expression of the corresponding attachment dimensions. On the other hand, given that they correspond to different caregiving features, the attachment dimensions are assumed to be independent, at least in terms of their function. However, since the same caregiver is usually responsible for the induction of multiple – if not all – dimensions, some characteristic patterns are to be expected. For example, when somaticity is the predominant dimension, then phobicity is also expected to be high because a defining caregiver will probably somehow limit their child's exploration (Guidano, 1991). Finally, disorganization and the β-dimensions explain how attachment is linked to psychopathology (Table 1.6), as further discussed below.

The APT focuses on dimensionality and imprinting as the central aspects of attachment that derive from its evolutionary predefinition. It proposes that these seven dimensions specify the full range of adaptation-vital information, and imprinting provides the necessary stability to its acquisition – making it a durable and reliable adaptive base for the child and the future adult. In contrast, the SAT has been exclusively concentrating on the information acquired within the first two years of life and on the possibility of its change. As a result, key aspects of attachment could not be identified.

1.5.1.2. Implications for personality

Personality is a complex construct, and the APT focuses on the representational aspect of it. This allows the recognition of attachment as the basis of personality by providing a set of seven dimensions that have a well-defined origin and area of influence. Given the characteristics of attachment, humans can be considered biological machines preordained to be programmed in attachment interactions. The first and most influential relationships are those with our early primary caregivers, who – by inducing the imprinting of our attachment dimensions – shape the core of our personality.

In order to discuss the features of the APT compared to the current personality models, representative models of two general categories are considered: empirical and theoretical.

(1) Empirical models. The Five-Factor Model (FFM) (or Big-Five) (McCrae and Costa, 2003) is a very influential empirical personality model. It consists of five traits –

Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism – that have been statistically extracted from linguistic descriptions of personality characteristics. The model can be applied to healthy subjects but has also been linked to personality disorders (Widiger et al., 2017). On the other hand, the Minnesota Multiphasic Personality Inventory-2 (MMPI-2) (Butcher et al., 2001), derived by correlating items with subjects diagnosed with clinical conditions, is probably the most widely employed personality test (Butcher and Williams, 2009). The empirical model related to the test outlines a personality profile on multiple clinical scales – Hypochondriasis, Depression, Hysteria, Psychopathic Deviate, Masculinity/Femininity, Paranoia, Psychasthenia, Schizophrenia, Hypomania, Social Introversion – and subscales.

These models are based on empirical studies and do not endorse any specific etiological theory of personality. They are purely descriptive and cannot explain where the dimensions they postulate come from. By contrast, the APT is grounded in attachment theory – a solid (and constantly empirically tested) theory of human relationships that finds in early experiences with the caregiver the foundation of personality, thereby offering an evident explanatory advantage. Nevertheless, in the conditions of its applicability, the APT can be expected to have no less descriptive power than these empirical models. Indeed, the set of α- and β-dimensions covers a broad range of personality features (Bowlby, 1969/1982; 1973; 1980; Guidano and Liotti, 1983; Guidano, 1987; 1991; 2007; Nardi et al., 2010; Liotti and Farina, 2011; Hesse, 2016; Mikulincer and Shaver, 2016). Given the meaning of the dimensions, some correlation between them and the empirical scales can also be expected. Somaticity, for example, is expected to be correlated with agreeableness, obsessivity with conscientiousness.

(2) Theoretical models. Clinical psychology is divided into many schools and orientations that are not informed by a shared theory of personality (Hall and Llewelyn, 2006; Plante, 2010). In fact, virtually each of them has a different one. However, the mainstream of the most influential clinical schools – the cognitive and the psychoanalytic ones – can be considered as a reference. Cognitive psychotherapy (Ellis, 1962; Beck, 1976; Castelfranchi et al., 2002; Leahy, 2004; Perdighe and Mancini, 2010; Beck et al., 2015) focuses on knowledge and its processing, in particular on beliefs and goals. Beliefs are logically linked to each other and hierarchically organized, and personality derives from a system of core beliefs that drive people toward goals. Personality is, therefore, an individual realization of which it is possible to find the causes. On the other hand, psychoanalysis focuses on relationships and finds in the early ones the origin of personality (Lichtenberg et al., 2010; Bresler and Starr, 2015; Orfanos, 2018). In this perspective, attachment is considered a central part of

personality, and the above-mentioned TAM model of Karterud and Kongerslev (2019) is an example.

These models are rooted in strong assumptions about the functioning of the mind and the role of relationships in the building of personality. By considering knowledge and attachment both central and causally related, the APT provides an integrative view of the two models, offering the advantage of a cognitive approach to attachment. The benefit is not only theoretical but also practical. In the APT, personality dimensions have a clear social explanation, which can considerably facilitate the creation of clinical tools and personality inventories.

1.5.1.3. Implications for psychopathology

The implications of the APT for psychopathology are even stronger than those for personality.

(1) Attachment disorders. As discussed above, the β-dimensions express core beliefs (Table 1.3) that clearly correspond to the cognitive organizations (CO) first identified by Guidano and Liotti (Table 1.5), who demonstrated the causal connection of the COs to the most common mental disorders. As a result, these dimensions are causally connected to specific psychopathologies (Table 1.6). The APT proposes the attachment origin of the β-dimensions, thereby connecting the vast and valuable clinical research related to the COs to a wider attachment framework. This link entails remarkable consequences. The two immediate ones are the following:

A. Any disorder that can be traced back to a β-dimension has an attachment etiology. These disorders are usually the most common ones – such as agoraphobia, depression, anorexia, bulimia, obsessive-compulsive disorder. Clearly, when a disorder has a β-dimension at its root, attachment plays a major role in its unfolding.

B. Attachment is also the principal mechanism underlying healing from these conditions. Since the change of a dimension is bound to attachment activation, the healing process implies the action of an attachment figure. In other words, when therapy is successful, the therapist offers through their – usually implicit – caregiving what has been called a 'corrective emotional experience' (Alexander and French, 1946; Mallinckrodt, 2010). The APT specifies the features of this experience – the successful intervention must have involved the patient's pathological dimensions. Of course, the intervention can be tailored to each patient by addressing their specific pathological dimensions.

Therefore, the APT suggests that – in these cases – the attachment relationship is both (A) the key pathogenic factor and (B) the key healing one. Of course, the same considerations apply to disorganization and related dissociative disorders. Consequently, the theory provides the basis for an etiological classification of psychopathology, with clear significant impact on assessment and treatment.

(2) Pathological dynamics and treatment. The APT can be linked to the general motivational dynamics as described by Liotti's motivational theory (Liotti and Monticelli, 2008; Liotti et al., 2017), which integrates attachment in a more general motivational framework. According to this view, human behavior can be described as underpinned by the continuous activation of built-in motivational systems (Table 1.1), which drive us to pursue evolutionarily relevant goals – such as exploration, sex, attachment, caregiving, cooperation. If a pathology is related to attachment, the activation of the attachment motivational system will be potentially problematic. The APT suggests that five specific domains – corresponding to disorganization and the β-dimensions – can cause issues when attachment is activated: a situation will more easily elicit a pathological reaction if it concerns a dysfunctional dimension. For example, a threat will be more problematic if one is disorganized, a separation if one is phobic, a loss if one is depressive. Given that a pathological attachment dimension is connected to intolerable internal states (Bowlby, 1969/1982; 1973; 1980; Guidano and Liotti, 1983; Guidano, 1987; 1991; Schore, 1994; Sroufe, 1995; Schore, 2000; Liotti and Farina, 2011; Brumariu, 2015), the individual who has such an issue will develop – from the preschool years – some strategies to avoid the activation of attachment in relation to the given dimension. These can be seen as strategies to regulate attachment activation – activating a non-attachment system to avoid that of attachment. For example, a child could activate caregiving with their mother, thereby taking care of her and inverting the attachment relationship (Bowlby, 1973). Regulation strategies have been identified for disorganization (Hennighausen and Lyons Ruth, 2005; Lyons-Ruth and Jacobvitz, 2008; Liotti, 2011; Liotti and Farina, 2011) and ambivalence and avoidance (Shaver and Mikulincer, 2002; Mikulincer et al., 2003; Mikulincer and Shaver, 2016). The APT suggests that they extend to the β-dimensions. In general, a regulation strategy can be defined as activating a non-attachment system to avoid attachment activation, with the specification that hyper-activating attachment can be thought of as a particular strategy where attachment activation is over-elicited rather than prevented by using another system. Attachment deactivation and hyper-activation – used by the avoidant and ambivalent respectively – can be considered primitive regulation strategies, usually acquired in infancy, while the regulation strategies concerning disorganization and the β-dimensions are not developed before the preschool years.

This view is very well supported. Indeed, the dysfunctional attachment patterns described by Crittenden in the preschool years (Crittenden, 1995; 2008; Farnfield et al., 2010) are evident regulation strategies. Moreover, providing the attachment foundation to the COs, the APT can be immediately integrated with the clinical approaches stemmed from Guidano and Liotti's research (Guidano, 2007; Nardi and Bellantuono, 2008; Arciero and Bondolfi, 2009; Liotti and Monticelli, 2014; Liotti et al., 2017). Finally, the concepts of attachment-related core belief and regulation strategy are analogous to those of interpersonal schema and interpersonal cycle (Safran and Segal, 1996; Dimaggio, 2015). As a consequence, as mentioned above, the APT is also perfectly compatible with the well-established metacognitive interpersonal therapy (Carcione et al., 2016; Dimaggio et al., 2017; Dimaggio et al., 2019; Gordon-King et al., 2019). Therefore, the APT – also in accordance with the TAM model – suggests the attachment origin of our central psycho-social beliefs and is consistent with the fundamental clinical role of metacognition.

In conclusion, it should be stressed that, given the close relationship between psychopathology and attachment, mental disorders can offer us important insights into the nature of personality. Since one's core beliefs are related to common psychopathologies, the study of such conditions can shed light on the structure and possible change of personality.

1.5.2. Limitations and suggestions for future work

Three limitations of the APT and possible ways to overcome them are suggested below.

1.5.2.1. Scope

The APT refers to the aspects of personality related to imprinted attachment data. Therefore, when other variables – such as the biological ones – have a non-negligible influence on personality, such variables should be taken into account. Reasonably, complexity should be added gradually to the theory, by considering new variables – and upgrading the theory itself – but only after adequate testing.

1.5.2.2. Testing

Although significant support was found for the hypotheses formulated here, the APT is a novel theoretical framework. As a consequence, it needs to be thoroughly empirically validated. In particular, four main hypotheses formulated by the APT can be considered: (H_A) The existence of seven dimensions of attachment; (H_C) The existence of seven caregiving features; (H_{CA}) The correspondence between attachment dimensions and caregiving features; (H_P) The role of the dimensions in

personality and psychopathology. And three different strategies to test them can be suggested (the last two of which are the object of the second part of this work).

A. **Case studies.** The most natural testing for the APT appears to be the clinical one, which can be performed not only directly, in clinical practice, but also indirectly, through the examination of case studies that include sufficient information about the attachment history of the patient (e.g. Bowlby, 1973; 1980; Guidano and Liotti, 1983; Guidano, 1987; 1991; Oltmanns et al., 2012). All the above main hypotheses are testable by analyzing clinical data, but especially H_P for its relevance in dysfunctional conditions. So far, this testing has fully confirmed the model. A systematic review of a larger number of cases is an optimal strategy for further testing.

B. **Questionnaires.** Questionnaires are a well-established assessment practice in attachment theory (Barone and Del Corno, 2006). Given the clear definition of the attachment dimensions and caregiving features provided by the APT, a self-report is particularly suitable for testing the independence between such dimensions (H_A) (Table 1.3) and features (H_C) and the correspondence between them (H_{CA}) (Table 1.4). To pursue this objective, the Attachment-Caregiving Questionnaire (ACQ) was developed (cf. Chapter 3). The ACQ is an APT-informed complex clinical self-report (380 items) that measures both the state of current attachment (i.e. the dimensions) and the childhood caregiving experience with the main maternal and paternal figures (i.e. the features). Gathered data can be analyzed through Principal Component Analysis (PCA) and/or Artificial Intelligence (AI), e.g. a neural network for pattern recognition. Given the considerable number of ACQ items, both methods require a large sample (probably, at least 500 participants). A preliminary PCA performed on 51 participants gave first support to the underlying dimensional assumptions of the APT. However, a pattern recognition analysis is suggested as more suitable than a PCA, and its possible employment is discussed.

C. **Computational modeling.** Attachment relationships can be represented mathematically and modeled computationally (Buono et al., 2006; Amengual, 2009; Stevens and Zhang, 2009; Petters and Beaudoin, 2017) – for example, by representing mother and child in a software virtual environment. A mathematical model that is built in accordance with a given theory allows for the testing of its hypotheses. Since the APT integrates attachment into the whole motivational dynamics and offers a dimensional view of attachment knowledge, it is particularly suitable for computational implementation. However, given the complexity of pathological circumstances, this kind of

testing seems to be more adequate to test H_A, H_C, and H_{CA} rather than H_P. Attachment dimensions and caregiving features can be represented by numerical variables – e.g. in the range between zero and one – and connected to aspects of the simulation environment. The APT was tested through an Attachment Computational Model (ACM) (cf. Chapters 4, 5). It consists of an agent-based model that simulates the interactions between a child and their caregiver through rules that translate the proposed theory. In particular, the dimensions of avoidance, ambivalence, and phobicity were considered as linked to the caregiver's insensitivity, unresponsiveness, and limitation respectively. In this way, both an original computational implementation of attachment and the testing of the implemented hypotheses were obtained. Simulations over different dimensional values – ranging from 0.1 to 0.9 – reflected the expected behaviors, thereby supporting the theory. Interestingly, the simulation environment can work as a lab of synthetic psychology (Braitenberg, 1984; Dawson, 2004; Prescott and Camilleri, 2018), where not only attachment phenomena can be reproduced, but new situations can be generated to further test and extend the theory.

1.5.2.3. Multidisciplinarity

The nature of this work is multidisciplinary in all its parts. The formulation of the presented APT primarily relied on attachment theory and clinical psychology but also required the integration of knowledge from developmental, evolutionary, and personality psychology, ethology, and neuroscience. Moreover, the APT was tested through a clinical questionnaire (the ACQ) and a computational model (the ACM). Connecting so many disciplines might involve gaps, which should however encourage collaboration and further investigation and testing.

Conclusions

In this chapter, I presented the Attachment-Personality Theory (APT) – an enhanced version of the Standard Attachment Theory (SAT). The APT puts forward a representational and dimensional perspective of attachment, according to which its adaptation function is essentially that of gathering key information from the closest social environment – one's caregiver. During the first years of life, the child's survival entirely relies on the assistance provided by their fundamental caregiver – usually the mother. The caregiver is the mediator between the child and the rest of the world and what the child needs to adapt to in the first place. According to the APT, the child realizes this adaptation through detecting several fundamental caregiving features, measuring them, and getting imprinted corresponding vital information. Seven caregiving features are identified as carrying such information. They express how

much the caregiver is (1) frightening, (2) insensitive, (3) unresponsive, (4) limiting, (5) unreachable, (6) defining, and (7) judgmental. Their subjective measure generates the level of corresponding attachment dimensions: (1) disorganization, (2) avoidance, (3) ambivalence, (4) phobicity, (5) depressivity, (6) somaticity, and (7) obsessivity respectively. Each of us gets all the seven dimensions imprinted during early sensitive periods (roughly, between 6 months and 6 years of age), but later imprintings remain possible. The acquired dimensions constitute the fundamental socio-psychological knowledge at the core of our personality and make us differentially sensitive to related evolutionarily relevant conditions, thereby explaining the connection between attachment, personality, and psychopathology. The names of the attachment dimensions remind of the typical dysfunctional conditions that correspond to their excessively high levels.

The SAT recognizes the essential role of attachment representations through the concept of internal working models. However, according to the SAT, a caregiver is a *"secure base from which a child or an adolescent can make sorties into the outside world and to which he can return knowing for sure that he will be welcomed when he gets there, nourished physically and emotionally"* (Bowlby, 1988, p.11). In other words, the primary function of attachment is seen as 'behavioral', meaning that it reflects the parental one of being a 'secure base'. This appears more concretely so in the early years and becomes more abstract while growing up.

In contrast, the APT proposes that the nature of attachment is primarily representational since the origin of the first attachment patterns. Core attachment information – defined as its f-IWM – is suggested to be implicit and elementary – the simplest and lowest level information sufficient to find the best adaptation to the caregiver. In this perspective, it is this knowledge that generates the behavioral and emotional patterns that are observed in infants (and then, children, adolescents, and adults). In other words, attachment is primarily a mechanism to acquire implicit knowledge, which is then used as a reference – a set-goal for the attachment control system (Bowlby, 1969/1982; Petters, 2019) – and underpins every attachment manifestation. Attachment representations match the received caregiving, thereby supporting its secure-base role.

Finally, I want to point out that I fully agree with those psychologists who believe that theoretical investigation is as important as the empirical one to the development of psychology (Borghi and Fini, 2019). In this spirit, I presented here a novel theory and hypotheses. However, it is also essential to me that the theory complies with the scientific requirements and the formulated hypotheses can be tested. In the second part of this work, I present how the APT was tested through the development of a

clinical self-report – the Attachment-Caregiving Questionnaire (ACQ) – and an agent-based model – the Attachment Computational Model (ACM).

Chapter 2

Attachment as a multidimensional control system

Introduction

In order to proceed toward the realization of a computational model that implements the Attachment-Personality Theory (APT) (Gagliardi, 2021) presented in the previous chapter, I first review, in this one, the literature concerning some of the most relevant computational models of attachment. Although attachment computational modeling has begun only recently, researchers have already tackled the issue by adopting different approaches and have reached results that can serve as useful references to this work. The review aims at both taking inspiration from these models and identifying possible causes of the problems they encountered.

The Attachment Computational Model (ACM) proposed in chapters 4 and 5 is inspired in its general design by the work of Petters (Petters, 2006; Petters and Waters, 2015; Petters and Beaudoin, 2017), who implemented an agent-based model that reproduces a limited two-dimensional environment where child and caregiver agents interact. The work of this author has confirmed the adequacy of agent-based modeling for the study of attachment, especially by simulating the Strange Situation Procedure (SSP) (Ainsworth et al., 1978). However, most previous models have embraced a behavioral (as opposed to representational) and categorical (as opposed to dimensional) conception of attachment that may well have been the cause of significant limitations. In fact, although behavioral patterns are the directly observable manifestations of attachment interactions, and they can be clustered into distinct categories, focusing on these features does not allow for adequate identification and modeling of the attachment representational and dimensional nature. This becomes particularly clear when considering that avoidance and ambivalence have been

generally treated as opposite manifestations of the same attachment dimension, causally related to the same caregiving feature.

Following the APT, I outline a general block diagram of an attachment module, which produces, stores, and employs data over seven dimensions. External and internal inputs and the maintained information contribute to generating an attachment internal state and behavior. The Internal Working Model (IWM), with its imprinted data, plays the central role by providing the goals that drive action. In other words, attachment works as a – representation-driven – multidimensional control system. The module is intended to be part of a complete cognitive architecture, which implements the selection of the behaviors that each of its modules wants to be acted out. This architecture could be, for example, the CogAff architecture used by Petters (Petters and Waters, 2015; Petters and Beaudoin, 2017) or the Distributed Adaptive Control (DAC) architecture designed and implemented by Verschure (Verschure, 2012; Verschure et al., 2014). However, given that the APT focuses on representation and dimensionality, in this work, a stand-alone version of the ACM is implemented, which only implements the attachment, caregiving, and exploration motivational systems to test the relationship between the involved variables and parameters for given dimensions. Consistently, the ACM corresponds to a particularized version of the general module presented here. The success of this test suggests the use of a more comprehensive architecture as a next step. In fact, such an upgrade is indispensable to simulate phenomena more relevant from a clinical perspective, given that psychopathology can be better understood by taking into account the role of attachment in the motivational dynamics. The chapter ends by suggesting how an attachment acquisition mechanism – a key part of the attachment module – could be realized.

2.1. Previous models of attachment

Despite the breadth of Standard Attachment Theory (SAT), relatively few computational models have been created to study attachment interactions and relationships. These models can be divided into three main categories: purely mathematical, agent-based, and robotic. For each category, one or more representative models are examined.

2.1.1. Mathematical models

Some models adopt a purely mathematical approach. For example, Buono et al. (2006) consider attachment as a decision making game. They refer to the interaction between child and mother in an SSP-like scenario and model how the styles A, B, and C can

emerge given the characteristics of the caregiver. The child can choose between three possible actions: 'Go' (seeking comfort), 'Don't Go' (not seeking comfort), and 'Half Go' (seeking comfort while simultaneously keeping guard). On the other hand, the mother can respond by attending – with probability q – or ignoring – with probability 1-q. The combination of possible child's actions, mother's responses, and consequent comfort received can be summarized in a payoff matrix. According to this matrix, the child decides what to do – i.e. what strategy to use given their caregiver's strategy (q) (which the child knows). Mother and child played this game many times before, and the current SSP is an additional play of the game that extracts the essence of all those previous interactions. The child decides after calculating the payoffs (P) for each possible action (P_{Go}, $P_{Don't\ Go}$, $P_{Half\ Go}$) as a function of q and the comfort received in the various cases. Their decision – made to maximize the received comfort – determines a corresponding attachment style: the optimal response to a caregiver with given q. The secure choice is to go, the avoidant not to go, and the ambivalent to half-go.

Cittern (2016) applies the free energy principle of brain functioning (Friston, 2010) considering the same payoff matrix as Buono and colleagues. According to this principle, the brain needs to minimize uncertainty and has a limited number of intrinsically preferred states that correspond to such minima. As a result, it drives agents to act, perceive, and learn in order to reach them. In other words, the brain naturally tends to reach some physiological and sensory states to resist disorder. Since low uncertainty corresponds to low free energy, this corresponds to guide action, perception, and learning toward the minimization of free energy. As any other mental phenomenon, attachment can be modeled in terms of free energy minimization. Accordingly, children are assumed to have an a priori preference for states of low stress. Again, the SSP is taken as a reference, and the comfort received by the infant is considered as depending on their action and the caregiver's responsiveness (q). Infants learn such responsiveness and an attachment style that can ensure a degree of comfort that minimizes their brain's free energy. In particular, the acquired style can be expressed in terms of the probability of action for each q. When q is: (1) low, then the child mostly does not seek comfort (avoidant); (2) high, then the child mostly seeks comfort (secure); (3) mid-low, then the child mostly seeks comfort while simultaneously keeping guard (ambivalent). Summarizing, the child starts with no knowledge of the caregiver's responsiveness and learns it becoming either avoidant, secure, or ambivalent. If the caregiver is: (1) unresponsive (q = 0.1), then the child becomes avoidant; (2) highly responsive (q = 0.9), then the child becomes secure; (3) inconsistently responsive (q = 0.4), then the child becomes ambivalent.

Stevens and Zhang (2009) consider attachment as a neurophysiological system whose goal is to regulate the distance from the caregiver and whose operation manifests

itself experientially as felt security. In other words, according to the authors' view, attachment is a regulation mechanism that operates toward a set-goal of optimal proximity translating the feedback from the caregiver into felt security. Behavior arises from the dynamic interplay of two systems: (1) a calming system (opioid-based) and (2) an arousing system (norepinephrine-based). The caregiver acts as a physiological regulator. Their action influences the child's neurophysiological balance: soothing stimuli increase the opioids level, and arousing stimuli increase the norepinephrine level. When the caregiver is far, the child experiences a need for soothing and an unsecure feeling (physiological withdrawal of opioids). As a result, they activate attachment and seek proximity. When the caregiver is close, the child experiences a need for arousal and a secure feeling (physiological withdrawal of norepinephrine). As a result, they activate exploration and seek novelty. Mathematically, this dynamic system is represented by two coupled differential equations. Their parameters account for the expressed behavior – such as proximity seeking and exploration – and the child's characteristics – such as the sensitivity to calming and arousing stimuli. Accordingly, the regions in the parameter space correspond to the attachment styles avoidant, secure, and ambivalent. The model identifies two attachment dimensions in terms of opioid and norepinephrine activity. If s_{cs} is the sensitivity to calming stimuli, s_{as} is the sensitivity to arousing stimuli, O is the (calming) emission of opioids, and N is the (arousing) emission of norepinephrine, then: (1) avoidance corresponds to high $s_{cs}O$ and low $s_{as}N$; (2) security corresponds to low $s_{cs}O$ and low $s_{as}N$; (3) ambivalence corresponds to low $s_{cs}O$ and high $s_{as}N$. These results match the experimental data from the SSP that show how avoidance and ambivalence are independent dimensions, the former characterized by high autonomy and low interaction, and the latter characterized by low autonomy and high interaction.

Since attachment involves learning and making decisions according to what has been learnt, a neural network seems to be an adequate tool to model it. Talevich (2017) develops a dynamic neural network model of attachment called Motivated Affective Behavioral System (MABS) Neural Network (NN). From attachment specific situations, the MABS-NN produces attachment specific messages considering three attachment components: motivation, emotion, and knowledge (i.e. the IWM). The implementation is realized through a Leabra NN (O'Reilly, 1996) whose: (1) nodes represent lower-level psychological variables (e.g. fear); and (2) weights represent strength of relation between two of such variables. Attachment is conceptualized as a complex system and, consistently, the network is thought of as a comprehensive mental module that generates an attachment style as an emergent property. In other words, the system models how the represented psychological components – motivation, emotion, and knowledge – self-organize into the avoidant, secure, and ambivalent styles. The SSP is taken as a reference and typical episodes corresponding

to the three styles are used to train the network. The process is assumed to follow a reinforcement schedule where the caregiver's responsiveness is the reward. According to this assumption: (1) The avoidant situation follows an extinction schedule; (2) The secure situation follows a constant-reinforcement schedule; (2) The anxious situation follows a partial reinforcement schedule. The weights adjust with each presented SSP-episode allowing the network to learn an IWM by embedding it in its structure. As a result, from attachment situations, the MABS-NN produces dismissive (avoidant), support-seeking (secure), and protesting (ambivalent) messages that express an attachment style.

2.1.2. Agent-based models

As Petters and Waters (2015) point out, in the case of attachment, agent-based models (ABMs) are a particularly attractive option. They allow for both a visual representation and the selection of the desired time scale – given that attachment can be considered as a phenomenon that unfolds on an evolutionary, developmental, or daily-life-interaction time scale. Petters has deeply studied attachment and started to address the problem of *"updating the information processing framework for attachment theory, originally set out by John Bowlby […] by reconceptualising it as a cognitive architecture that can operate within multi-agent simulations"* (Petters and Beaudoin, 2017, p.229). He adopts a cognitive-architectural approach based on scenarios – such as those provided by the SSP – to specify requirements that can provide metrics for evaluating modeling. Primarily focusing on the SSP, he illustrates various ABM implementations of architectures of different complexity (Petters, 2006; Petters and Waters, 2015; Petters and Beaudoin, 2017; Petters, 2019). They simulate attachment behavioral patterns by considering a virtual bidimensional environment where infant and caregiver agents are free to express their motivations. Simulations are performed using the SIM-AGENT Toolkit (Sloman and Poli, 1996; Sloman and Logan, 1999), an ABM open-source software that allows for the realization of different kinds of architectures. The author shows how the architectural designs that underpin his ABMs are specifications of the general cognitive architecture CogAff (Sloman, 2008). This architecture facilitates the simulation of cognitive and affective phenomena and can be particularized for the specific attachment case. The CogAff sees the brain as a physical machine that supports a virtual one – the mind – and works as both a computational and control system. It consists of three layers – reactive, deliberative, and meta-management – and three columns – perceptual, central processing, and action. In the SSP case, the CogAff is instantiated to implement attachment by considering attachment patterns as long-term control states corresponding to the goal of proximity. This architectural approach allows the modeler to simulate both the learning and post-learning processes that underpin the

attachment secure-base behavior. A simulation of the secure, avoidant, and ambivalent patterns followed by the dyad infant-caregiver can be obtained through designs of different complexity, in particular, through both reactive and deliberative architectures. In the reactive design, data is perceived and then processed to finally generate action, whereas, in the deliberative design, processing is enhanced by 'look-ahead reasoning'. The meta-management design further increases complexity by adding the capability of self-reflection.

In this perspective, considering the child as motivated by attachment and exploration, the formation of an attachment style can be modeled as the solution to a problem of distance regulation – the secure-base problem. The child – who can either move or signal – learns their caregiver's responsiveness to their attachment need, thereby assuming a behavioral pattern. The infant's attachment behavior can be expressed by approaching the caregiver and signaling their need for care, while their explorative behavior by searching around and moving toward a toy. The variable relevant to attachment security is considered the caregiver's responsiveness – i.e. how ready the caregiver is to provide care when the child asks for it – which determines the Safe-Range Limit (SRL) that the child adopts – i.e. the distance from the caregiver within which the child feels safe. The activation of different motivations changes depending on the current situation with a winner-take-all selection mechanism. When the infant is near the caregiver (within the SRL), attachment is lower-activated, and exploration is higher-activated: hence, the infant explores. In other words, the caregiver works as a secure-base for the infant's exploration. In contrast, when the infant is far from the caregiver (outside the SRL), attachment is higher-activated, and exploration is lower-activated: hence, the infant attaches. However, the winner-take-all-mechanism allows attachment to be activated even with high exploration. The different alternations of exploration and proximity seeking generate behavioral patterns of secure-base dynamics that correspond to the attachment styles. Learning is realized by simulating the interactions between infant and caregiver over the first year of life. Through a reinforcement system, the infant learns the caregiver's responsiveness from interactions. When the caregiver usually responds promptly, the SRL is large. Conversely, when the caregiver usually responds tardily, the SRL is small.

Examples of architectures derived from the CogAff design are the GS (Goal-Switching), GL (Goal-Learning), RAL (Reactive-Action-Learning), and HAR (Hybrid-Action-Reasoning) (Petters, 2006). The GS is a basic reactive architecture that can simulate how the child in an SSP switches between goals. It is provided with four goal-activation modules – termed exploration, socialization, anxiety, and fear – that can alternatively lead to action. The GL extends this design to incorporate the learning process. It can simulate secure and ambivalent patterns by learning the degree of security

corresponding to the caregiving pattern. Two different specifications of the GL are: (1) the Goal-Learning-from-Anxiety (GLA) – which implements learning in situations of insecurity – and (2) the Goal-Learning-from-Warmth (GLW) – which implements learning in situations of socialization. A more complex version – the RAL – can also simulate the avoidant pattern by implementing exploration as a displacement behavior. Finally, the upgrade of the GL design to a deliberative one – the HAR – is able to simulate secure, avoidant, and ambivalent patterns by considering the caregiver's negative response to an emotional signal as a rejection.

2.1.3. Robotic models

A natural application of a computational model of attachment is its implementation on a robot with the goal to endow it with a more human-like behavior.

Likhachev and Arkin (2000) made an early attempt of this kind by introducing the concept of comfort in robotics. They consider a robot in a basic environment where an 'object of attachment' for the robot is present. This object makes the robot feel comfortable and represents a secure base for exploration. The authors consider a simple linear relationship between attachment and comfort: the nearer the robot is to the object, the more it feels comfortable. Outside a safe zone, the robot feels uncomfortable, ceases exploration, and heads toward the object. This system simulates a very basic secure pattern.

Amengual (2009) realizes a 3D robotic simulation that represents a slightly more complex model of attachment using Gazebo – a software simulation tool. The model simulates the second episode of the SSP for a secure infant. Accordingly, two robots representing mother and child interact in a room with toys and create a behavioral pattern. The child is provided with the motivations to attach and explore, while the mother performs fixed behaviors. The infant robot assesses the situation (through a Petri Net) and selects an action (through a Bayes net). The situation assessment takes environmental cues – such as the distance from the mother – as input and generates a level of attachment activation as output. The mother is perceived as always available, even when she is out of sight (secure attachment). The action selection takes the attachment level as input and generates a motor action as output – that can be either an attachment or explorative behavior. The implemented attachment behaviors are proximity seeking and contact seeking, while the explorative ones are locomotion, manipulation, and visual exploration. Simulation results are evaluated by comparing them to the behavior of secure children in the real SSP.

2.2. Previous models and the ACM

Previous works gave valuable contributions to attachment modeling and represented a solid reference for this work. As the above literature review shows, while each of them has original aspects, they also have important characteristics in common, in particular, in terms of attachment conceptualization. Here, between the general features that can be relevant for the effectiveness of a model, an emphasis is placed on such a conceptualization. The ACM, although relatively simple, is indeed meant to suggest that a model might gain significant advantages by virtue of a more adequate reference theory.

2.2.1. All models are limited

As with any natural phenomenon, while simulating attachment, it is essential to aim at a sufficient level of detail with respect to its defining elements. Nevertheless, all models will be necessarily limited, and they can look as such especially when considered from a 'naïve' perspective.

As clinical psychologists, for example, we might find some attachment models very far from real attachment. Buono et al. (2006) refer to the basic secure-base situation and aim to distinguish between secure, avoidant, and ambivalent attachment. But attachment patterns cannot simply correspond to different degrees of approach. Talevich (2017) considers a complex neural network that represents the fundamental aspects of attachment. Although this design looks at multiple psychological components, attachment representations remain hidden in the network. Likhachev and Arkin (2000) present a very basic configuration with an exploring child-robot 'tied' to a stationary attachment object. In the model from Amengual (2009), the caregiver-robot's actions are predefined.

As computational modelers, we are aware that, given the complexity of the subject, such specific design limitations are well understandable – especially in robotic implementations. Nonetheless, the APT suggests that a foundational feature of the previous models might have significantly hindered their simulation power, regardless of the particular design characteristics. According to the APT, representation is a primary aspect of attachment, which is, however, not emphasized by the early attachment theoretical framework. As a result, the main limitation of the reviewed models may be their reference theory (rather than some aspects of their own design). This point is now discussed in more detail.

2.2.2. Theory: A superordinate limitation

Modeling derives directly from the conceptualization of the phenomenon to be modeled, i.e. the theoretical formulation taken as a reference. Therefore, a conceptual issue inevitably becomes a modeling one. An attachment example of how theory can be reflected on a model is provided by two different conceptualizations of disorganization present in the literature. (1) This dimension has been recognized as deriving from frightening caregiving (Main and Solomon, 1990; Lyons-Ruth and Jacobvitz, 2016), and its manifestations are fully explained by the activation of two incompatible motivational systems – attachment and defense, both elicited by a caregiver who frightens the child (Liotti, 2004; Ogden et al., 2006; van der Hart et al., 2006; Liotti, 2011; Liotti and Farina, 2011). The conflictual behaviors showed by a disorganized child in the SSP express, indeed, two opposite goals: receiving care from the attachment figure and not being hurt by them. The child can, for example, appear stuck in a sequence of approaches and retreats from the caregiver. (2) Nevertheless, disorganization is often thought of as the combination of avoidance and ambivalence (Mikulincer and Shaver, 2016), dimensions that, although they typically lead to avoiding and approaching the caregiver respectively, are not related to a frightening experience. Needless to say, these two conceptualizations would entail very different models to generate the same behaviors, with probably overlapping but not coinciding – and crucially different – outcomes. The first formulation requires implementing a defensive system, which the second one does not need, for example. It is, therefore, indispensable for an attachment model to start with an adequate conceptual representation of its object.

Focus on behavior and categories. Previous models of attachment generally refer to the early conceptualization of attachment, which concentrated on the relationship between the child and their caregiver in the first years of life and had a strong orientation toward empirical observation. The study of the evident behavioral dynamics between child and mother naturally led to thinking of attachment especially as a proximity problem and of attachment patterns in categorical terms. Bowlby pointed out how *"from eight months onwards an infant begins to use his mother as a secure base from which to explore"* (Bowlby, 1969/1982, p.326) – a phenomenon that is empirically measurable through the SSP (Ainsworth et al., 1978), which categorizes four patterns of attachment – secure, avoidant, ambivalent, and disorganized. This conceptualization and corresponding assessment tool focus on behavior (as opposed to representation) and categories (as opposed to dimensions).

A superordinate limitation. The APT suggests that focusing on behavior and categories hides the core psychological features of attachment: its representational

and dimensional nature (Gagliardi, 2021). In this perspective, attachment is primarily about information, and this information belongs to several dimensions. Once representation is available, it drives behavior, and dimensions generate categories. These attachment features have not captured attachment researchers' attention in the first stage of theory development, which is usually taken as a reference by computational modelists. As a result, previous models of attachment do not generally model them directly and concentrate on the secure-base phenomenon and the simulation of behavioral patterns – which can also have subtle characteristics and be difficult to distinguish. The 'resistant' behavior of an ambivalent can manifest itself in non-approaching the caregiver, for example, which can look like avoiding them. But it can also resemble a disorganized conflict, like in the half-go characterization of this pattern from Buono et al. (2006) and Cittern (2016). Therefore, two features generally shared by previous models can be identified that may have significantly hampered their efficacy.

(1) The first is the general focus on the behavioral aspects of attachment (as opposed to representational). As discussed above (cf. 1.4.1, 1.4.2), each dimension refers to a piece of data that is first acquired in the early years of life through attachment interactions. This information constitutes an f-IWM that drives action over different dimensions. A model that focuses on behavior and does not explicitly represent the multiple pieces of data involved cannot use them as set-goals to drive action. While the SAT proposes attachment to be a system controlled by the set-goal of proximity, the APT suggests that representation drives attachment.

(2) The second is the reference to a categorical view of attachment (as opposed to dimensional), which considers avoidant and ambivalent patterns as induced by the same caregiving feature and, therefore, as different aspects of the same dimension. In particular, following Ainsworth et al. (1978, p.152), the caregiver's sensitive-responsiveness to the child's requests for care is taken as affecting the security-anxiety dimension. However, as discussed above (cf. 1.4.1), avoidance and ambivalence cannot be reduced to a single dimension. Therefore, a model that implements this conceptualization will inevitably miss capturing some relevant characteristics of the relationship. Even though they have very different designs, most of the presented models follow the one-dimensional view.

Therefore, the behavioral-categorical perspective may well have compromised the effectiveness of attachment computational modeling. These conceptual issues can be thought of as superordinate limitations. They belong to the theoretical framework assumed as a reference and are not inherent in the model design. Previous models of

attachment simply implement the SAT in its early formulation (which is also often taken as a reference in current attachment research).

The ACM is a stand-alone agent-based model (ABM), and, in many regards, the ABMs realized by Petters (Petters, 2006; Petters and Waters, 2015; Petters and Beaudoin, 2017) have inspired its development and can be considered a reference for its enhancement. As discussed above, this author adopts an architectural approach, and his designs reach great complexity compared to the one presented here. The current ACM's goal is to test the implementability and validity of the APT representational and dimensional perspective by simulating a subset of attachment dimensions – avoidance, ambivalence, and phobicity (cf. Chapters 4, 5). This discussion suggests that – for any given design – such a perspective could help obtain simulations more compliant with psychological data.

2.3. Modeling an enhanced attachment theory

The attachment relationship is as central in human psychological life (Bowlby, 1969/1982; 1973; 1980) as it is difficult to conceptualize, as three core issues still controversial in the SAT demonstrate: (1) intergenerational transmission (van Ijzendoorn, 1995; Verhage et al., 2016; van Ijzendoorn and Bakermans-Kranenburg, 2019), (2) stability (Waters et al., 2000; Fraley, 2002; McConnell and Moss, 2011; Pinquart et al., 2013; Kobak et al., 2016), and (3) relationship with psychopathology (DeKlyen and Greenberg, 2016; Stovall-McClough and Dozier, 2016) (cf. 1.3, 1.4). However, an advantageous theoretical formulation is essential to effective modeling. In chapter 1, a novel theory is put forward – the APT – that is meant to provide such a formulation. Coherently, in chapter 4, a model will be presented – the ACM – based on the APT to empirically test it and demonstrate its modeling potential. Before doing that, a further step toward a concrete implementation is taken here by outlining the block diagram of an attachment module informed by the APT.

As a preliminary step, the APT concepts most relevant to the design of an attachment module are briefly reviewed. They concern: (1) Attachment as a motivational system; (2) The representational and dimensional nature of attachment; and (3) Imprinting as the mechanism of attachment knowledge acquisition. In fact, the two main characteristics of attachment are the innate motivation to attach and the information acquired in the process.

2.3.1. Attachment as a motivational system and the motivational dynamics

The term attachment describes the complex phenomena that concern the interactions and consequent formation of a relationship between a subject who asks for care – an attacher – and another who provides it – a caregiver (Bowlby, 1969/1982). The prototypical attachment relationship is the one between child and mother, but such a relationship can be formed between any two people over the entire course of life (Bowlby, 1969/1982; Allen, 2008; Kerns and Brumariu, 2016; Marvin et al., 2016; Mikulincer and Shaver, 2016; Fraley and Roisman, 2019). Attachment has been widely studied in humans, but it also pertains to many non-human animals (Harlow, 1959; Shipley, 1963; Salzen, 1967; Lorenz, 1981; Roth et al., 2016; Opendak and Sullivan, 2019) – and, as discussed above, it can be extended to artificial agents (Likhachev and Arkin, 2000; Amengual, 2009; Petters and Beaudoin, 2017). In all cases, the attachment relationship is primarily supported by the attacher's intrinsic motivation to attach, which finds its counterpart in the caregivers' intrinsic motivation to provide care (Bowlby, 1969/1982; 1973; 1980). Therefore, an attachment module needs to be general enough to represent any possible attachment relationship and account for the motivation to attach.

However, humans are driven by a larger number of intrinsic motivations, not just attachment and caregiving – eating, regulating body temperature, mating, exploring, cooperating, for example. Human motivations can be thought to correspond to a set of motivational systems located in the brain (Bowlby, 1969/1982; Lichtenberg et al., 2010; Panksepp and Biven, 2012; Liotti et al., 2017; Schaller et al., 2017), which interact with each other generating the motivational dynamics that underpins every human action. With regards to early attachment relationships, besides attachment and caregiving, the exploration motivational system plays a major role. At the beginning of their motor development, the child typically maintains a proper balance between attachment and exploration by keeping their caregiver as a secure base (Bowlby, 1969/1982; Ainsworth et al., 1978). Therefore, an attachment module also needs to take into account the interplay with the other motivations and be designed as part of a more general architecture that encompasses all of them.

The outlined APT-based module meets these requirements. It will be particularized for the ACM to reproduce the attacher's motivational dynamics involving attachment and exploration and the caregiver's motivational dynamics involving caregiving and exploration.

2.3.2. The representational and dimensional nature of attachment

Attachment is evolutionarily grounded. It is an adaptation mechanism essential for survival and reproduction (Bowlby, 1969/1982; Chisholm, 1996; Chisholm and Sieff, 2014; Simpson and Belsky, 2016; Szepsenwol and Simpson, 2019; Young et al., 2019). The attachment system is preordained to allow for the child's acquisition of fundamental socio-psychological information (Bowlby, 1973; Bretherton and Munholland, 2008; Sherman et al., 2015; Marvin et al., 2016). In particular, according to the APT, within the first six years of life, the child builds a core representation of the caregiver and the self (with respect to each other), which implicitly defines the attachment relationship. This knowledge functions in the relationship as an f-IWM that drives the child's actions toward the caregiver. In other words, attachment has a representational nature: it is primarily about acquiring evolutionarily vital information to set the goals of the system and regulate interactions. Therefore, a module is proposed that explicitly represents this information and uses it to make decisions aimed at the maintenance of a match between the perceived state of the relationship and its target representation.

Attachment has been first studied in children and measured through the SSP (Ainsworth et al., 1978; Main and Solomon, 1990; Hesse, 2008). Through this lab technique, four categories of attachment have been identified – avoidance (A), security (B), ambivalence (C), and disorganization (D) – which correspond to specific behavioral and emotional patterns expressed by the child during the procedure. The success of the SSP has been then consolidated by the Adult Attachment Interview (AAI) (George et al., 1985; Main and Hesse, 1990; Hesse, 2016), through which the state of mind with respect to attachment can be measured in adults. The AAI identifies four attachment styles that correspond to the patterns identified by the SSP, thereby supporting the persistence of attachment phenomena throughout life. These kinds of measures consider attachment as a categorical phenomenon with four mutually exclusive possible patterns (Figure 2.1).

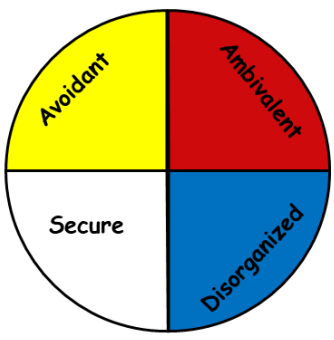


Figure 2.1. Categorical view of attachment.

Attachment has been described as characterized by four mutually exclusive categories: avoidance, security, ambivalence, and disorganization. The SSP first found these categories, which have been then confirmed by the AAI.

Although the categorical view of attachment is still in use, further research has shown that attachment can be better characterized as a dimensional phenomenon. The four identified categories can be described by three relatively independent dimensions (Bartholomew and Horowitz, 1991; Brennan et al., 1998; Fraley and Spieker, 2003; Liotti and Farina, 2011; Fraley et al., 2015; Paetzold et al., 2015; Mikulincer and Shaver, 2016) that, following the SSP, in this work, are referred to as avoidance, ambivalence, and disorganization. These three dimensions can fully express the range of attachment behaviors and internal states detectable through the SSP at around one year of age, including the coexistence of different patterns (Figure 2.2).

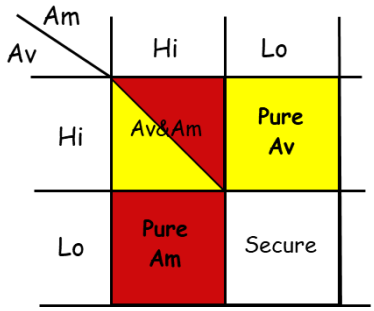


Figure 2.2. Dimensional view of attachment with respect to avoidance and ambivalence.
Attachment can be better described as characterized by relatively independent dimensions. According to this view, the two dimensions of avoidance (Av) and ambivalence (Am) can generate four categories: (1) Low Am and Low Av; (2) High Am and High Av; (3) Low Am and High Av; and (4) High Am and Low Av. This perspective accounts for the simultaneous presence of avoidant and ambivalent characteristics in the same subject.

Therefore, an APT-based attachment module needs to consider attachment information in dimensional terms. Each dimension corresponds to specific information. Moreover, this consideration needs to be extended to the caregiving features.

2.3.2.1. Seven attachment dimensions and seven caregiving features

According to the APT, the two basic attachment dimensions – avoidance and ambivalence – are induced by the two basic caregiving features – insensitivity and unresponsiveness respectively. Avoidance is a primarily emotional dimension and corresponds to attachment de-activation, while ambivalence is a primarily physical dimension and corresponds to attachment hyper-activation (Shaver and Mikulincer, 2002; Mikulincer et al., 2003; Mikulincer and Shaver, 2016). On the other hand, attachment disorganization is connected to the experience of frightening caregiving (Main and Solomon, 1990; Lyons-Ruth and Jacobvitz, 2016). The disorganized is

characterized by contrasting motivations: seeking care from the caregiver and defending against them. Therefore, this dimension represents a quite particular and delicate case.

However, the APT proposes attachment dimensionality to be higher than three. More specifically, it introduces four additional dimensions – phobicity, depressivity, somaticity, and obsessivity – and suggests each of them to be induced by a specific caregiving feature – limitation, unreachability, definition, and judgment respectively. The introduction of the new dimensions allows for the full explanation of the relationship between attachment and psychopathology (DeKlyen and Greenberg, 2016; Stovall-McClough and Dozier, 2016), and the identified relationship between caregiving and attachment allows for bridging the transmission gap (Whipple et al., 2011; Bernier et al., 2014; van Ijzendoorn and Bakermans-Kranenburg, 2019).

Therefore, an attachment module based on the APT needs to consider attachment as intrinsically dimensional, with each dimension causally related to a specific caregiving feature. The ACM will first focus on the two dimensions of avoidance and ambivalence and corresponding caregiving features of insensitivity and unresponsiveness. It will then be extended to phobicity and limitation.

2.3.3. Imprinting: The mechanism of attachment acquisition

Attachment is first acquired in infancy through a specific mechanism that Bowlby (1969/1982) called imprinting, borrowing the term from ethology (Lorenz, 1937; Harlow, 1959; Hess, 1959; Shipley, 1963; Salzen, 1967; Lorenz, 1981). Indeed, *"imprinting represents the learning process which supports all attachment phenomena"* (Schore, 1994, p.88). In general, it is a mechanism preordained by evolution:

1. to happen for the first time early in life over a specific time frame called sensitive period;
2. to possibly happen again later in life but with much more difficulty and only in conditions particularly relevant for adaptation.

Imprinting accounts for the stability of attachment, which still represents a controversial issue in the SAT (Waters et al., 2000; Fraley, 2002; McConnell and Moss, 2011; Pinquart et al., 2013; Kobak et al., 2016). The child first learns the identity of their caregiver and then the main features of their relationship, corresponding to the IWM and the attachment dimensions (Bowlby, 1969/1982; Marvin et al., 2016).

The APT proposes that all dimensions are acquired by imprinting and for the first time during a sensitive period within the sixth year of life (Table 2.1). More specifically, disorganization, avoidance, and ambivalence (termed α-dimensions) are suggested to have a sensitive period between 6 and 24 months (α-period) and phobicity, depressivity, somaticity, and obsessivity (termed β-dimensions) to have a sensitive period between 2 and 6 years (β-period). Therefore, an APT-based attachment module needs to account for the dimensional imprinting – the attachment knowledge acquisition process.

Type		Caregiving	Dimension	Sensitive Period
α	1	Frightening	**Disorganization**	6-24 Months
	2	Insensitive	**Avoidance**	
	3	Unresponsive	**Ambivalence**	
β	4	Limiting	**Phobicity**	2-6 Years
	5	Unreachable	**Depressivity**	
	6	Defining	**Somaticity**	
	7	Judgmental	**Obsessivity**	

Table 2.1. Caregiving features, attachment dimensions, and sensitive periods.
According to the APT, seven caregiving features induce seven attachment dimensions, and the dimensions are first acquired in early sensitive periods.

2.4. Attachment module design

The above literature review of the previous models of attachment (cf. 2.1, 2.2) has shown that they have been inspired by the early formulation of the SAT. On the other hand, the overview of the implementation-relevant aspects of the APT has identified the conceptual features that – according to this new theoretical formulation – should inspire the outline of an attachment module (cf. 2.3). These analyses indicate a clear mismatch between the attachment implementations realized until now and the one suggested by the APT. While the early SAT focused on behavior and categories, the APT is primarily representational and dimensional. The module presented here is meant to incorporate the main APT features, thereby narrowing the gap between the theory and its computational implementation. If – as it is suggested – the APT is a better conceptual representation of attachment compared to the SAT, then an APT-based attachment module will correspond to potentially better computational implementations. The Attachment Computational Model (ACM) described below (cf. Chapters 4, 5) provides the first confirmation of this hypothesis. The details of the proposed attachment module are now examined.

2.4.1. An APT-based attachment module

The APT conceptualization of attachment as the core of personality with its seven fundamental dimensions imprinted as an f-IWM can be synthesized into the attachment module presented below in the form of a block diagram (Figure 2.3). In particular, from the theory, five general requirements that need to be fulfilled have been identified (cf. 2.3). The module should:

1. suit any attachment relationship;
2. represent a single intrinsic motivation but considering the whole set of them;
3. represent information and its role (especially as a set-goal) explicitly and in dimensional terms;
4. consider the specific relationship between attachment dimensions and caregiving features;
5. account for the specific attachment acquisition process.

Given the generality of these requirements, the presented module represents only one of the possible graphical concretizations of the theory. In particular, according to the APT, attachment is both a motivational system and a data structure, and these components can be designed in different ways. Nonetheless, the block diagram sets out key implementation specifications.

Importantly, the scheme clarifies that attachment is driven by the f-IWM. What is learnt is a representation of the caregiver and the self, which implies a representation of the attachment relationship. Attachment behaviors are a consequence of the caregiving signals and the imprinted f-IWM. Any available and suitable behavior can be recruited by the module in order to pursue its goal (i.e. the behavior does not need to be attachment-specific). Ontogenetically, attachment is initially supported by specific behaviors (Bowlby, 1969/1982), but it is primarily about learning a representation, not behaviors. The representation is learnt through imprinting in situations of subjective high survival value, namely when the subject feels that the situation is highly relevant for their life, either positively (because the caregiver is protective/caring) or negatively (because the caregiver is not protective/caring).

Since the module is meant to be part of a general architecture of the mind (Carruthers, 2006; Petters and Beaudoin, 2017), the diagram comprises both internal and external characteristics. All the components of the module, inputs, and outputs are detailed below, along with some explanation about the design logic.

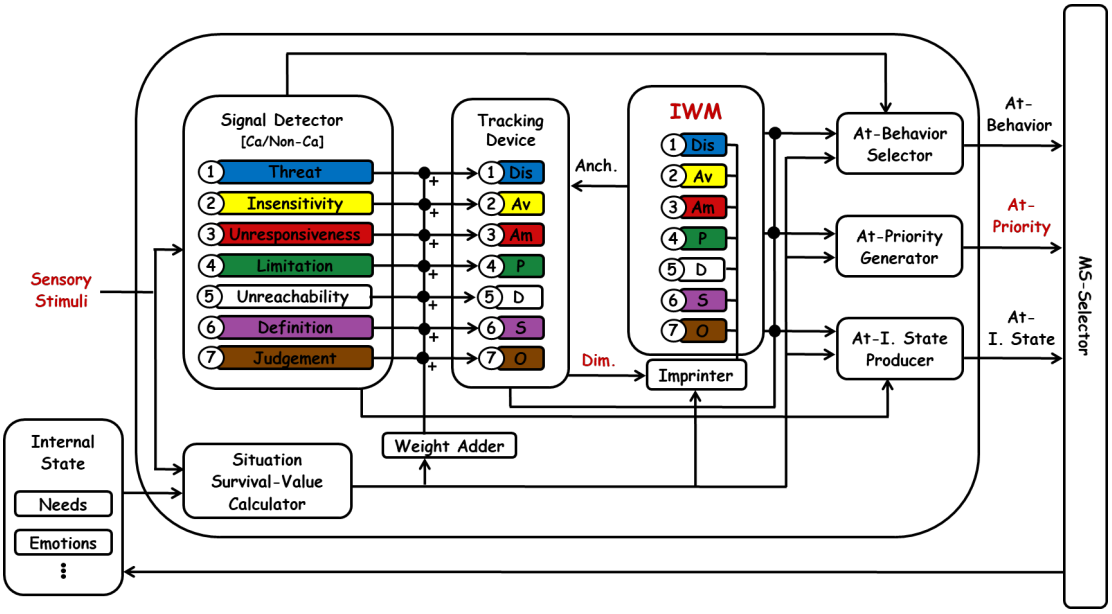


Figure 2.3. Attachment module.
The module highlights the role of attachment as an intrinsic motivation and basic implicit information. Such information constitutes our fundamental socio-psychological knowledge.

External modules. The attachment module communicates with the two following external ones:

1. The 'Internal State' module. It includes the variables that account for the subject's internal condition, primarily needs and emotions.
2. The 'MS-Selector'. It takes inputs from all motivational systems and selects the systems that can produce an action.

Inputs. The module receives the following two input signals:

1. The 'Sensory Stimuli'. It provides the current state of the scene as perceived by all the senses.
2. The 'Internal State'. It provides the subject's internal state (from the above external module).

Outputs. The module emits the following three output signals:

1. The 'At-Priority'. It signals the urgency level of the attachment motivation.
2. The 'At-Behavior'. It signals the behavior to be executed to pursue the attachment motivation.
3. The 'At-Internal State'. It signals the internal state to be expressed to pursue the attachment motivation (e.g. emotion).

Subsystems. The module consists of the following submodules:

1. The 'Signal Detector'. It examines the sensory stimuli and extracts those related to each attachment dimension, thereby identifying each caregiving feature.
2. The 'Situation Survival-Value Calculator'. It attributes a (subjective) survival-value to the current situation.
3. The 'IWM' (Internal Working Model). It is the firmware data structure that contains the imprinted values of the seven attachment dimensions (f-IWM).
4. The 'Tracking Device'. It tracks the perceived caregiving features to produce a current dimensional representation. The tracking mechanism (cf. 2.4.4) allows this representation to be possibly imprinted in the f-IWM, which contains the dimensional values that set the goal of the system. Given the adaptation role of each feature-dimension, it can be reasonably assumed that, usually, at any given interaction, a single (most) relevant feature determines the corresponding elicited dimension to be processed (although it cannot be ruled out that multiple features could be simultaneously relevant).
5. The 'Weight Adder'. It adapts the caregiving signals by weighing them with respect to the – subjectively perceived – survival value of the situation.
6. The 'Imprinter'. It imprints new dimensional values in the f-IWM. This happens when the perceived dimension is significantly different from the imprinted one (cf. 2.4.4);
7. The 'At-Behavior Selector'. It selects an attachment behavior by considering multiple inputs. Any available and suitable behavior is selectable. There is no restriction to specific attachment behaviors.
8. The 'At-Internal State Producer'. It produces an attachment internal state (especially an attachment emotion) by considering multiple inputs (such as caregiving history and various representations).
9. The 'At-Priority Generator'. It generates the attachment motivational system priority value by considering the dimensions and the survival condition.

2.4.2. Attachment as a multidimensional control system

The outlined attachment module incorporates the requirements imposed by the APT. In particular, the behavior selected for the attachment system depends on the assessment of the current caregiving features – translated into corresponding perceived dimensional values – and their comparison with the imprinted dimensions. Therefore, this mechanism acts as a – representation-driven – multidimensional control system. The representation of the perceived attachment situation over its seven dimensions is compared with the one stored in the system as a reference – the f-IWM – which sets the goal of the system. This imprinted representation corresponds

to what was learned to be the best fit with the caregiver and, therefore, maximizes wellbeing. In this regard, a situation very far from the reference one might correspond to intolerable internal states. For example, an avoidant child will have a given representation of their mother as insensitive (i.e. poor in her loving attitude) and will act to meet such a representation (e.g. staying relatively near to the mother but, at the same time, not looking for emotional care from her), which the child expects to maximize their wellbeing. If the mother expresses an unexpected loving act, the child will probably ignore it, thereby acting to maintain their imprinted representation. One or more dimensions will impose stricter conditions than the others and, consequently, be more relevant for attachment control. For example, an infant may be very sensitive to the avoidant dimension of the relationship, another to the ambivalent one. Their behavioral patterns will then easily be classified accordingly. In general, the evaluation of the situation with respect to the most relevant dimensions will determine the selected behavior.

2.4.3. Attachment and motivational dynamics

In the mind, all motivational systems need to compete for being selected and gaining access to the resources – such as the cognitive and motor ones – necessary to pursue the corresponding goals (Figure 2.4). The result of such competition is the motivational dynamics, from which any activity – and, in particular, the observable behavior – arises (Liotti and Ardovini, 2008; Liotti et al., 2017). For example, the attachment patterns observed in infancy are usually the outcome of the interplay of attachment with a few other systems such as exploration and defense. The dynamics is usually harmonious and tends to maximize goal achievement. At any given moment, more than a system can be active, and the same action can serve multiple purposes. An adult could, for instance, activate attachment and sex toward a romantic partner. Another could switch from cooperation to competition with a friend or vice versa. An action such as walking can have an attachment purpose as well as an explorative one. In all cases, the motivational dynamics is accompanied by corresponding internal states, especially emotions, which serve the systems' goals. The same emotion can be used by different systems, but some emotions usually belong to the functioning of certain systems. Anger, for example, is a typical competition and attachment emotion. In general, characteristic behaviors and internal states – especially emotions – correspond to each motivational system, but any given behavior or internal state can belong to the operation of more than one motivational system.

An architecture of the mind that includes the attachment module will need to support the motivational dynamics by assigning the appropriate priority to each system.

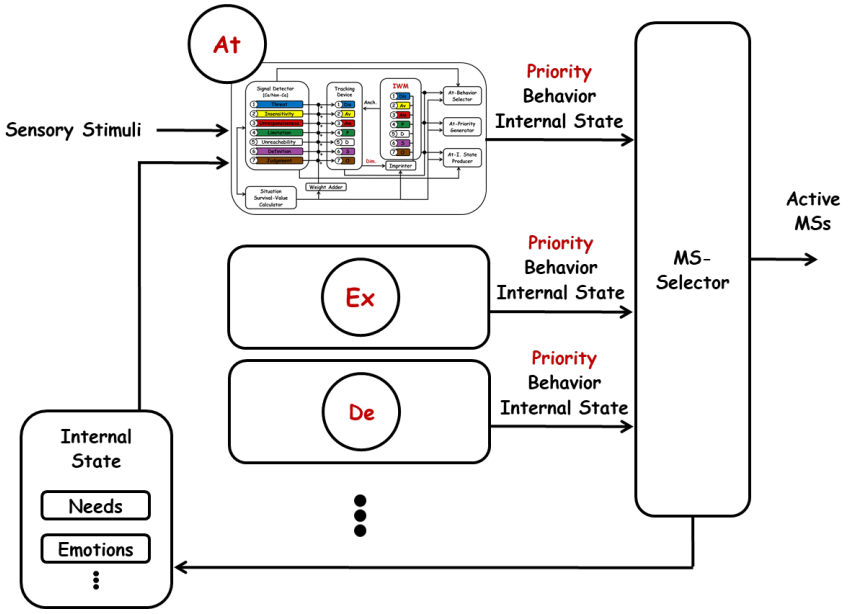


Figure 2.4. The attachment module involved in the motivational dynamics.
Motivational systems compete to gain access to the available resources, such as the cognitive and motor ones. (For simplicity, inputs to non-attachment motivational systems are omitted.)

Regulation strategies in the motivational dynamics

The analysis of the attachment module and its involvement in the motivational dynamics has significant clinical implications. According to the APT, when the f-IWM is pathological, attachment activation can become critical and needs to be regulated (cf. 1.5.1.3). More precisely, the subject manages the situation by regulating attachment through regulation strategies, in general, using another motivational system in order to prevent attachment from being activated[8] (Figure 2.5). Bowlby had a similar perspective. He believed that *"much psychopathology is […] due to models that are in greater or less degree inadequate or inaccurate"* (Bowlby, 1969/1982, p.82) and *"originates in early life"* (Bowlby, 1969/1982, p.84). Moreover, he considered the models with the *"greatest influence"* as being *"fairly primitive"* and possibly *"relatively, or completely unaware"* (Bowlby, 1973, p.205). Finally, he identified *"defensive exclusion"* – a process of *"persistent exclusion […] of information"* (Bowlby, 1980, p.45) – *"as being at the heart of psychopathology"* and causing the *"deactivation of a behavioural system"* (Bowlby, 1980, p.65). In other words, Bowlby recognized that most psychopathology comes from dysfunctional models and identified the etiological role of early experiences but focused on the possibility of the defensive exclusion of disturbing information as the primary cause of persistence. This perspective was consistent with the psychoanalytic concept of defensive processes. By identifying the origin and content of the attachment dimensions, the APT suggests the opposite causal link between system activation and information exclusion to be primary. In

[8] The ambivalent hyper-activates attachment.

order to avoid the intolerable internal states related to the activation of attachment, such activation is regulated by using other motivational systems, thereby causing the possible systematic exclusion of information. In fact, switching motivation – from attachment to ranking or caregiving, for example – can cause a radical change in the information being focused on and processed.

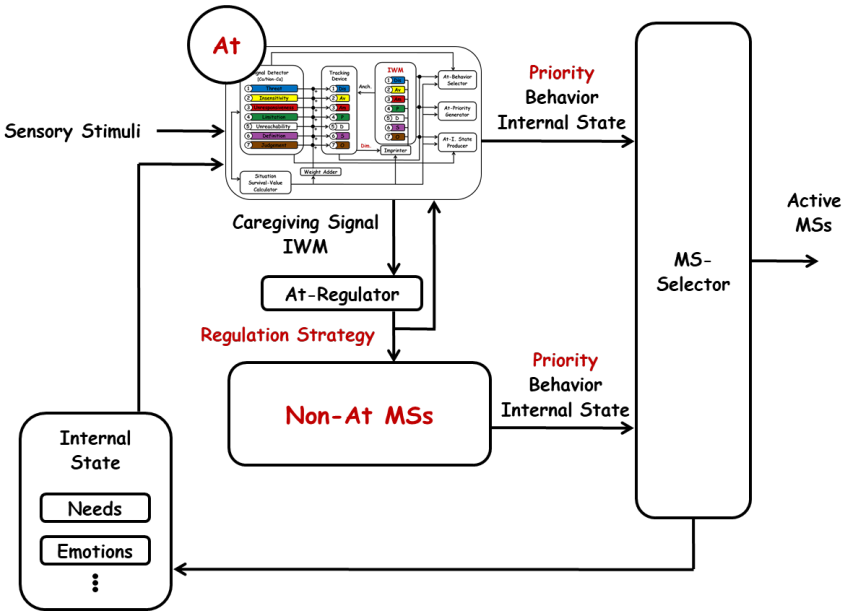


Figure 2.5. Regulation strategies in the motivational dynamics.
Regulation strategies affect the motivational dynamics by preventing attachment from being activated. When the caregiving signal is intolerable given the f-IWM, another motivational system is set off instead of attachment. (For simplicity, inputs to non-attachment motivational systems are omitted.)

2.4.4. Imprinting learning mechanism

A crucial aspect of the attachment module is the update of the f-IWM – the data structure that holds the imprinted dimensions. Imprinting is assumed to be the specific attachment acquisition method. It is evolutionarily programmed to occur during consecutive early sensitive periods (between six months and six years of age) but can also take place later, although with much more difficulty. In any case, for the process to happen, attachment needs to be activated, and the situation to be identified as having (subjectively) high survival value.

The attachment module realizes the imprinting through two dedicated submodules: the 'Tracking Device' and the 'Imprinter' (Figure 2.3). According to the APT, for each dimension, the learning process can be hypothesized to unfold as follows (Figure 2.6). After the first acquisition (which might be a predefined level), the imprinted value works as a reference – termed anchor – for its possible update. The Tracking Device keeps track of the history of each caregiving feature (e.g. insensitivity) and translates

it into a perceived dimensional value (a current representation of the dimension) (e.g. avoidance) by considering the anchor and the survival value of the situation. The perceived dimensional value is imprinted – by the Imprinter – to become the new value held by the f-IWM only if it diverges significantly from the old one.

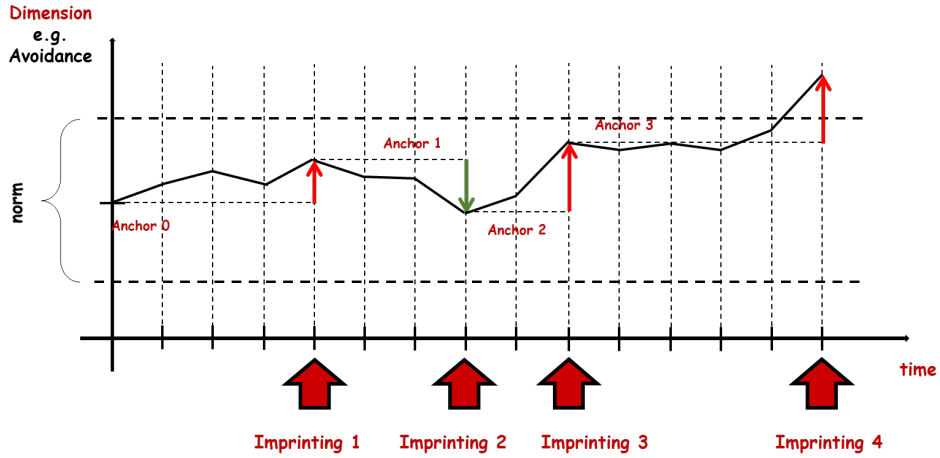


Figure 2.6. The imprinting process of a dimension.
A new value is imprinted if the perceived dimension diverges enough from the currently imprinted one.

Conclusions

In this chapter, I selected a number of representative computational models of attachment from the literature and discussed their features. They have represented an indispensable reference to this work, and their most significant limitations are suggested to come from the early Standard Attachment Theory (SAT) assumed as a reference. This first formulation of the SAT adopts an inconvenient behavioral and categorical perspective on attachment that – it is argued – does not capture its essence. The theory conceptualizes attachment as a control system driven by the set-goal of proximity and considers the two basic attachment patterns – avoidance and ambivalence – as different manifestations of the same dimension.

In contrast, the Attachment-Personality Theory (APT) centers on the representational and dimensional nature of attachment and is therefore suggested to be not only theoretically more adequate but also significantly more advantageous for the modeling. Representation drives behavior, and alike behaviors can be the product of different representations. Similarly, dimensions underpin categories. The APT sees attachment as a – representation-driven – multidimensional control system, identifies seven dimensions as its knowledge core and connects each of them to a specific caregiving feature. According to this view, avoidance and ambivalence are different dimensions, induced by different features – insensitivity and unresponsiveness respectively. Following the APT and its focus on representation and dimensionality, an

Attachment Computational Model (ACM) will be presented (cf. chapter 4) that very well reproduces the characteristics of avoidant and ambivalent interactions.

I conclude the chapter by reviewing the APT concepts most relevant to computational implementation and synthesizing them in the design of an attachment module as a preliminary step before modeling. The module is presented as a block diagram to be included in a more general architecture of the mind. It embodies the two main features of attachment: being both an information processor and a control system. In particular, it shows that each attachment dimension corresponds to a specific caregiving feature and attachment works as a multidimensional controller driven by representation.

Before implementing the APT computationally, the theory is clinically tested. The Attachment-Caregiving Questionnaire (ACQ) presented in the following chapter is designed for this purpose.

Chapter 3

The Attachment-Caregiving Questionnaire (ACQ)

Introduction

This work is based on the Attachment-Personality Theory (APT) (Gagliardi, 2021) – an enhancement of the Standard Attachment Theory (SAT). Adopting a cognitive-clinical perspective, the APT considers attachment nature to be representational and dimensional. The theory suggests a number of hypotheses that have never been formulated before and need, therefore, to be empirically tested. Here, I present the **Attachment-Caregiving Questionnaire** (ACQ) – a self-report that I developed to pursue this goal (cf. Appendix A). The chapter is organized along the same line followed for development and testing:

(1) **Conceptualization** (section 3.1). A careful analysis was carried out to specify the main properties of the questionnaire.
(2) **Realization** (section 3.2). Having specified the questionnaire main properties, its items could be formulated.
(3) **Study** (section 3.3). Finally, a preliminary test of the APT through the questionnaire administration could be performed.

(1) The APT is a clinical theory focused on the development of personality. It finds in attachment phenomena the foundation of (the knowledge part of) personality and connects such phenomena to psychopathology. Therefore, using a clinical instrument appears to be a natural way to test it. For the conceptualization of the ACQ, the problem of adult attachment assessment was carefully considered, in particular, through reviewing several representative questionnaires. The analysis of these tools showed that they do not fit into the APT definition of the avoidant and ambivalent dimensions. Similarly, the available assessment instruments of the 'personal meaning organizations' (Guidano, 1991) were analyzed and also considered as not matching

the APT definition of the phobic, depressive, somatic, and obsessive dimensions. Therefore, these analyses suggested not to take the previously developed instruments as a strict reference for the development of the ACQ and to proceed toward a more independent construction instead. Theoretical considerations related to knowledge hierarchy and language clarified the difference between 'what is said' and 'what is meant' and the necessity to take such a difference into account in the design of the questionnaire. As a result, the questionnaire consists of three main sections and six subsections, of which the ones more directly involved in the testing of the APT are: (1) an attachment questionnaire (Q_A) that investigates the current attachment dimensions as an adult and (2) two caregiving questionnaires (Q_{CM} and Q_{CF}) that investigate the caregiving features experienced as a child with the two principal attachment figures (the maternal and paternal one respectively). Q_{CM} and Q_{CF} have analogous items but in a different order.

(2) The phases that led to the realization of the ACQ are discussed in detail. The process lasted about a year and required the collaboration of external clinicians. Such intervention was essential to continuously refine the items taking advantage of their mediated presentation into a clinical context, thereby also confirming their clinical relevance. The ACQ is, indeed, a clinical questionnaire – that also works as a personality inventory – meant to be administered to adults from both general and clinical populations (although, for the presented study, the administration was limited to the general population). The tool allows for the testing of three key APT hypotheses: (1) the seven-dimensionality of attachment (H_A); (2) the seven-dimensionality of caregiving (H_C); and (3) the correspondence between caregiving features and acquired attachment dimensions (H_{CA}). Q_A is directly involved in the testing of H_A, while Q_{CM}, and Q_{CF} in the testing of H_C. To test H_{CA}, Q_A, Q_{CM}, and Q_{CF} need to be all considered.

(3) Although the ACQ is suitable for a full test of the APT, the goal was here to create the tool and perform a preliminary test. In fact, a full test would require a large-scale administration – which, given the questionnaire size, would most likely correspond to not less than 500 subjects (Bandalos and Boehm-Kaufman, 2009; Rouquette and Falissard, 2011) – and a corresponding excessively demanding analysis. Instead, the ACQ items were grouped according to the theory, forming scales of attachment dimensions and caregiving features and allowing a meaningful test to be conducted on a sample of only 51 volunteers. A statistical analysis of these scales based on factor extraction provided an initial confirmation of the key APT hypotheses (H_A, H_C, H_{CA}). Although such hypotheses cannot be considered fully confirmed, the performed analysis provided results entirely consistent with the theory.

Importantly, both the conceptual analysis and the study suggested the necessity of considering ways additional/alternative to factor analysis to develop an attachment self-report – in particular, the use of artificial intelligence.

3.1. Conceptualization: Identifying the main properties

Before concretely realizing the questionnaire, the key issues involved were carefully evaluated. The process started with the consideration of how adult attachment has been assessed until now and focused on the analysis of the most relevant attachment-related self-reports. A critical point was identified in relation to knowledge hierarchy and language. The outcome of this stage was the clarification of the main properties of the questionnaire, especially in terms of its structure.

3.1.1. Adult attachment assessment

Although it is most evident in childhood, attachment is a life-long phenomenon (Bowlby, 1969/1982), the assessment of which has become of central importance since the first stages of the SAT. As already discussed, the first evaluation tool to be conceived was the Strange Situation Procedure (SSP) (Ainsworth et al., 1978; Main and Solomon, 1990) – a lab technique developed to measures attachment in infancy that classifies attachment patterns into four categories: Avoidant (A), Secure (B), Ambivalent (C), and Disorganized (D). Since then, numerous tools have been devised to evaluate attachment at different ages and with different methods (Crowell et al., 2016; Solomon and George, 2016). Between these tools, questionnaires have proved their realizability and, given the possibility to be self-administered to a large number of adults, they seem to be the most appropriate to obtain an adequate and convenient testing of the APT. However, the reference tool for attachment assessment in adults is an interview and not a self-report. Therefore, given its importance, before discussing several relevant questionnaires, its main features will be outlined.

3.1.1.1. Adult Attachment Interview

The Adult Attachment Interview (AAI) (George et al., 1985; Main and Hesse, 1990; Hesse, 2016) has been developed to measure attachment in adults and, in particular, their ‘state of mind’ with respect to childhood experiences with their two main attachment figures – maternal and paternal. Since its conception, the AAI has assumed exceptional relevance given its correspondence with the SSP (van Ijzendoorn, 1995; Behrens et al., 2016), which has first suggested the persistence of attachment phenomena with similar characteristics throughout life. The attachment classification of a parent provided by the AAI matches the one of their child provided by the SSP. The instrument is a semi-structured interview of 20 open questions posed in a

predefined order. During the administration, the interviewer is allowed some degree of freedom to follow the particular answers provided by the interviewee. The questions elicit both specific memories and general evaluations of the subject's childhood experiences. In particular, the interviewee is asked to provide five adjectives to describe each of their parents and connect a specific episode to each adjective. The subject is also asked to evaluate their experiences from a current perspective as an adult. And, finally, their attitude as a parent toward a real or possible child is investigated.

The AAI transcript is analyzed twice. (1) First, two sets of scales are applied: one concerning the probable experience with each attachment figure and the other concerning the state of mind of the subject with respect to attachment. The former set refers to what the subject described, while the latter one to the subject's representations. (2) Then, the transcript is considered as a whole. The analysis results in assigning the subject to one of the following categories: Secure-autonomous (F), Dismissing (Ds), Preoccupied (E), and Unresolved/disorganized (U). As mentioned above, these categories assessed in a parent have been found to be predictive of those assessed in their child through the SSP – Secure (B), Avoidant (A), Ambivalent (C), and Disorganized (D) respectively. Importantly, in the categorization process, the most relevance is given to the discourse coherence rather than to its content. Such coherence is evaluated by referring to the four maxims of cooperative conversation provided by Grice (1975): (1) Quality: *"Be truthful, and have evidence for what you say"*. (2) Quantity: *"Be succinct, and yet complete"*. (3) Relation: *"Be relevant to the topic as presented"*. (4) Manner: *"Be clear and orderly"* (Hesse, 2008, p.557). This is consistent with the assessment of the state of mind rather than the described concrete episodes.

The secure adult has adequately elaborated on their experiences and is able to relate them in a clear, coherent way – consistently connecting experiences and their evaluation – even when such experiences have been negative from an attachment perspective. In other words, the secure discourse respects Grice's maxims. On the other hand, the insecure one does not, with different characteristics in the avoidant and ambivalent cases. In particular:

The avoidant (i.e. dismissing) adult: *"Violates the maxim of quality (consistency/truthfulness), in that positive generalized representations of history are unsupported or actively contradicted by episodes recounted. Violates the maxim of quantity—either via repeated insistence on absence of memory; or via brief contemptuous derogation of, or active contemptuous refusal to discuss, a particular event or figure."* (Hesse, 2008, p.568).

The ambivalent (i.e. preoccupied) adult: *"Violates manner, quantity, and/or relevance, while quality/truthfulness may not be violated. In regard to quantity, sentences or conversational turns taken are often excessively long. In regard to manner, responses may be grammatically entangled or filled with vague usages ("dadadada," "and that"). In regard to relevance, the present may be brought into responses to queries regarding the past (or vice versa), or persons or events not the objects of inquiry may be brought into the discussion."* (Hesse, 2008, p.568).

Finally, the instrument has been demonstrated to be reliable and independent of a variety of individual characteristics, such as IQ score, personality, and social desirability (Bakermans-Kranenburg and van Ijzendoorn, 1993; Zeanah et al., 1993; Sagi et al., 1994).

What do adult and infant attachment have in common?

From the SAT formulation, three key points emerge. (1) First, the AAI reveals the prominence of internal representations and processes with respect to attachment. (2) Moreover, the adult assessment provided by the AAI is strictly related to the infant one provided by the SSP. (3) Finally, the central role of representations in attachment phenomena is recognized by the SAT since infancy. The theory supposes that the child starts to build up their working models from the end of the first year of life, greatly enhances these models through language, and uses them to make attachment plans (Bowlby, 1969/1982, p.354).

However, as soon as possible in infancy, proximity becomes the set-goal of attachment (Bowlby, 1969/1982, pp.180,199) – i.e. attachment aims to maintain the caregiver as a secure base – and such a goal is kept from infancy to adulthood (Bowlby, 1969/1982, pp.206-207). In other words, the SAT maintains its focus on proximity as a goal. Attachment is the means through which we maintain another as a secure base (Bowlby, 1988). Therefore, according to the SAT, attachment representations and plans have a proximity goal, i.e. to keep the caregiver as a secure base.

By investigating the representational and dimensional nature of attachment, the APT suggests that proximity might well result – since infancy – from a representational and multidimensional set-goal. More specifically, attachment knowledge is suggested to be dimensional. Seven attachment dimensions – that correspond to seven caregiving features – are imprinted for the first time in early sensitive periods between six months and six years. These representations set how the attachment relationship needs to be in order to achieve the best fit with the caregiver, and proximity is maintained as a consequence of acting toward the representational goal. An avoidant child, for example, is particularly sensitive to their caregiver's loving attitude and

pursues the most convenient proximity – in this regard – by aiming to respect their avoidant representation through their avoidant behavioral pattern. Similarly, an ambivalent child is particularly sensitive to their caregiver's physical availability and pursues the most convenient proximity – in this regard – by aiming to respect their ambivalent representation through their ambivalent behavioral pattern. Mixed patterns are the consequence of different levels of dimensional sensitivity and different eliciting contexts. Moreover, the representations that the child acquires in the sensitive periods will continue to exist and exert their influence on the attachment control system throughout life. They work as a (foundational) firmware in our information processing system, which affects the building up of subsequent (higher-level) software (cf. 1.4.4). The whole attachment knowledge system will then have an influence on behavior in a complex way – although the firmware will maintain its primacy.

This perspective (1) is founded on a conceptualization of attachment as both an information processor and control system, (2) endorses the relevance given to attachment representations for building plans, (3) connects attachment knowledge and processes from infancy to adulthood, and (4) is coherent with the SAT concept of a secure-base. Moreover, by identifying the precise relationship between caregiving and attachment, it is convenient from a computational perspective.

These considerations will be key to the development of the ACQ. But to proceed in this direction, several relevant adult attachment questionnaires first need to be reviewed.

3.1.1.2. Attachment questionnaires

Although an interview was the first measure of adult attachment, soon afterward, many questionnaires have been developed to assess attachment, especially toward a romantic partner (Barone and Del Corno, 2006; Ravitz et al., 2010). Hazan and Shaver (1987) first tried to translate the attachment patterns as assessed by the SSP into corresponding styles in romantic relationships, considering the connection between infancy and adulthood as due, at least partially, to attachment working models. They realized a self-description of the three adult styles and found that they were distributed similarly to the infant ones: 56% secure, 25% avoidant, and 19% ambivalent (Hazan and Shaver, 1987). According to their conceptualization, secure individuals are those who feel comfortable both in getting close to others and having some reciprocal dependence, with no significant worries about the relationship. On the other hand, insecure subjects adhere to the following self-descriptions:

Avoidant: *"I am somewhat uncomfortable being close to others; I find it difficult to trust them completely, difficult to allow myself to depend on them. I am nervous when anyone gets too close, and often, love partners want me to be more intimate than I feel comfortable being"* (Hazan and Shaver, 1987, p.515).

Ambivalent: *"I find that others are reluctant to get as close as I would like. I often worry that my partner doesn't really love me or won't want to stay with me. I want to merge completely with another person, and this desire sometimes scares people away"* (Hazan and Shaver, 1987, p.515).

The work of these authors prompted a significant amount of studies on the topic and the development of numerous questionnaires. Importantly, these instruments will generally share the common characteristics of relying on a dimensional view of attachment and investigating the two dimensions of avoidance and ambivalence (Brennan et al., 1998; Crowell et al., 2016), from which four categories can be derived (Figure 3.1):

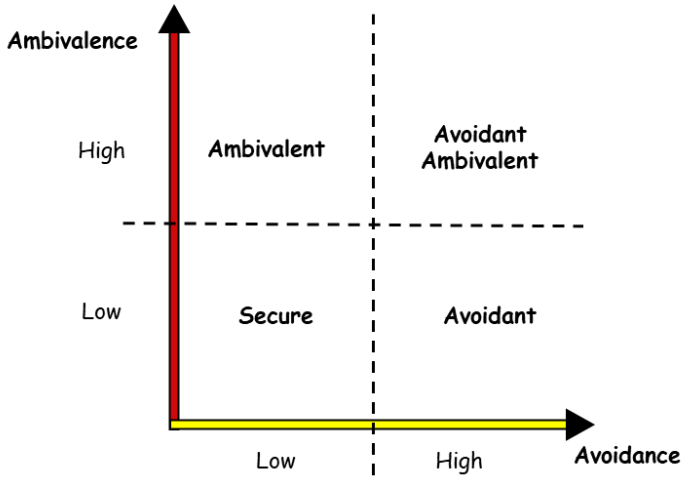


Figure 3.1. The two-dimensional space of attachment generated by avoidance and ambivalence. Adult attachment questionnaires generally refer to a dimensional conception of attachment, according to which the two basic attachment dimensions – that are here termed avoidance and ambivalence – generate four attachment styles depending on their high or low value. A secure individual is one who shows low levels of both avoidance and ambivalence.

Although they rely on different definitions of avoidance and ambivalence – given the similarity of purpose – several relevant SAT questionnaires have been considered for the development of the ACQ. A few of them, most of which have been widely used over the years, are reviewed here.

The Relationship Questionnaire (RQ)

The RQ (Bartholomew, 1990; Bartholomew and Horowitz, 1991) has been devised to assess the differences in adult attachment by relying on a two-dimensional model[9]. The two dimensions of avoidance and ambivalence are considered – termed, in this case, avoidance and dependence. The instrument consists of 4 items, each of which measures a different combination (of values) of the two dimensions.

Following the previous work of Hazan and Shaver (1987), the RQ presents the subject with some brief self-descriptions – each representing an attachment style – and asks the subject to rate – on a 1-to-7 Likert scale – how much they agree with each description. The instrument introduces an important innovation compared to previous attachment assessment tools: the proposed styles are four instead of the usual three. Bartholomew (1990) hypothesized a four-style model by discussing the definition of the avoidant category, considering both the one that referred to childhood experiences with a parental figure (George et al., 1985) and the one that referred to romantic relationships with a partner (Hazan and Shaver, 1987). The author considered that each individual maintains internal models concerning the other and the self and that these models can express a positive or negative evaluation at different degrees. Therefore, she suggested that four styles arise by the combination of such evaluations. In other words, her two-dimensional model of attachment led to four categories (Table 3.1).

	Model of self Low Dependence (high worthiness/lovability)	**Model of self High Dependence (low worthiness/lovability)**
Model of Other Low Avoidance (of Intimacy) (high trustworthiness/acceptance)	**Secure**	**Preoccupied**
Model of Other High Avoidance (of Intimacy) (low trustworthiness/acceptance)	**Dismissing**	**Fearful**

Table 3.1. Bartholomew's two-dimensional model of attachment.
Low and high levels of avoidance (model of other) and dependence (model of self) generate four categories of attachment.

The two dimensions of avoidance and dependence generate the four categories secure, dismissing, preoccupied, and fearful. Avoidance refers to the model of the other in terms of how much they are perceived as trustworthy and accepting, while dependence refers to the model of the self in terms of how much one feels to be worthy and lovable. As a consequence: The secure feels comfortable both in intimate

[9] The RQ can be found on the internet at:
http://labs.psychology.illinois.edu/~rcfraley/measures/rq.html

relationships and being autonomous. The dismissing does not feel comfortable in intimate relationships and is over-independent. The preoccupied is worried about the relationships. The fearful is both uncomfortable in intimate relationships and dependent on the other. According to Bartholomew (1990), this last category had not been explicitly considered with respect to parental figures but could partially match the description of the avoidant style provided by Hazan and Shaver (1987) with respect to a partner. Later Brennan et al. (1991) confirmed that the secure, fearful, and preoccupied styles well correspond to the secure, avoidant, and ambivalent ones from Hazan and Shaver (1987) respectively and that the dismissing style can be considered additional to them.

The four categories are meant to be prototypes and not mutually exclusive. In other words, each category is a model that the subject can match to a different degree. Indeed, most subjects fit into more than one prototype. This corresponds to assuming a different style in different relationships or in the same relationship at different times. The subject's attachment style is assessed as the overall profile that arises from taking into account the correspondence to each prototype.

Despite the innovation and simplicity of the RQ, other tools have been then realized that rely on multiple short items and have become much more popular.

The Adult Attachment Scale (AAS) and its revised version (RAAS)

The AAS (Collins and Read, 1990) and RAAS (Collins, 1996) measure three attachment styles – termed close, depend, and anxiety[10] – which are, however, underpinned by two dimensions (Brennan et al., 1998; Collins et al., 2006). According to the APT nomenclature, close and depend correspond to avoidance, and anxiety corresponds to ambivalence. Both the instruments consist of 18 items, and each style is associated with 6 of them. Therefore, 12 items are associated with avoidance and 6 with ambivalence. Items have been developed by drawing on the literature, especially the attachment style descriptions from Hazan and Shaver (1987).

The subject is asked to think about their romantic relationships and how they generally feel about them. The three styles measure how much one: (1) feels comfortable in being close/intimate with another (close); (2) feels comfortable in depending on/trusting another for their availability in case of need (depend); and (3) worries about not being loved and being abandoned (anxiety).

[10] The AAS and RAAS can be found on the internet at: https://labs.psych.ucsb.edu/collins/nancy/UCSB_Close_Relationships_Lab/Resources_files/Adult%20Attachment%20Scale.doc

The Adult Attachment Questionnaire (AAQ)

The AAQ (Simpson et al., 1992; Simpson et al., 1996) assesses the avoidant and ambivalent dimensions of attachment[11]. It consists of 17 items – 8 associated with avoidance, 9 with ambivalence. As with the AAS, the items have been mostly developed starting from the attachment style descriptions given by Hazan and Shaver (1987).

The avoidant dimension measures the extent to which one finds a close/intimate relationship to be uncomfortable. Avoidants tend to avoid such closeness and cut off their emotional needs (attachment deactivation). On the other hand, the ambivalent dimension measures the extent to which one finds the other as reliable in a relationship. Ambivalents tend to worry about the relationship and expect the other to be unavailable when needed (attachment hyper-activation). The secure attachment style is simply the result of low avoidance and low ambivalence.

The Experiences in Close Relationships (ECR), its revised version (ECR-R), and the Relationship Structures one (ECR-RS)

The ECR (Brennan et al., 1998) and ECR-R (Fraley et al., 2000) measure the avoidant and ambivalent dimensions of attachment[12]. They both consist of 36 items – 18 associated with avoidance, 18 with ambivalence. The avoidant dimension is conceptualized as a measure of the discomfort with closeness/dependency on the attachment figure, while ambivalence as a measure of fear of rejection/abandonment from the other.

The ECR is the result of a factor analysis – more specifically, principal component analysis[13]– applied to a large number of items and constructs derived from the literature. 323 items corresponding to 60 constructs related to attachment were factor-analyzed and reduced to the two dimensions of avoidance and ambivalence. These dimensions generate four attachment styles that correspond to the ones found by Bartholomew (1990) related to one's model of the other (avoidance) and the self (ambivalence). The 36 remaining items showed strong correlations with the two dimensions. The highest item-correlation with avoidance (.73) came from *"I prefer not*

[11] The AAQ can be found on the internet at:
https://rholeslab.files.wordpress.com/2018/08/aaq-adult-attachment-questionnaire.pdf
[12] The ECR, ECR-R, and ECR-RS can respectively be found on the internet at:
http://labs.psychology.illinois.edu/~rcfraley/measures/ecl.html
http://labs.psychology.illinois.edu/~rcfraley/measures/ecrritems.htm
http://labs.psychology.illinois.edu/~rcfraley/measures/relstructures.htm
[13] Strictly speaking, principal component analysis is not a factor analysis (and a component is not a factor). However, since they are very similar, principal component analysis will be here referred to as a factor analysis (and a component as a factor), as it is often done (Denis, 2018; Field, 2018; George and Mallery, 2019).

to show a partner how I feel deep down" and the lowest (.60) from *"I tum to my partner for many things, including comfort and reassurance"*, which show the relation between this dimension and the avoidance of intimacy. On the other hand, the highest item-correlation with ambivalence (.67) came from *"I worry about being abandoned"* and the lowest (.50) from *"I resent it when my partner spends time away from me"*, which show the relation between this dimension and worrying about the other's availability (Brennan et al., 1998). Interestingly, although two questionnaires (e.g. the ECR and the RQ) can produce the same categories, the sizes of the corresponding categories can be different. This is consistent with the dimensional nature of attachment and the production of categories as regions in the generated space (Fraley and Waller, 1998).

The revision of the instrument was intended to enhance the psychometric properties of the original version. However, the two questionnaires both show excellent properties, and choosing one or the other seems more a matter of preference in the formulation of the items (Sibley et al., 2005; Mikulincer and Shaver, 2016). Moreover, the two ECR-R scales for avoidance and ambivalence seem highly correlated with each other (.41), more than the ECR ones (Cameron et al., 2012; Mikulincer and Shaver, 2016).

Finally, the ECR-RS (Fraley et al., 2011) is intended to measure attachment avoidance and ambivalence in different kinds of relationships – such as those with a parent figure, a romantic partner, or a friend. It consists of only 9 items – 6 associated with avoidance, 3 with ambivalence.

3.1.1.3. Assessment of personal meaning organizations

Guidano (1991) conceived the personal meaning organizations as personality characteristics, not connected to corresponding attachment dimensions. Coherently, the two assessment tools realized to measure them have been intended as personality inventories and not attachment ones. However, the APT shows how the Guidanian organizations correspond to high-level descriptions of the elementary information carried by the four β-dimensions – phobicity, depressivity, somaticity, and obsessivity. Given this close connection, the self-report measures of the organizations have been considered for the development of the ACQ. The two questionnaires that have been realized so far are reviewed below.

The Personal-Meaning-Questionnaire (PMQ)

The PMQ[14] (Picardi and Mannino, 2001; Picardi et al., 2003)[15] measures the four personal meaning organizations – phobic, depressive, eating disorder, and obsessive – conceptualized by Guidano and consists of 68 items – 17 associated with each organization. The Guidanian post-rationalist clinical-psychological theory (Guidano, 1987; 1991; 2007) has provided the organizations' descriptions from which the items have been devised. The theory has been first constructed mainly through clinical research and practice (Guidano and Liotti, 1983). And the organizations are, indeed, connected to specific psychopathologies, which represent their typical extreme manifestation – to the extent that each organization's name is that of a disorder or class of disorders. However, Guidano has then extended the theory, until his untimely death, to be a general conception of self-development. In this more general perspective, an organization expresses a personality trait that belongs to every individual. As a result, the PMQ has been developed as a personality inventory. The items associated with each organization are meant to identify a subject characterized by the following specific features and tendencies.

Phobic organization. The subject tends to be caught by the conflicting feelings of perceiving a relationship both as protective and restricting. Consistently, they have a special sensitivity to both the themes of home and freedom and, typically, perceive the world as dangerous. On the one hand, the phobic feels vulnerable and preemptively controls the environment and relationships in an attempt to prevent such a vulnerability from becoming a worry for them. On the other, challenging their sense of vulnerability is also essential to them. They are usually focused on the physiological substrate and expression of their internal states, especially emotions, rather than on the relational meaning of such states.

Depressive organization. The subject tends to feel that being lonely and relying exclusively on themselves are normal conditions. To the occurrences of life, they also tend to attribute the meaning of losing something, which is especially evident in what pertains to their relationships. As a result, they usually feel incapable of maintaining a durable relationship, although they can feel well capable in other life domains. From an attachment perspective, they tend to be avoidant rather than ambivalent.

Eating disorder organization. The subject tends to feel uncertain of themselves (their own state) – a feeling that can correspond to a sense of emptiness. They tend to alternate such a feeling with that of being intruded upon by another. In fact, they

[14] My translation from the Italian 'QSP' (Questionario del Significato Personale).
[15] The QSP – original Italian version of the PMQ – can be found on the internet at: https://www.terapiacognitiva.eu/tc/dwl/QSP_web.pdf

usually rely on someone as a reference to define their thoughts and emotions. They tend to look up to this defining-other and, in general, to strive to be approved by others, being particularly sensitive to their disapproval. They also comply with social standards they assume as references. On the other hand, they can be very critical toward who or what does not comply with those standards. Overall, they are highly perceptive of others' attitudes towards them, especially in regard to what is expected from them.

Obsessive organization. The subject tends to focus on respecting some rules that they hold as essential to them. In this regard, they tend to oscillate between the opposite poles of feeling either completely compliant with such rules or not compliant at all. Their rules often become abstract and assume the form of general principles, although they can manifest themselves in very specific ways. The obsessive typically feels the need to control the aspects of life they associate with their rules and rely on their rational abilities to do that. Such a need often manifests itself in controlling their own thoughts and acts. The focus on rationality easily corresponds to scarce attention to emotional aspects.

The PMQ has been developed in Italian and validated. An English translation has also been realized (Picardi et al., 2004).

The Mini Questionnaire of Personal Organization (MQPO)

The MQPO (Nardi et al., 2012) measures the four personal meaning organizations theorized by Guidano (1987; 1991; 2007) according to the evolution of his theory developed by Nardi – the adaptive post-rationalist (APR) approach (Nardi and Bellantuono, 2008). The four organizations are renamed as: 'controller' (phobic), 'detached' (depressive), 'contextualized' (eating disorder), and 'principle oriented' (obsessive) organization. The questionnaire consists of only 20 items – 5 associated with each organization. As with the PMQ, the MQPO items have been devised based on their theoretical descriptions, and the instrument works as a personality inventory. The items are intended to identify a subject for how they have built their self. In particular, in the four prototypical cases, the self is conceptualized to be constructed as follows:

- **Controller organization.** The subject has built their self by focusing on the balance between receiving protection and obtaining autonomy from the other.
- **Detached organization.** The subject has built their self by focusing on facing solitude (felt as the inevitable condition of their life) through making an effort to reach some personal achievements.

- **Contextualized organization.** The subject has built their self by focusing on their relationships and current events in their life. Others are seen as those who can define the subject's self by either approving or disapproving, confirming or disconfirming.
- **Principle oriented organization.** The subject has built their self by focusing on some fundamental rules that determine the correct (right) and incorrect (wrong) quality of one's thoughts and feelings, and one's nature in general.

As with the PMQ, the MQPO has been developed in Italian and validated, and an English translation has also been realized. The APR model has also received some empirical confirmation (Nardi et al., 2010).

3.1.2. The role of the ACQ-related questionnaires in its development

Despite the above-reviewed questionnaires that measure attachment and personal meaning organizations being closely related to the ACQ, they could not be taken as a reference for its development. In this section, the issue is discussed.

3.1.2.1. ACQ and adult attachment questionnaires

The adult attachment questionnaires represent a strong point of the SAT. By generally following strict psychometric guidelines, they aim to provide a scientifically solid assessment of the phenomenon. Developers have started by directly drawing on concepts related to developmental research (Hazan and Shaver, 1987). They have then progressively conceived numerous effective tools, which have contributed to building a more articulate theory of adult attachment. In other words, from initial more theoretical formulations (Main et al., 1985; Bartholomew, 1990), psychometrical methods have assumed a central role in helping theory progress toward a gradually better definition. In particular, these methods have definitely clarified the dimensional nature of attachment (Brennan et al., 1998; Fraley et al., 2000; Ravitz et al., 2010). However, in spite of their merits, for two main reasons, adult attachment questionnaires could not be taken as a reference for the development of the ACQ. First, their SAT representation of avoidance and ambivalence does not match the APT one. And second, the dimensional conceptualization that they refer to is limited to these two basic attachment dimensions. These two points are now considered in more detail.

Difference in the conceptualization of avoidance and ambivalence

The SAT adult attachment questionnaires refer to a two-dimensional view of attachment: the two dimensions of avoidance and ambivalence generate four attachment styles that can be identified as regions in a plane. Researchers agree on

this. What remains to be more clearly defined is the precise meaning of the dimensions. According to Crowell et al. (2016) – and consistently with the above-review – with this respect, there are two interpretations, which are generally seen as compatible – and not opposing – perspectives. Following Crowell and colleagues, they can be called the cognitive and the motivational perspectives.

SAT Cognitive Perspective (CP). The cognitive perspective on attachment dimensions is the one proposed by Bartholomew and implemented by the RQ (Bartholomew, 1990; Bartholomew and Horowitz, 1991). According to it, the dimensions correspond to internal representations of the other and the self. The model of the other is related to avoidance, and the model of the self is related to ambivalence. More precisely, an avoidant maintains an internal model of the other as untrustworthy and rejecting, and an ambivalent maintains an internal model of the self as unworthy and unlovable. These representations generate the avoidant and ambivalent styles respectively. On the other hand, high levels of both dimensions correspond to the fearful style, and low levels of both to the secure style.

SAT Motivational Perspective (MP). The motivational perspective on attachment is the one usually preferred by adult attachment researchers and, therefore, adopted in their questionnaires (Fraley and Shaver, 2000; Mikulincer and Shaver, 2016). This is probably due to the easier operationalization of attachment as a motivational rather than knowledge system. In particular, Crowell and colleagues refer to the conceptualization proposed by Hazan and Shaver (1994), according to which the avoidant and ambivalent patterns correspond to two different functions of the attachment system. More specifically:

- Avoidance concerns the choice to either activate or deactivate the attachment system to solve some safety-related anxiety. In the activation case, the subject tries to use the caregiver as a secure base. In the deactivation one, they try to manage the situation by themselves.
- Ambivalence concerns the evaluation of the caregiver's psychological availability. If the subject deems that the caregiver is unavailable, they worry about that, otherwise they can undertake other activities – such as exploring the environment.

As discussed below, both these conceptualizations do not appear completely plausible since they do not fully match the available evidence (cf. Chapter 1). As a result, they also do not match the conceptualization proposed by the APT. In particular, (CP) concerning the cognitive perspective, the avoidant and ambivalent representations are both first built in infancy (within the first year) in the interactions with the caregiver, who, for both evolutionary and developmental reasons, is the first

candidate as an object of representation. Representations of the self – in relation to both dimensions – can be built later. (MP) Concerning the motivational perspective, the proposed motivational strategies do not appear consistent with central characteristics of the avoidant and ambivalent: (1) The avoidant feels uncomfortable in intimacy, which is not a safety-related anxiety (at least, directly); (2) The ambivalent worries and complains against the caregiver, which is a psychological strategy that would be employed toward someone who is not psychologically available. Moreover, these interpretations do not match the evolutionary argument according to which avoidance corresponds to the unwillingness to care and ambivalence corresponds to the inability to care.

APT Cognitive-Motivational Perspective. The APT formulates coherent cognitive and motivational hypotheses that are fully supported by the available evidence (cf. Chapter 1). In particular, according to the APT, (CP) the information contained in the Internal Working Model (IWM) related to avoidance and ambivalence primarily refers to the caregiver. An avoidant implicitly knows that their caregiver is emotionally unloving, and an ambivalent implicitly knows that their caregiver is physically unavailable. These hypotheses differ from the SAT cognitive perspective. (MP) Moreover, the APT proposes that the avoidant deactivation strategy and the ambivalent hyper-activation strategy are related to such representations. An avoidant has no reason to seek comfort from a caregiver that is seen as emotionally cold and, therefore, does not engage in intimacy (deactivation). An ambivalent sees a caregiver that shows to be psychologically connected when they want to and, therefore, has all the reasons to complain for not being physically attended to (hyper-activation). These hypotheses differ from the SAT motivational perspective. Importantly, according to the APT, the cognitive and motivational perspectives are intrinsically connected: the goal of the attachment motivational system is to match what is perceived (i.e. the current representations) with the target attachment representations held by the subject.

The theoretical inconsistencies between the SAT and the APT make the adult attachment questionnaires not an adequate reference for the development of the ACQ. A few questionnaire items taken as examples will help further clarify the problem.

RQ. The two following items assess the avoidant and ambivalent dimensions according to the RQ (Bartholomew and Horowitz, 1991) (Table 3.2). The avoidance item (1) refers to emotional closeness and independence. On the other hand, the ambivalence item (2) refers to emotional intimacy, closeness, and personal value. Interestingly, emotional intimacy and closeness are implied to be synonyms. The APT conceptualizes

emotional connection as characterizing avoidance and not ambivalence. Moreover, according to the APT, self-worthiness also belongs to avoidance as a consequence of implicitly knowing not to be loved. Therefore, the SAT and APT lead to different item formulations.

1	*"I am comfortable without close emotional relationships. It is very important to me to feel independent and self-sufficient, and I prefer not to depend on others or have others depend on me."*
2	*"I want to be completely emotionally intimate with others, but I often find that others are reluctant to get as close as I would like. I am uncomfortable being without close relationships, but I sometimes worry that others don't value me as much as I value them."*

Table 3.2. Two items from the Relationship Questionnaire (RQ).
Item 1 (in yellow) measures the 'dismissing-avoidant' style, and item 2 (in red) measures the 'preoccupied' style according to the QR (Bartholomew and Horowitz, 1991). They correspond to the avoidant and ambivalent dimensions respectively.

RAAS. The four following items measure the avoidant and ambivalent dimensions according to the RAAS (Collins, 1996) (Table 3.3). The avoidance items (1 and 2) refer to closeness. Item 2 also refers to being worried about that. On the other hand, the ambivalence items (3 and 4) refer to love and closeness. In addition, item 3 refers to being worried about not being loved. As with the RQ, closeness appears in items related to both dimensions. Moreover, again, as with the RQ, unlovability refers to ambivalence. Therefore, as the previous one, this questionnaire is not compatible with an APT-based development.

1	*"I find it relatively easy to get close to people"*
2	*"I don't worry about people getting too close to me"*
3	*"I often worry that romantic partners don't really love me"*
4	*"I find that others are reluctant to get as close as I would like"*

Table 3.3. Four items from the Revised Adult Attachment Scale (RAAS).
Items 1 and 2 (in yellow) measure avoidance, and items 3 and 4 (in red) measure ambivalence according to the RAAS (Collins, 1996).

ECR-R. The four following items assess the avoidant and ambivalent dimensions according to the ECR-R (Fraley et al., 2000) (Table 3.4). The avoidance items (1 and 2) refer to deep/private thoughts and feelings. On the other hand, the ambivalence items (3 and 4) refer to love. Item 3 also refers to being worried about not being loved. The APT conceptualizes emotional connection – as a synonym of love – as characterizing avoidance and not ambivalence. Coherently, according to the APT, lovability also belongs to avoidance and not ambivalence. This confirms once more that the SAT and APT lead to incompatible item formulations.

1	*"I prefer not to show a partner how I feel deep down"*
2	*"I feel comfortable sharing my private thoughts and feelings with my partner"*
3	*"I'm afraid that I will lose my partner's love"*
4	*"I often worry that my partner doesn't really love me"*

Table 3.4. Four items from the Experiences in Close Relationships Revised (ECR-R) questionnaire. Items 1 and 2 (in yellow) measure avoidance, and items 3 and 4 (in red) measure ambivalence according to the ECR (Fraley et al., 2000).

For the development of a questionnaire, the connection between theory and item formulation is a critical point, related to the connection between what is intended to be measured and what is actually measured (or appears to be measured). In this case, the SAT seems to often consider love and closeness/intimacy as belonging to both avoidance and ambivalence, thereby complicating the differentiation between them. On the other hand, in the questionnaires, items that refer to closeness/intimacy are assigned to both avoidance and ambivalence, but those that refer to love to ambivalence only. There is reason to think that this complicated situation is due to the complexity and ambiguity of natural language. In English, for example, the word love can assume numerous meanings. It goes without saying that the interpretation of an item can be heavily affected by its whole formulation and the concepts it recalls more than by the precise words that it employs. All this significantly complicates both formulating items to be then interpreted according to the reference theory and drawing theoretical inferences from statistical studies. These crucial issues will be further discussed below.

Difference in the number of dimensions considered

According to the SAT, attachment involves the two basic dimensions of avoidance and ambivalence, plus disorganization, which is treated as a special condition. These three are here referred to as α-dimensions. However, the APT proposes to consider four additional dimensions – phobicity, depressivity, somaticity, and obsessivity – which are termed β-dimensions. Therefore, although conceived to assess avoidance and ambivalence, SAT adult attachment questionnaires can occasionally involve a β-dimension. A few examples from the adult attachment questionnaires discussed in the above review will help clarify this point too.

RQ. The two RQ-items reported above (Table 3.2) are intended to measure avoidance (item 1) and ambivalence (item 2). Item 1 refers to independence and self-sufficiency, which are typical phobic themes. Phobicity is focused on the need to balance the protection received and the freedom obtained from a reference figure, which is evoked by the idea of being independent and self-sufficient. On the other hand, item 2 refers to complete emotional intimacy with another, which is a typical somatic

theme. Somaticity is focused on the need to be defined by another, who is seen as a potential intruder. This is evoked by the idea of emotional fusion implied in the item. Therefore, when more dimensions are considered, items need to be more discriminative.

ECR. The four following items assess the avoidant and ambivalent dimensions according to the ECR (Brennan et al., 1998) (Table 3.5). The avoidance items (1 and 2) refer to closeness to someone – in particular, feeling either comfortable or uncomfortable being close. This reference may well elicit the phobic sense of constriction or the somatic sense of intrusion. Therefore, three dimensions are involved in these formulations. On the other hand, the ambivalence items (3 and 4) refer to loss (item 3) and disapproval (item 4). Loss is a typical depressive theme, while disapproval is a typical somatic one. These items clarify that, when adding the β-dimensions to the α-ones, the formulation needs to be more specific.

1	*"I am very comfortable being close to romantic partners."*
2	*"Just when my partner starts to get close to me I find myself pulling away."*
3	*"I worry a fair amount about losing my partner."*
4	*"When romantic partners disapprove of me, I feel really bad about myself."*

Table 3.5. Four items from the Experiences in Close Relationships (ECR) questionnaire.
Items 1 and 2 (in yellow) measure avoidance, and items 3 and 4 (in red) measure ambivalence according to the ECR (Brennan et al., 1998).

This point (number of dimensions) – as the previous one (conceptualization of dimensions) – demonstrates that the SAT adult attachment questionnaires cannot be taken as a reference for the development of an APT-based questionnaire.

3.1.2.2. ACQ and personal-meaning-organization questionnaires

The two questionnaires that measure the personal meaning organizations – the PMQ (Picardi et al., 2003) and MQPO (Nardi et al., 2012) – have been developed following the Guidanian post-rationalist conception (Guidano, 1987; 1991; 2007). They are both devised as personality inventories and try to capture the main features of the four organizations. Each scale corresponds to a prototypical description of a personality trait. As the adult attachment questionnaires, the PMQ and MQPO could not be taken as a reference for the development of the ACQ. In this case, as in the previous one, there are two reasons. First, the ACQ has a different focus compared to these self-reports. Second, there is also a difference in the number of dimensions considered. Both issues are discussed in turn.

Difference in the reference definitions

The post-rationalist questionnaires try to capture four personality prototypes. To do that, the formulation of their items generally involves both central personality aspects and more peripheral ones, which are, however, considered typical of the considered organization. In contrast, the ACQ is intended to measure the attachment dimensions that constitute the core of personality. Therefore, it focuses on the elementary information that is assumed to characterize each of them. In particular, the ACQ aims to express the following dimensional themes:

- Phobicity: easily elicited senses of constriction and vulnerability. The former arises when the attachment figure is perceived as too near, the latter when such a figure is perceived as out of reach.
- Depressivity: easily elicited senses of loss and defeat, a looming sense of solitude. All possibly related to any life event.
- Somaticity: easily elicited senses of uncertainty and intrusion. The former arises when the defining attachment figure is perceived as missing, the latter when such a figure is perceived as too insistent.
- Obsessivity: easily elicited sense of responsibility, which concerns a set of rules taken as a strict reference.

The PMQ and MQPO include these themes, but many items involve their typical correlates. To further clarify this issue, four items from the PMQ and four from the MQPO are considered. They are intended to measure the organizations that correspond to phobicity, depressivity, somaticity, and obsessivity respectively. For the PMQ (Table 3.6), item 1 concerns health, which is often involved in phobicity although not central to it. Item 2 concerns drinking and suffering, which is not strictly related to depressivity. Item 3 is about getting discouraged, which is not a primary somatic point. And finally, item 4 concerns anger, which is also not a key obsessive matter.

1	*"I think it's better to lose one's dignity than one's health"*
2	*"I understand the people who drink to soothe their suffering"*
3	*"When I don't immediately get a result, I get discouraged"*
4	*"You can feel anger towards someone only for very valid reasons"*

Table 3.6. Four items from the Personal-Meaning-Questionnaire (PMQ).
These Items from the PMQ (Picardi et al., 2003) measure the organizations that correspond to the following dimensions: (1) phobicity (in green); (2) depressivity (in black); (3) somaticity (in purple); (4) obsessivity (in brown).

Although the MQPO appears to be much more focused, for the selected items (Table 3.7), similar considerations can be made. The first is related to being annoyed more than constricted, which is instead key in phobicity. The second is about a typical

outcome of depressivity – getting by by oneself – but not a defining theme. The third concerns feeling important as a consequence of being required. Not central in somaticity. The fourth is about commitment, which is a possible correlate of following a rule – an obsessivity defining theme.

1	*"I feel good with reliable people who don't oppress me with their requests"*
2	*"In my life I always had to get by myself, as I cannot count on other's help"*
3	*"I feel myself important if I am appreciated and required by others"*
4	*"The commitment I put in doing things makes me feel good, rather than others' appreciation"*

Table 3.7. Four items from the Mini Questionnaire of Personal Organization (MQPO).
These Items from the MQPO (Nardi et al., 2012) measure the organizations that correspond to the following dimensions: (1) phobicity (in green); (2) depressivity (in black); (3) somaticity (in purple); (4) obsessivity (in brown).

Overall, compared to the post-rationalist self-reports, the ACQ item formulation needs to be more focused on the APT definitions of the attachment dimensions.

Difference in the number of dimensions considered

The PMQ and MQPO only measure the four personal meaning organizations, which correspond to the β-dimensions – phobicity, depressivity, somaticity, and obsessivity. Therefore, their items can include references to the three α-dimensions – disorganization, avoidance, and ambivalence. A few examples from the PMQ are provided below (Table 3.8).

1	*"It is important for me to know where my partner is at all times"*
2	*"I think that avoiding becoming attached to another person is a good way to avoid suffering"*
3	*"It occurs to me that I fantasize and daydream"*
4	*"I have great faith in rationality and logic"*

Table 3.8. Four items from the Personal-Meaning-Questionnaire (PMQ).
These Items from the PMQ (Picardi et al., 2003) measure the organizations that correspond to the following dimensions: (1) phobicity (in green); (2) depressivity (in black); (3) somaticity (in purple); (4) obsessivity (in brown).

These four items touch on the three α-dimensions. Item 1 involves knowing about the availability of the partner, which pertains to ambivalence. Item 2 implies avoidance of attachment. Item 3 concerns daydreaming and fantasizing, which are related to disorganization as dissociative symptoms. Finally, item 4 refers to the appreciation of rationality and logic, typical avoidant characteristic. Overall, similarly to the case of adult attachment, the personal meaning questionnaires are not discriminative enough to be taken as a reference for the development of an APT-based questionnaire.

3.1.2.3. Taking stock: ACQ and related questionnaires

The first step in the development of a questionnaire can reasonably be to take similar questionnaires as a reference. This option was carefully considered for the development of the ACQ. The possible reference self-reports were (A) the SAT adult attachment questionnaires and (B) the post-rationalist personal meaning questionnaires. The former ones (A) investigate the α-dimensions. More precisely, avoidance and ambivalence, since disorganization is generally treated as a special condition. The latter ones (B) involve the β-dimensions – phobicity, depressivity, somaticity, and obsessivity.

The present review of adult attachment self-reports identified two critical issues that suggested not to take them as a reference. (1) These questionnaires endorse the SAT definition of avoidance and ambivalence, which diverges from the APT one. (2) They also consider two attachment dimensions, while the ACQ considers seven of them. These issues make it impossible to use these questionnaires as a reasonable basis for development.

The personal meaning inventories also pose insurmountable problems. (1) They do not focus on the central features of the β-dimensions but consider more peripheral characteristics as well. In contrast, the ACQ intends to investigate precisely those central features. (2) As the adult attachment self-reports, these questionnaires concern only a subset of dimensions, thereby allowing for the involvement of the missing dimensions in the formulation of their items. In other words, they are not as discriminative as the ACQ requires.

In conclusion, for the development of the ACQ, no other questionnaire could be taken as a reference. In fact, the ACQ should also have a broader use compared to the examined self-reports. Since the APT is both a personality and clinical theory, the ACQ should be not only a personality inventory but also a clinical tool.

3.1.3. The ACQ specifics and structure

The goal of the ACQ is to test the APT. Therefore, it has to meet the specifics necessary to comply with the theory. In particular:

1. The ACQ needs to measure the **seven attachment dimensions** currently working in the adult subject. Such dimensions operate with current caregivers, especially romantic partners. They are:
    a. Three α-dimensions: disorganization, avoidance, and ambivalence;
    b. Four β-dimensions: phobicity, depressivity, somaticity, and obsessivity;

And constitute the **Internal Working Model** (IWM) – the core attachment knowledge.

2. The ACQ needs to measure the **seven caregiving features** experienced in childhood with the primary maternal and paternal figures. They are:
    a. Three α-features: frightfulness, sensitivity, and unresponsiveness.
    b. Four β-features: limitation, unreachability, definition, and judgment/ blame.
3. Items need to focus on the **central characteristics** of each dimension/feature (the pieces of information held by the f-IWM in the attachment case).
4. Items need to be formulated so that subjects will correctly refer them to the **intended dimensions/features**.
5. It needs to be considered that the response to attachment-related items can be affected by attachment activation due to multiple **external factors** – such as life events, environmental conditions.
6. It needs to be considered that the response to attachment-related items depends on **knowledge hierarchy and language**.

Taking care of all these points is essential to building a questionnaire consistent with the APT and, therefore, testing it. They have been considered in the various stages of development discussed below. In particular, the last point – concerning knowledge hierarchy and language – is related to the problem of item interpretation and requires special attention. Indeed, this point plays a primary role in the ACQ development and is preliminarily discussed in the following section.

3.1.3.1. The hierarchy of knowledge: what we say and what we mean

The APT adopts a cognitive-clinical approach to attachment and personality. The mind is an information processor and control system supported by the brain, which fundamentally aims to achieve adaptation through action (Bowlby, 1969/1982; Tooby and Cosmides, 1992; Clark, 1997; Buss, 2005; Carruthers, 2006; Petters, 2019). As discussed above (cf. 1.4.4), the theory considers the IWM to be the firmware of our mind, suggesting a rudimentary brain-computer analogy that turns out to be essential for the conception of an attachment questionnaire. Before elaborating on the issue, it is important to stress that such an analogy is only used to highlight a different status in the attachment knowledge hierarchy through terms – firmware and software – that immediately recall such a difference, with no further implications.

Firmware and software. According to the simplest form of the brain-computer analogy, the brain is the hardware, while what is thought of is the software. This distinction may suggest that any piece of stored information has equal status. But this is not the case. Firstly, some knowledge is innate – evolutionarily incorporated in the

brain structure – and provides the substrate for subsequent acquisitions (Margolis and Laurence, 2013). In the case of attachment, for example, this is made evident by the imprinting of the caregiver's identity: the infant knows that whoever 'is there' in the sensitive timeframe is the caregiver (Bowlby, 1969/1982). More generally, there is evidence for different kinds of knowledge, especially in terms of 'read' and 'write' properties – i.e. how easily the information processor can read such information or (re)write it (thereby changing its content) respectively. With this respect, the knowledge system of the mind is hierarchical. Different kinds of knowledge correspond to different kinds of long-term memories (implicit and explicit) (Rovee-Collier et al., 2001; Gray, 2006). In accordance with these considerations, in regard to our socio-psychology, the APT suggests extending the brain-computer analogy to include at least the firmware as an implicit information category intermediate between hardware and software. This kind of knowledge can be considered partially embedded in the hardware and, therefore, at a very low level in the data hierarchy, although still re-writable. The IWM of attachment has these characteristics and can be thought of as the socio-psychological firmware of our mind. More precisely, it is the simplest and lowest-level information of such a kind and, therefore, plays the primary role in our relational life (Bowlby, 1973; Schore, 2003; Liotti, 2016; Gagliardi, 2021). Over the years, attachment-related knowledge is continuously acquired by the system at different levels, but the f-IWM remains the basis of such knowledge. This data structure has an implicit (non-verbal) nature (**firmware**), while the development of language boosts the acquisition of explicit (verbal) attachment representations (**software**). Given its evolutionarily vital role, the content of the f-IWM is imprinted. It needs to be easy to read and durable. Its level can be thought of as the level of '**what we mean**', which is related to the fundamental attachment experiences, those that determine the imprinted attachment dimensions. This is indeed the level that informs what Guidano (1991) called our 'personal meaning organizations'. On the other hand, other attachment-related knowledge is not imprinted. It is not as vital as the f-IWM and can be much more easily (re)written. Its level can be thought of as the level of '**what we say**', which can or can not correspond to the fundamental attachment experiences and the f-IWM. Metaphorically extremized, these two levels can be visualized as what is 'carved in stone' and what is 'written on paper' (Figure 3.2).

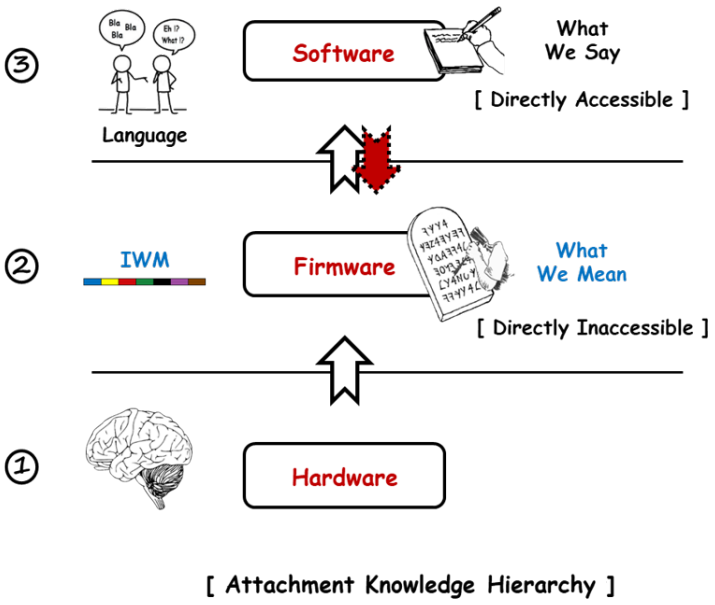


Figure 3.2. The attachment knowledge hierarchy.
The (implicit and non-verbal) IWM can be thought of as the attachment firmware – level of 'what we mean'. On the other hand, other attachment-related (explicit and verbal) knowledge can be thought of as the attachment software – level of 'what we say'.

This classification provides a first rudimentary but, nonetheless, operational model that makes a difference by defining the minimal attachment knowledge hierarchy to be considered. According to the APT, the firmware-software distinction of knowledge status between the IWM – as the firmware basis of attachment – and the rest of software attachment-related knowledge is as simple as essential. It is crucial not only to the understanding of attachment phenomena but also to the development of a questionnaire that investigates such phenomena. An attachment self-report needs to distinguish between the firmware and the software because the firmware is hard to change and is what has – by far – the most influence on the system.

It is worth noting that, although the SAT adopts a more general and informal definition of IWMs compared to the APT, Bowlby's words fully confirm the APT conceptualization:

"Starting, we may suppose, towards the end of his first year, and probably especially actively during his second and third when he acquires the powerful and extraordinary gift of language, a child is busy constructing working models" (Bowlby, 1969/1982, p.354). *"In a person suffering from emotional disturbance it is common to find that the model that has greatest influence on his perceptions and forecasts, and therefore on his feeling and behaviour, is one that developed during his early years and is constructed on fairly primitive lines, but that the person himself may be relatively, or completely, unaware of; while, simultaneously, there is operating in him a second, and*

perhaps radically incompatible, model, that developed later, that is much more sophisticated, that the person is more nearly aware of and that he may mistakenly suppose to be dominant" (Bowlby, 1973, p.205).

Therefore, Bowlby recognizes the dominant role of early attachment acquisitions – at a firmware level – and the possible incongruencies with the later ones – at a software level. These differences are clinically evident (Berne, 1973; Bowlby, 1973; Guidano and Liotti, 1983; Guidano, 1991; Liotti, 2016). Moreover, Schore's description of how *"early forming internal working models of the attachment relationship are processed and stored in implicit-procedural memory systems in the right hemisphere"* (Schore, 2003, p.62) matches the foundational firmware role of the IWM.

The two following sections go into the details of questionnaire problems that are related to knowledge hierarchy and language (point 6 above). They concern accessing and correctly interpreting information. More specifically, problems arise in two cases: when the subject refers to (software) attachment-related knowledge that is either (1) inconsistent with the f-IWM or (2) consistent with the f-IWM but incorrectly interpreted because of language.

Reference to information inconsistent with the f-IWM

The difference between firmware and software reflects the one between implicit-non-verbal knowledge and explicit-verbal one. Given the complexity of the overall knowledge system, internal inconsistencies between the two levels are likely to occur. The representation evoked by a questionnaire item can suffer from this problem. An example can be made using the following item from the adult attachment questionnaire RAAS (Collins, 1996):

"I find it relatively easy to get close to people."

This item is meant to measure the avoidance dimension. However, closeness can be referred to attachment knowledge that does or does not correspond to the imprinted avoidant information. An avoidant subject could draw on a (firmware-disconfirming) representation of being close as talking about their work-day or watching a movie with their partner. In this case, the subject would report finding it easy to get close. On the other hand, another avoidant subject could draw on a (firmware-confirming) representation of avoiding being close that corresponds to the unpleasant internal states they experience when a conversation topic becomes intimate. In this case, the subject would report not finding it easy to get close. In other words, these two representations would lead to very different ratings of the same question. When the software representation does not match the firmware one, the reported answer does not correspond to the investigated dimension (Figure 3.2). Every item can potentially

be affected by this mismatch. Therefore, the hierarchy of knowledge always poses an interpretation problem – the representation the subject refers to may not correspond to the f-IWM.

Reference to information consistent with the f-IWM but incorrectly interpreted because of language

A questionnaire is based on language, and language finds its meaning in one's own experiences. In different individuals, the same sentence can evoke qualitatively different experiences – or, inversely, qualitatively different experiences can be expressed by similar or identical expressions. For one individual, a warm day can correspond to sweating at a temperature of 30 C, for another to being in a usual physiological state at a temperature of 15 C. This is valid in general, for any kind of language expression, and, in particular, for the items of a questionnaire. Two cases can be considered and illustrated by two examples.

(A) A subject can refer an item to the correct dimension (i.e. consistent with the f-IWM) but inappropriately interpret (i.e. label) their experience (e.g. an avoidant experience interpreted as secure). An example can be taken from the adult attachment questionnaire ECR (Brennan et al., 1998):

"I am very comfortable being close to romantic partners."

This item is meant to measure the avoidance dimension. However, the same representation that is related to closeness and associated with an f-IWM-consistent experience can be interpreted (i.e. labeled) in very different ways by different subjects. For example, two avoidant subjects could have the same representation of being close – e.g. sharing their thoughts and feelings about their relationship with their partner. Moreover, the two subjects could both connect this representation to an unpleasant feeling. In this case, the representation would be consistent with the subjects' avoidant f-IWM. Nevertheless, although one subject might interpret/label their experience as uncomfortable and give the item 'I totally disagree', the other might well do just the opposite – i.e. interpret/label their experience as comfortable and give the item 'I totally agree'. Incorrect labeling might come from different reasons – what is called being 'defensive', for example – but, regardless of the reason, the outcome remains the same.

(B) A subject can correctly refer an item to a dimension (i.e. consistently with the f-IWM) but different from the one the item was intended to investigate (e.g. an ambivalent item interpreted as depressive). For an item, evoking a representation consistent with the f-IWM is not sufficient. The evoked representation needs to

correspond to the dimension that the item is meant to assess. Another example from the ECR (Brennan et al., 1998) illustrates this problem:

"I worry a fair amount about losing my partner."

In this case, the idea evoked by losing the partner can involve different attachment dimensions. One individual could think of being abandoned by a partner that seeks another relationship, which involves ambivalence. Another could think of the death of the partner, which involves depressivity. Both representations could be consistent with the subject's f-IWM, and the two subjects could both rate this item as 'I totally agree' but with a very different meaning. In general, items need to be formulated to maximize the probability of correct attribution by the subject – i.e. to be correctly referred by the subject to the intended dimension (or caregiving feature).

Interpretation problems are amplified by the inherent ambiguity of language, which is particularly high with respect to psychological terms given their abstract nature. The word 'love' offers an interesting example. We can love: (1) A mother/father (attachment); (2) A son/daughter (caregiving); (3) A brother/sister (kinship); (4) A partner (mating); (5) A Friend (cooperation); (6) An acquaintance (what motivation?); (7) A stranger (what motivation?), (8) A soccer team (affiliation), and so on.

3.1.3.2. APT vs SAT attachment knowledge hierarchy

According to the APT, the embodied information that corresponds to a fundamental attachment experience can be thought of as 'what we mean' (meaning), and an attachment-related sentence as 'what we say' (language). The f-IWM – related to the subject's fundamental experiences over seven dimensions – contains what is meant. The above examples from SAT adult attachment questionnaires clarify the crucial difference between what is meant and what is said and the possible misleading labels an experience can be given. As a result, attachment cannot be exclusively assessed at the level of what is said, and a questionnaire cannot exclusively rely on extracting information at the sentence level: meaning does not belong to that level (Figure 3.2).

The APT considers the problem of understanding what individuals mean, while the SAT focuses on capturing what they say and clustering sentences as avoidant and ambivalent. The problem is that sentences may well not be representative of the f-IWM. Indeed, the APT explicitly refers to an attachment knowledge hierarchy on two levels (different for language and meaning), while the SAT implicitly refers to an attachment knowledge hierarchy on a single level (same for language and meaning) (Figure 3.3).

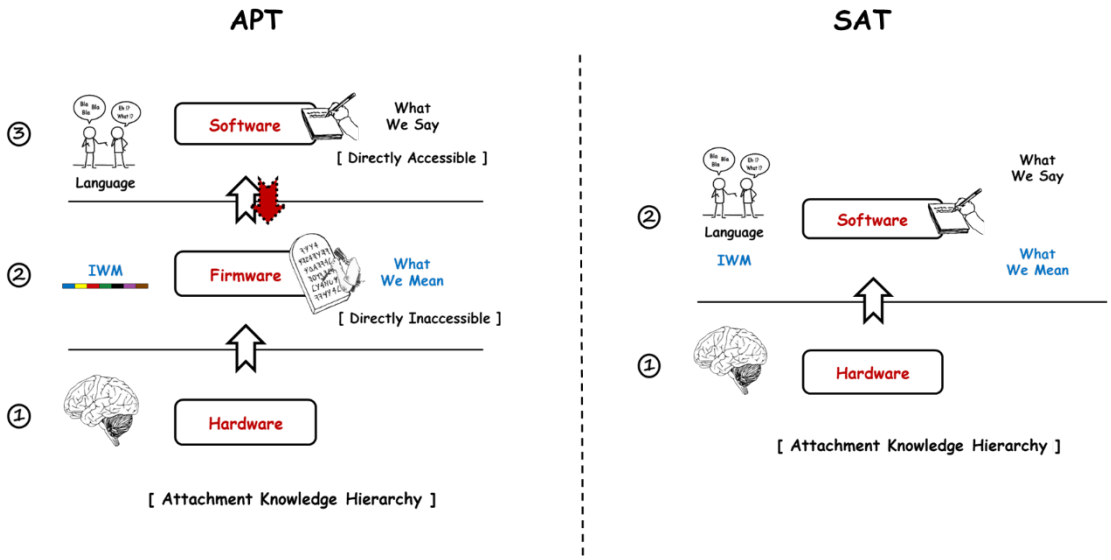


Figure 3.3. The attachment knowledge hierarchy.
The APT explicitly proposes that at least two levels of knowledge need to be distinguished: the level of what we mean (firmware) and the level of what we say (software). In contrast, the SAT implicitly considers knowledge as belonging to a single (software) level by considering what is said equivalent to what is meant.

Mapping problems. Multiple effects related to hierarchy and language (cf. 3.1.3.1) hinder a clear mapping of information from the firmware to the software. In other words, even if a statistical analysis on items could correctly detect the actual underlying dimensions (factors), when these items are rated by a subject, the answers cannot be expected to be correctly (i.e. as the statistical analysis indicates) mapped to the subject's dimensions. A subject that is classified as non-avoidant may actually be avoidant (or vice versa), one that is classified as non-ambivalent may actually be ambivalent (or vice versa).

In particular, a self-report that investigates avoidance and ambivalence through N items could reveal an underlying two-dimensional structure, but the single items could actually not refer to the correct dimensions, or the items could often lead to a wrong assessment. In general, what appears at the language level does not correspond to what lays underneath at the meaning level. Meaning should be extracted not exclusively looking at the scales formed by grouped items.

As discussed above, language is psychologically highly ambiguous, and questionnaire scales and items need to be as discriminative as possible at the meaning level. For example, the ECR (Brennan et al., 1998, p.56) refers to the following definitions of avoidance and ambivalence (termed 'anxiety' by the authors):

- Avoidance: (1) Avoidance of Intimacy; (2) Discomfort with Closeness; and (3) Self-Reliance.
- Anxiety: (1) Preoccupation; (2) Jealousy/Fear of Abandonment; and (3) Fear of Rejection.

These definitions are given in terms of the three scales more highly correlated to the two dimensions. Although scales and corresponding items are clearly identified, the meaning of such scales and items remains not completely clear. For example, what is meant by intimacy or closeness is not. The following tables present the items of the ECR (Brennan et al., 1998) (Table 3.9) and ECR-R (Fraley et al., 2000) (Table 3.10) that explicitly refer to closeness. What is closeness? How do subjects interpret the related questions? If closeness defines avoidance, how does referring to it in an ambivalence-related item affect the answer?

1	*"I am very comfortable **being close** to romantic partners."*
2	*"Just when my partner starts to **get close** to me I find myself pulling away."*
3	*"I get uncomfortable when a romantic partner wants to **be very close**."*
4	*"I want to **get close** to my partner, but I keep pulling back."*
5	*"I am nervous when partners **get too close** to me."*
6	*"I try to avoid **getting too close** to my partner."*
7	*"I find it relatively easy **to get close** to my partner."*
8	*"I prefer not to **be too close** to romantic partners."*
1	*"My desire to **be very close** sometimes scares people away."*
2	*"I find that my partner(s) don't want to **get as close as** I would like."*

Table 3.9. ECR items that directly refer to closeness.
ECR avoidance (in yellow) and ambivalence (in red) items that directly refer to closeness (such a reference is highlighted in purple). References to closeness appear in items related to both scales. How are they interpreted? Why? An ambivalence item of the ECR refers to merging ("I often want to merge completely with romantic partners, and this sometimes scares them away."). What is the difference between being close and being merged?

1	*"I am very comfortable **being close** to romantic partners"*
2	*"I prefer not to **be too close** to romantic partners"*
3	*"I get uncomfortable when a romantic partner wants to **be very close"***
4	*"I find it relatively easy to **get close** to my partner"*
5	*"It's not difficult for me **to get close** to my partner"*
6	*"I am nervous when partners **get too close** to me"*
1	*"I find that my partner(s) don't want to **get as close as** I would like"*
2	*"My desire to **be very close** sometimes scares people away"*

Table 3.10. ECR-R items that directly refer to closeness.
As with the ECR, the ECR-R has items that directly refer to closeness (such a reference is highlighted in purple). And some of them belong to the avoidant scale (in yellow), others to the ambivalent one (in red). Therefore, again, references to closeness appear in both scales. How are they interpreted? Why?

According to the APT, to adequately assess attachment, a questionnaire needs to fully clarify meaning differences and to reach a reasonable degree of confidence that subjects will interpret items in accordance with the intended meaning. Adult attachment questionnaires are statistically accurate but do not focus on these key issues.

SAT: Interview vs Questionnaire. The necessity of focusing on meaning – beyond the level of language content – is confirmed by the AAI (George et al., 1985; Main and Hesse, 1990; Hesse, 2016), whose transcripts are rated mostly based on their form (adherence to Grice's maxims) rather than their content (cf. 3.1.1.1). As a demonstration of the relevance of this aspect, the correlation between the AAI and adult attachment self-reports has been found to be very little (0.09) (Roisman et al., 2007b; Crowell et al., 2016). Researchers usually explain this mismatch by assuming that the interview and the questionnaires measure different constructs (Brennan et al., 1998; Ravitz et al., 2010; Crowell et al., 2016). However, according to the APT, there is no reason for such constructs to be different – because there is no reason to suppose different firmware structures at different ages or for different caregivers.

3.1.3.3. An intelligent pattern recognizer to find meaning

According to the APT, attachment knowledge is hierarchically organized and cannot be considered as all having the same status (Figure 3.2). To a first approximation, the IWM can be thought of as a firmware data structure and the rest of attachment-related knowledge as software. The firmware dominates the hierarchy: it is hard to change and exerts great influence. However, it is implicit (non-verbal) and cannot be directly accessed. By contrast, in general, the software is explicit (verbal) and directly accessible. Importantly, the two levels – firmware and software – can be inconsistent with each other. This incongruency is often evident in psychopathology. This model – although extremely simple – allows making crucial operational considerations.

The ACQ is intended to measure the attachment firmware and, to do that, the analysis needs to go deeper than the superficial language level. SAT adult attachment self-reports do not explicitly consider the different status of attachment knowledge and its implications (Figure 3.3). As a result, they cannot adequately target the most relevant attachment data. On the other hand, personal meaning self-reports are conceived as personality inventories, not directly related to attachment dimensions. Both kinds of instruments have been built by employing classical statistical methods (i.e. factor analysis) to cluster similar items into (rigid) scales related to the constructs to be measured.

According to the above analysis (cf. 3.1.3.1, 3.1.3.2), this is not sufficient to assess the f-IWM. To understand what is meant, information cannot be superficially taken from what is said. The AAI effectively overcomes the issue by relying on transcripts coherence more than content. In a questionnaire, a given item needs to be allowed to have different meanings – i.e. to belong to multiple scales according to the meaning the subject gives to it. In other words, scales need to be flexible, whereas those produced by classical factor analysis are rigid, predetermined.

Given its characteristics, Artificial Intelligence (AI) can be expected to be a valid tool to extract information beyond the superficial content of the items (Duda et al., 2000; Bishop, 2006). More specifically, an intelligent pattern recognizer – in the form of a neural network, for example – could learn to identify the meaningful response patterns that a questionnaire can express (Figure 3.4).

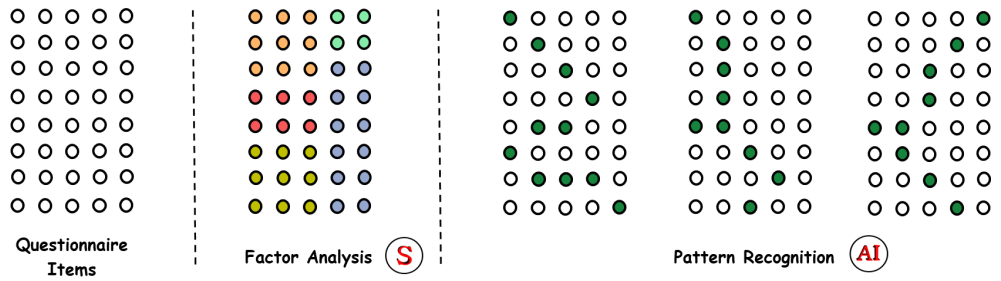


Figure 3.4. A 2D representation of questionnaire items and scales.
The items of a questionnaire can be analyzed through at least two methods: (1) ('Classical') Statistics (S); and (2) Artificial Intelligence (AI) (which can be considered 'More Advanced Statistics'). (1) Usually, statistics is utilized in the form of factor analysis to select and cluster items into rigid scales. This means relying on the items content. (2) An alternative method is using an intelligent pattern recognizer to select and cluster items into flexible scales. Since a rigid scale can be considered as a pattern, this method can be thought of as a more general factor analysis (AI allows patterns to have elements in common, while S generates mutually exclusive patterns).

This would allow an item to belong to multiple patterns according to the meaning it is given by the subject and scales to be flexible, each starting from a base-scale defined as a set of items that typically but not necessarily belong to a given dimension. The ACQ sub-questionnaires Q_A, Q_{CM}, and Q_{CF} provide such base-scales (cf. Appendix B) – which are referred to as scales by default. Moreover, to use the pattern recognizer more effectively, the questionnaire should be extended to help the subject express meaning. In the case of attachment, besides items strictly associated with a dimension, items that help solve possible interpretation doubts should be included. For this reason, the ACQ is provided with a first additional section Q_D concerning more general (especially attachment-related) data. This way, doubts concerning a given item can be solved by using items from other scales or items not strictly related to any scale. In practice, an intelligent pattern recognizer can work as an artificial clinician

that is able to see beyond the single answers and find a more comprehensive read from all of them.

In sum, theory, questionnaire conceptualization/design, and the method employed to extract information are strictly related. In this case, key choices depend on whether people can be expected to express their attachment knowledge directly in their statements. I argued that this is not the case and, therefore, that a usual factor-based self-report is not sufficient. Consistently, I built a clinical questionnaire that is more wide-ranging than the common attachment self-reports and hypothesized AI to be a more adequate tool to analyze it. Usual statistical methods still remain a valuable source of information but overall insufficient to extract attachment meaning.

3.1.3.4. ACQ structure

The ACQ structure reflects its conceptualization and the objective of testing the APT, in particular, the three key hypotheses:

1. H_A: attachment consists of seven dimensions – disorganization, avoidance, ambivalence, phobicity, depressivity, somaticity, and obsessivity – as defined by the APT;
2. H_C: caregiving consists of seven features – frightfulness, insensitivity, unresponsiveness, limitation, unreachability, definition, and judgment/blame – as defined by the APT;
3. H_{CA}: each attachment dimension corresponds to a caregiving feature (in the order specified at points 1 and 2).

The questionnaire is composed of three main sections – Q_D, Q_A, and Q_C – where Q_A and Q_C are expressively dedicated to the above hypotheses, and Q_D extends the possibility to extract meaning. Overall, the ACQ layout is the following (Figure 3.5).

Section 1: Q_D (General Data, 56 items). This is a preliminary section for the collection of information not directly related to the attachment and caregiving scales but useful both to integrate such scales and for general clinical purposes. It consists of three subsections:

1. **Q_{DP}** (Personal Info, 20 items). This section collects general personal data (sex, age, weight, height, education, occupation, nationality, native language, children, siblings). The actual number of items to be answered to is less than 20 since some belong to alternatives.
2. **Q_{DG}** (General Condition, 19 items). This section concerns general wellbeing. The subject is asked about current and past psychological discomfort, and possible help received. Physical health condition is also briefly enquired about. Finally, an item about the overall level of stress is intended to provide a general subjective evaluation of the current condition. More in detail, the following points are touched on: (1) Psychological well-being (with reference to psychological discomfort, panic attacks, depression, eating disorders, obsessive-compulsive disorder, post-traumatic stress disorder, a formal diagnosis from a mental health professional, help received by a psychotherapist); (2) Physical well-being (with reference to serious physical-health issues); (3) Other issues; (4) Current level of stress. This information can provide useful hints for the interpretation of the scales.
3. **Q_{DS}** (Specific Issues, 17 items). This section is about specific psychological issues. In particular, conditions that may affect the current sense of constriction (phobicity), loss (depressivity), intrusion/uncertainty (somaticity), and caregiving (obsessivity). The use of alcohol and drugs is also investigated. These items can provide essential information to solve doubts in the interpretation of the scales, especially the attachment ones.

Section 2: Q_A (Attachment, 125 items). This central section is dedicated to the direct investigation of the current state of the subject's seven attachment dimensions – imprinted in their f-IWM. Items are, therefore, focused on the subject's thoughts and feelings about their current state with respect to attachment relationships and directly related matters. In particular, part of the section addresses romantic relationships.

Section 3: Q_C (Caregiving, 183 items). This last section is devoted to the direct investigation of the seven caregiving features as experienced as a child, especially with the two principal attachment figures – referred to as the mother and father (or maternal and paternal figure respectively). Attention is also given to the family as a whole. To be more specific, there are three subsections:

1. $\mathbf{Q_{CFy}}$ (Family, 17 items). This brief section collects some information about the subject's experience in their family of origin, in particular, related to the disorganized, phobic, depressive, and somatic dimensions.
2. $\mathbf{Q_{CM}}$ (Maternal figure, 83 items). This first individual caregiving section concerns the seven features experienced in the relationship with the mother (the principal maternal figure).
3. $\mathbf{Q_{CF}}$ (Paternal figure, 83 items). This second individual caregiving section concerns the seven features experienced in the relationship with the father (the principal paternal figure).

In summary, the ACQ is divided into sections and subsections for a total of 380 items. It is meant to allow a deep – human or artificial – assessment of the current attachment state and the experienced caregiving, thereby working as a clinical tool and a personality inventory. Behind this design is the conceptualization of a hierarchical organization of attachment knowledge with its foundation in a seven-dimensional f-IWM (Figure 3.2).

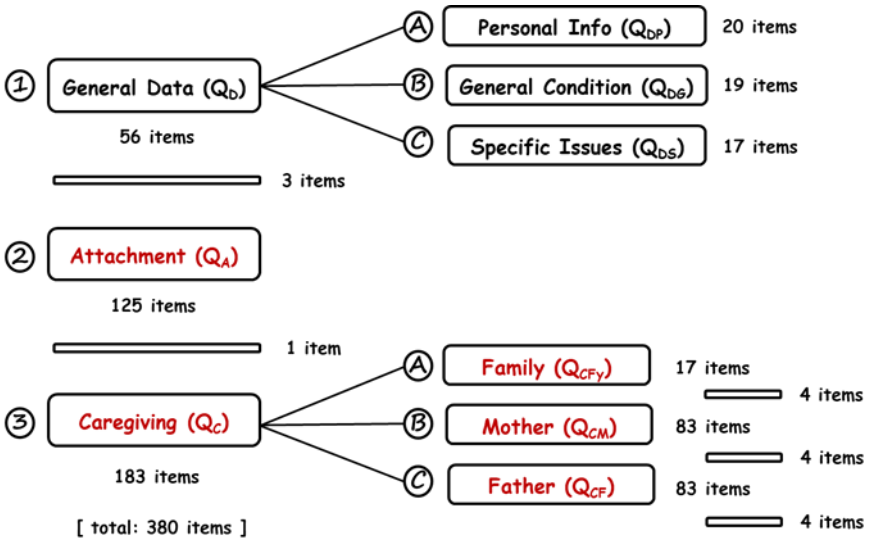


Figure 3.5. The structure of the Attachment-Caregiving Questionnaire (ACQ).
The ACQ consists of three main sections: (1) General Data; (2) Attachment; (3) Caregiving. The first and the third are divided into three further subsections.

Having laid out the structure of the ACQ, it can now be compared to those of the reviewed attachment-related questionnaires.

As discussed above, SAT adult attachment questionnaires do not explicitly consider a differential organization of knowledge (Figure 3.3) and its implications. Consequently, they try to assess attachment by exclusively relying on language content. On the other hand, post-rationalist questionnaires are intended to measure higher-level personality traits rather than basic attachment dimensions. As a result, both SAT adult attachment and post-rationalist self-reports are based on classical statistics (i.e. factor analysis) and consist of correlated items grouped into (mutually exclusive) scales. Therefore, all these instruments consist of a single section and a small number of items (Figure 3.6).

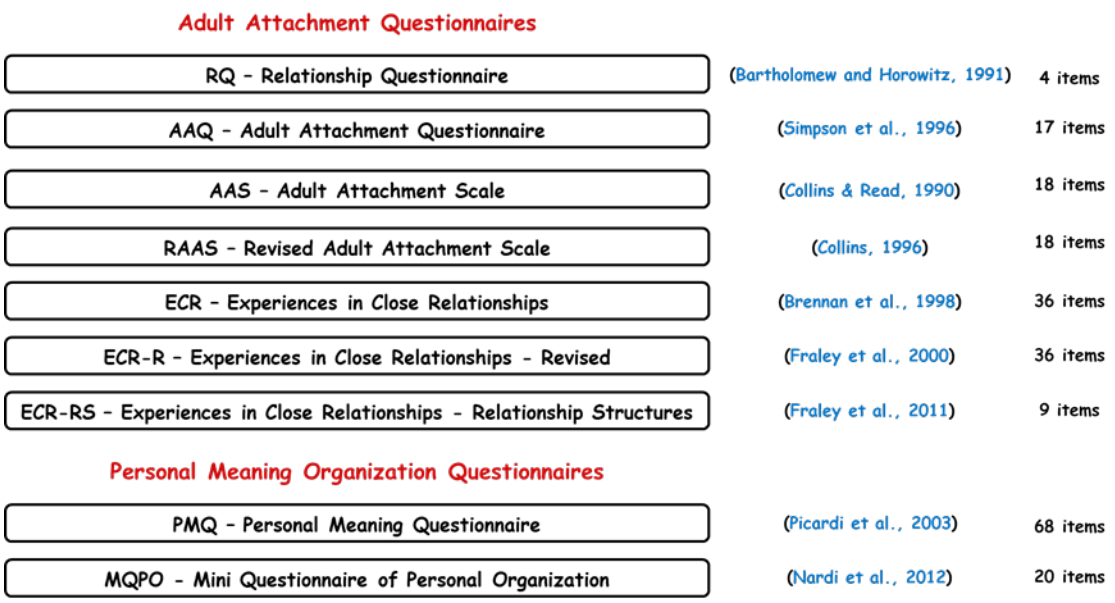


Figure 3.6. The reviewed ACQ-related questionnaires and their items.
The adult attachment questionnaires are devised to measure avoidance and ambivalence. On the other hand, the personal meaning organization questionnaires are devised to measure personality traits related to phobicity, depressivity, somaticity, and obsessivity. All of them only include items for direct assessment.

Different conceptualizations – APT on the one side and SAT and post-rationalist on the other – lead to different questionnaire designs. Although the ACQ has a more complex structure, it is worth noting that the presented version is the initial one, and its high number of items is meant to be reduced through following studies.

3.2. Realization: Formulating the items

The specification of the questionnaire main properties allowed for the formulation of its items. In particular, the structure of the instrument (Figure 3.5) identified different areas of inquiry.

3.2.1. Item formulation

The first formulation of the ACQ items focused on Q_A (attachment) and Q_C (caregiving). The writing was carried out through a thorough content analysis of both attachment dimensions and caregiving features (Table 3.11). Each construct was divided into content domains – which make up the whole construct (Trochim et al., 2015, p.130). In other words, both attachment dimensions and caregiving features were analyzed to extract their central characteristics.

In regard to attachment, the objective was to capture meaning by focusing on the f-IWM content (Table 1.3), i.e. to read what is written in the f-IWM from the subjects' answers. The formulation considered the review of the (1) SAT adult attachment and (2) post-rationalist personal meaning questionnaires. As discussed above, the SAT self-reports implement a different conceptualization of attachment knowledge than the one proposed by the APT, and the post-rationalist inventories are meant to measure higher-level personality traits. Moreover, both SAT and post-rationalist questionnaires are less discriminative than an APT-based self-report needs to be (they consider fewer dimensions). Therefore, they could help formulate some items but not be taken as a reference for the ACQ.

In this first phase, 201 items for Q_A and 123 each for Q_{CM} and Q_{CF} were formulated (Table 3.12). Q_{CM} and Q_{CF} have formally identical items (for the mother and the father respectively) but present them in a different order.

	Attacher		Caregiver	
	Definition	Characteristics	Definition	Characteristics
1	Disorganized	Scared/Impotent Specific RSs (Ca, Ra) Loss-phobia/Closeness-phobia Dissociative (Depersonalization/Derealization) (e.g. Daydreaming, Absorbed, Amnesic)	Frightening	Frightening Dissociated Abusive Demanding Intrusive Hostile
2	Avoidant	Not Receiving Love General RS: At-De-Activation: Not seeking Emotional Connection Hyper-Autonomous Emotionally Inhibited (No Affective Touch/Hug/Kiss/ No Talk about Feelings)	Insensitive (Emotionally)	Cold/Unloving/Emotionally Disconnected Unwilling Detached/Dismissing Pushing toward autonomy Emotionally Inhibited (No Affective Touch/Hug/Kiss/ No Talk about Feelings)
3	Ambivalent	Not being attended to (physically taken care of) General RS: At-Hyper-Activation: Worried About the Relationship Eager to get Attention Protester to Caregiver Angry at Caregiver In Need for Caregiver Access Fear of Abandonment	Unresponsive (Physically)	Not Physically There When Needed Unable To their own schedule Busy with Something Else
4	Phobic	Vulnerable/Constricted Specific RSs: Ex, Ca Weakness/World Dangerousness Hyper-controlling (Autonomic State, Relationships, Environment) Explorative attitude Bound/Free Separation Anxiety Sense of Constriction	Limiting (Exploration)	Holding Hyper-Protective (child's vulnerability/environmental hostility) Not Responsible Physically Controlling Threatening Protection Loss (by Claiming Critical Problem)
5	Depressive	Defeated Specific RSs: Ca, Ra Loss Reaction: Anger (RSs – Ra)-Hopelessness Loneliness Compulsive Self-Reliance Self-Blame	Unreachable (Emotionally)	Absent Dead/Away/Severely impaired Rejecting Demanding (Affectionless Control)
6	Somatic	Dependent/Intruded upon Specific RSs: Ca, Ra Indefinite Sense of Self/Bodily Sensitivity/Preference for Sharp Sensations Need for Reliable Defining Other Generalized Compliance Sensitivity to Disconfirmation/Disappointment Somatic Paradox	Defining (Internal States)	Intrusive (Psychologically) Misattuned Inhibiting Self-Expression Enmeshed Family
7	Obsessive	Wicked Specific RSs: Ra Guilty Sensitive Areas Need for Certainty Controlling Attitude Rational Attitude	Judgmental	Blaming & Rejecting Strict/Authoritarian Moral Disgusted/Contemptuous Hostile/Caring Looming (Inducing Hyper-vigilance) Dictatorial Family

Table 3.11. Content analysis.
The APT conceptualizes seven attachment dimensions – (1) disorganization, (2) avoidance, (3) ambivalence, (4) phobicity, (5) depressivity, (6) somaticity, and (7) obsessivity – and seven caregiving features – (1) frightfulness, (2) insensitivity, (3) unresponsiveness, (4) limitation, (5) unreachability, (6) definition, and (7) judgment/blame. For them, the colors blue, yellow, red, green, black (or white), purple, and brown are used respectively. Each attachment dimension and caregiving feature was analyzed to specify its characteristics. The main ones are listed. In particular, for the attacher, regulation strategies are reported. The specific ones involve the use of a non-attachment system (e.g.: Ex: Exploration; Ca: Caregiving; Ra: Ranking) to inhibit attachment. The general ones are used with respect to avoidance and ambivalence and imply de-activation and hyper-activation of attachment respectively.

	Attachment Questionnaire (Q_A)			Caregiving Questionnaire (Q_{CM}, Q_{CF})	
	Dimension	**Number of Items**		**Caregiver**	**Number of Items**
1	**Disorganization**	28		**Frightening**	16
2	**Avoidance**	31		**Insensitive**	19
3	**Ambivalence**	26		**Unresponsive**	16
4	**Phobicity**	27		**Limiting**	17
5	**Depressivity**	29		**Unreachable**	15
6	**Somaticity**	31		**Defining**	21
7	**Obsessivity**	29		**Judgmental**	19
		201			123

Table 3.12. Number of items of Q_A and Q_C after the first formulation.
For each sub-questionnaire, the number of items of each scale is provided.

3.2.2. Item revision and reduction

After the first formulation, a phase of revision and reduction followed. This was the longest (about a year) and most challenging stage of development. Each item was re-analyzed, and most were progressively refined or eliminated. Some new items were also introduced following the lead of old ones.

Face and content validity. Consistency with the construct and content domains was continuously checked. Three different versions of the ACQ were examined by (native-speaker) English teachers from the university language center. They reviewed the items for grammar mistakes, readability/clarity, and consistency with the questionnaire purpose. Adherence to the theory was continually tested by three expert clinical psychologists and psychotherapists, who gave their support during the entire course of this phase.

The intervention of expert clinicians proved to be key to the development. Through their mediation, the items could be presented and discussed in the clinical setting with their patients. This process allowed gathering precious information on the items' effectiveness and interpretation, giving directions for improvement. At the end of this stage, Q_A consisted of 125 items, while Q_{CM} and Q_{CF} of 83 items each, distributed in their seven scales (Table 3.13) (cf. Appendix B). Overall, 76 items were dropped for Q_A and 40 for each Q_C. Most of the remaining items underwent some revision.

	Attachment Questionnaire (Q_A)		Caregiving Questionnaire (Q_{CM}, Q_{CF})	
	Dimension	**Number of Items**	**Caregiver**	**Number of Items**
1	**Disorganization**	16	**Frightening**	12
2	**Avoidance**	18	**Insensitive**	13
3	**Ambivalence**	15	**Unresponsive**	11
4	**Phobicity**	19	**Limiting**	12
5	**Depressivity**	19	**Unreachable**	10
6	**Somaticity**	19	**Defining**	12
7	**Obsessivity**	19	**Judgmental**	13
		125		83

Table 3.13. Number of items of Q_A and Q_C after reduction (administered version).
For each sub-questionnaire, the number of items of each scale is provided.

This was not the only achievement of this phase. An entirely new section of the questionnaire (Q_D) was devised, as well as a subsection of Q_C (Q_{CFy}) (Figure 3.5). Q_D collects general data related to attachment phenomena, while Q_{CFy} accounts for caregiving experiences that could not be directly or conveniently attributed to a specific attachment figure. These sections proved to be indispensable to help correctly interpret the information coming from the scales.

Integration of information external to a scale. The continuous clinical feedback and item-refinement made it clear that a scale-based questionnaire that only relies on answers at the level of language could not allow grasping the wanted meaning with an adequate degree of certainty. What is meant cannot be derived from what is said (directly asked for). A few examples can further help clarify this critical point.

Example 1. An avoidant could easily answer a direct question meant to detect their avoidance as a secure does. Given a question similar to one from the ECR (Brennan et al., 1998), such as *"I am very comfortable being close to romantic partners."*, the subject could readily (and sincerely) think something like "Sure, what's the problem?"

and agree. However, going deeper into the details of this topic, their discomfort would appear clear.

Example 2. An ambivalent could easily answer a direct question meant to detect their ambivalence as a secure does. Again, given a question similar to one from the ECR (Brennan et al., 1998), such as *"I worry about being abandoned."*, the subject could readily feel too angry to agree. Such anger would appear evident in an interview.

Example 3. A non-phobic who is experiencing particular pressure in their life – which elicits their sense of constriction – could answer a direct question meant to detect their phobicity as a phobic does. In this case, the investigation of the current life condition with this respect can help the assessment of the dimension. Q_D collects this information.

Example 4. A non-obsessive who, in their life, endured the significant experience of taking care of a loved one – which elicited their sense of responsibility – could answer a direct question meant to detect their obsessivity as an obsessive does. In this case, as in the previous one, the investigation of this kind of life experiences can help assess the dimension. Q_D collects this information.

Example 5. A question about internal rules meant to assess obsessivity could easily receive a high score from a somatic just because they experience social rules as internal.

Although the single Q_A, Q_{CM}, and Q_{CF} questions were formulated aiming to maximize meaning-extraction and discriminative power, integration of information external to each scale was needed to reach such a goal. In this respect, it was clear that items from different attachment and caregiving scales could usefully be combined and contribute to a deeper understanding. But more general items – not meant to specifically investigate the attachment dimensions and caregiving features – were also essential to complete such an integration. These items came from Q_D and Q_{CFy}. Therefore, item formulation supported by clinical work showed that an intelligent pattern recognizer is indispensable to develop the questionnaire and test the theory (cf. 3.1.3.3).

3.2.3. Questionnaire development and APT testing

When developing a questionnaire, the underlying objective is always to reach the highest level possible of psychometric quality, especially in terms of:

- (Construct) Validity: The extent to which the instrument measures what it is supposed to measure – the construct (Trochim et al., 2015, p.128); and

- Reliability: The extent to which the instrument measures consistently in different measurements (assuming no variation in what has been measured) (Trochim et al., 2015, p.119).

This is usually pursued by applying rigorous statistical methods. In this regard, although there is variability according to the specific task at hand, the reference procedure for questionnaire development can be identified as follows (Parsian and Dunning, 2009; Dancey and Reidy, 2011; Trochim et al., 2015).

1. **Item formulation.** Items are formulated with reference to the construct they should represent according to the theory. The construct is divided into content domains – a set of domains that make up the whole construct (Trochim et al., 2015, p.130).
2. **Item revision and reduction.** Items are analyzed and revised. Some are refined, redundant and inadequate ones are eliminated. Different methods are possible. This phase should ensure (Trochim et al., 2015, p.130):
    a. (1) **Face validity**. (The questionnaire is face-valid for an examiner when the examiner reads its items and considers them a good translation of the construct they refer to – in terms of superficial characteristics, such as consistency with the questionnaire purpose and readability).
    b. (2) **Content validity**. (The questionnaire is content-valid for an examiner when the examiner considers that its items reflect the content domains of the construct. Therefore, knowledge of the underlying theory is required).
3. **Pilot study.** The questionnaire is administered to a sample of adults from the general population to perform the first statistical analysis and item reduction.
4. **Data analysis and item reduction.** The data collected from the pilot study is statistically analyzed through:
    a. **Factor analysis – in particular, Principal Component Analysis (PCA)[16].** This analysis tests validity. It extracts the factor/dimensions underlying the whole set of items. In other words, items that are highly correlated with the same dimension are clustered together (into a scale).
    b. **Cronbach's alpha.** This analysis tests reliability, in particular, internal consistency for each dimension. In other words, it is an index of how cohesive is the link between the items of a scale.

[16] As pointed out in a previous note, strictly speaking, principal component analysis is not a factor analysis (and a component is not a factor). However, since they are very similar, principal component analysis will be here referred to as a factor analysis (and a component as a factor), as it is often done (Denis, 2018; Field, 2018; George and Mallery, 2019).

Both factor analysis and Cronbach's alpha allow for item reduction. Items that do not adequately fit into a dimension are candidates for exclusion.

5. **Administration.** The questionnaire is administered to a (larger) sample of adults from the general population.
6. **Statistical analysis and final version.** The data collected through the administration are analyzed statistically for confirmation and possible corrections.

This workflow is focused on factor analysis, which requires a sample size adequate for the questionnaire to be developed (in terms of the number of items). In this regard, there are different indications in the literature, but, in this case (Q_A 125 items, Q_{CM} and Q_{CF} 83 items each), the most optimistic ones seem to suggest at least 500 subjects (Bandalos and Boehm-Kaufman, 2009; Rouquette and Falissard, 2011). A similar constraint applies to Cronbach's alpha.

Until this point, the ACQ was built following this line (steps 1-2). However, since a large sample administration was not the objective of this work, and the analysis carried out for the ACQ also suggested the usual procedure not to be the preferable one, a decision had to be made on how to realize the testing. It is worth noting that, in accordance with the requirements specified in the literature, the sample size obtained for the presented study (51) could not allow performing a valid PCA on Q_A and Q_C (the correlation matrix resulted 'not positive definite').

APT testing. To test the APT, Q_A, Q_{CM}, and Q_{CF} were considered constituted by their scales (cf. Appendix B). More specifically: (1) For Q_A, items theorized to belong to each of the 7 attachment scales were averaged and considered as a single variable; (2) For Q_{CM} and Q_{CF}, items theorized to belong to each of the 7 caregiving scales were also averaged and considered as a single variable. On these variables, a valid PCA was performed, extracting factors whose loading distribution was checked for compliance with the APT. In other words, testing consisted in checking whether the theory was able to interpret the distribution of loadings produced by the factorization.

Therefore, testing was made through PCA, but with a procedure different from the above indicated usual one – although it presents similarities with its 'pilot study' and 'data analysis' (steps 3-4). In the next section, the study is explained in detail.

3.3. Study: Testing the theory

Once the questionnaire was created, the following study was realized to test the APT. The study was approved by the Ethics Committee of the University of Sheffield, Faculty of Engineering, Department of Computer Science (Reference 032300).

3.3.1. Method

This section details the method of the study in terms of (1) questionnaire format, (2) participants, and (3) data analysis and testing.

3.3.1.1. Questionnaire format

The ACQ was implemented on Google Forms and administered over the internet (cf. Appendix A). Online administration is particularly suitable for self-reports both on the participant and researcher side. Subjects can complete the questionnaire at their convenience, and a large number of them can potentially be easily reached. In order to facilitate data collection and processing, all questionnaire items had a closed answer – such as a multiple-choice or drop-down list. In particular, the items in the attachment and caregiving sections (Q_A, Q_C) were rated on a 0-to-10 scale, where zero corresponds to non-adherence with the subject's view and ten to full adherence.

3.3.1.2. Participants

Participants were recruited through the university's internal mailing list dedicated to research volunteers. 51 subjects (14 males, 37 females) completed the ACQ, mostly university students (Table 3.14). Of them, 19 were no English native speakers, which did, however, not reduce the effective sample size given their overall high language skill level (M=8.42, SD=1.071, in a 0-to-10 self-rated scale).

Sex

	Frequency	Percent
Male	14	27.5
Female	37	72.5
Total	51	100.0

Age

	Frequency	Percent
18-30	34	66.7
31-72	17	33.3
Total	51	100.0

Native English

	Frequency	Percent
Yes	32	62.7
No	19	37.3
Total	51	100.0

Occupation

	Frequency	Percent
Student	34	66.7
Other	17	33.3
Total	51	100.0

Table 3.14. Participant descriptive statistics.
Most participants were female students. A relevant number of participants was a non-English native speaker but with a high skill level.

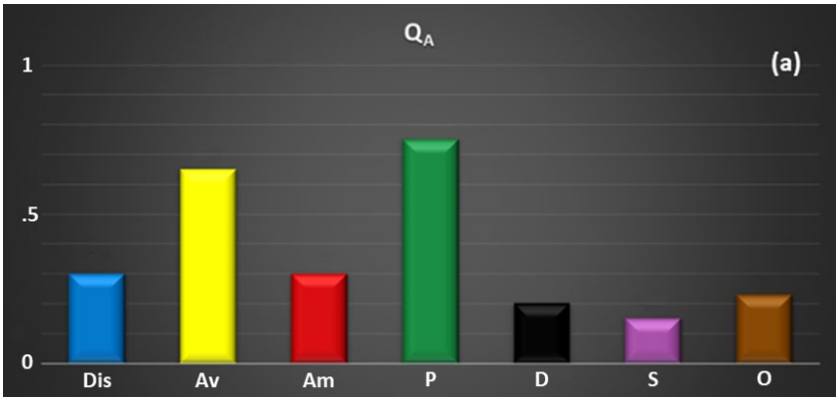
Participants were encouraged to provide comments about the questionnaire and the experience of filling it in. All of them completed the self-report with no remarks about the readability and comprehensibility of the items, except one, who asked for clarification about an item.

3.3.1.3. Data analysis and testing

After the administration phase ended, the data collected from the completed ACQs was prepared for statistical analysis to be performed on SPSS[17].

[17] Statistics software from IBM (https://www.ibm.com/products/spss-statistics).

Analysis of the scales. The items that were theoretically formulated to belong to each scale of Q_A, Q_{CM}, and Q_{CF} (cf. Appendix B) were averaged and considered as a single variable. In other words, for each scale, the scores of each item were added up and divided by the number of items (a simple arithmetical mean, where each element is given the same weight). This procedure reduced the number of variables to seven for each of the three sub-questionnaires. Some items were excluded from the averaging process for reasons related to their particular interpretation[18]. The resulting variables were named according to the scales. For Q_A: (1) disorganization, (2) avoidance, (3) ambivalence, (4) phobicity, (5) depressivity, (6) somaticity, and (7) obsessivity. For Q_{CM} and Q_{CF}: (1) frightfulness, (2) insensitivity, (3) unresponsiveness, (4) limitation, (5) unreachability, (6) definition, and (7) judgment/blame. The scales correspond to raw attachment and caregiving profiles that, when standardized, become comparable[19]. An example is reported below (Figure 3.7). The three bar-diagrams represent the case of a phobic personality and corresponding limiting caregiving. Q_A corresponds to the current attachment state, Q_{CM} and Q_{CF} to the childhood caregiving experience with the maternal and paternal figures respectively. From these two profiles (Q_{CM} and Q_{CF}) and the one corresponding to the whole family (Q_{CFy}), a weighted mean (Q_C) could also be taken to have an estimate of the overall caregiving experience. Indeed, in general, the two attachment figures have a different influence on the subject, and, to investigate this matter, the ACQ explicitly askes for an estimate of the proportion of time that the subject spent taken care of by the mother (with respect to the overall mother and father caregiving time).



[18] The excluded items were the following. For Q_A: 63, 82 (phobic scale). For Q_{CM}: 66 (limiting scale); 26, 43 (unreachable scale); 83 (defining scale); 68 (judgment/blame scale). For Q_{CF}: 64 (limiting scale); 27, 44 (unreachable scale); 82 (defining scale); 34 (judgment/blame scale).

[19] Standardization ($z = (x - \bar{x})/S$, $\bar{x}$: mean, S: standard deviation) implies making each variable (z) have the same mean and variance.

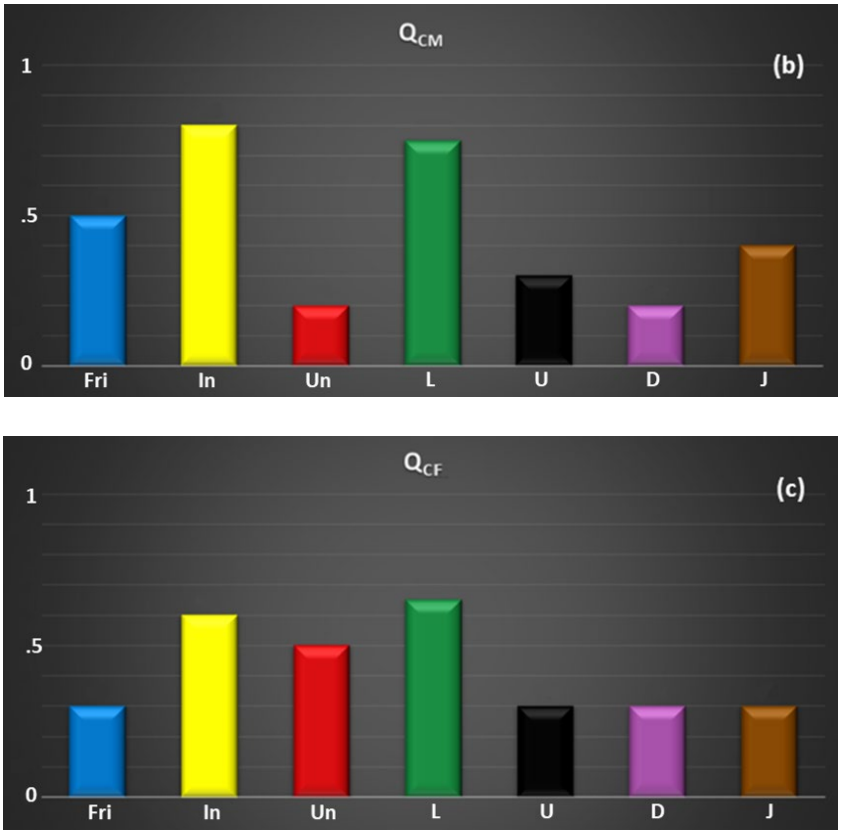


Figure 3.7. Q_A, Q_{CM}, and Q_{CF} profiles resulting by averaging the corresponding scales.
(a) The current attachment activation indicates a prevalence of phobicity (blue: disorganization; yellow: avoidance; red: ambivalence; green: phobicity; black: depressivity; purple: somaticity; brown: obsessivity). (b) The childhood experience of maternal caregiving indicates a prevalence of insensitivity and limitation, and (c) the childhood experience of paternal caregiving indicates a prevalence of limitation and insensitivity (blue: frightfulness; yellow: insensitivity; red: unresponsiveness; green: limitation; black: unreachability; purple: definition; brown: judgment/blame).

The administration produced 51 raw profile sets and, on them, a valid PCA could be performed. Indeed, the adequacy of the analysis was proved by the following tests on the distribution of values (Denis, 2018; George and Mallery, 2019):

- Kaiser–Meyer–Olkin (KMO): A test of the adequacy of the sampling for factor analysis. The test measures the diffusion in the pattern of correlations, and its result is a 0-to-1 number. The higher the outcome, the more the correlations are compact, and the more appropriate is expected to be the analysis. According to Kaiser, the results can be described as follows: 0-to-.5 *'unacceptable'*; .5-to-.6 *'miserable'*; .6-to-.7 *'mediocre'*; .7-to-.8 *'middling'*; .8-to-.9 *'meritorious'*; .9-to-1 *'marvellous'* (Kaiser, 1974, p.35). In practice, values greater than .5 should be acceptable (Field, 2018).
- Bartlett: A test of sphericity for the correlation matrix. The more this matrix is close to identity, the more the PCA is invalid. A test outcome greater than .05

indicates this case. In other words, values smaller than .05 correspond to valid PCA (correlation matrix significantly different from identity).

Once the PCA is performed, the number of factors to retain needs to be decided. To do that, two empirical rules can be followed (Denis, 2018; George and Mallery, 2019):

- Kaiser-Rule: the factors with eigenvalues greater than one are retained.
- Scree-Plot-Rule: the factors' eigenvalues are graphed in descending order, and factors with eigenvalues below a certain threshold are excluded. Such a threshold is set where the eigenvalues start to drop significantly and remain practically steady (the 'scree at the cliff foot').

The Kaiser-rule alone could lead to non-optimal retention, and considering the scree-plot in addition to it is suggested (Heppner et al., 2006; Parsian and Dunning, 2009). Finally, in general, consistency between the scales, is tested by calculating the Cronbach's alpha (Field, 2018).

APT testing. When (following the usual procedure discussed above) variables correspond to actual items, loading distribution and Cronbach's alpha can be used to optimize the factorization by discarding items (Hair et al., 2013). However, in this case, the goal of the analysis – rather than to improve the factorization – was to test the APT by checking if the theory was able to interpret the distribution of loadings produced by the factorization. Therefore, all scales were retained, and relevant loadings were interpreted according to the APT.

3.3.2. Results

The details of the factor analysis performed on the scales are now examined. The three cases of Q_A (current attachment), Q_{CM} (maternal caregiving), and Q_{CF} (paternal caregiving) are considered separately. Results depend on the factors (or components) extracted – the variables that are found to underly the data – and factor loadings – the correlation between the scales and each factor (Field, 2018). Importantly, for maternal and paternal caregiving, outcomes are influenced by the roles these figures had in each case. The subjects provided the percentage of time that their maternal and paternal figures took care of them in their childhood. The mean of these ratings was 74.78% for the mother and 25.22% for the father, meaning that the mother was by far the most influential attachment figure. The results presented in this section are discussed in the following one.

3.3.2.1. Results from the analysis of Q_A

For the Q_A scales, the PCA was considered valid according to both the KMO and Bartlett's tests (Table 3.15). In particular, the KMO was .807, which is rather satisfactory.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.807
Bartlett's Test of Sphericity	Approx. Chi-Square	193.906
	df	21
	Sig.	.000

Table 3.15. Results of KMO and Bartlett's tests for Q_A scales.
KMO sampling adequacy is rated 'meritorious' according to Kaiser, and Bartlett's test of sphericity is significant (correlation matrix significantly different from identity). PCA is deemed valid.

According to the Kaiser criterion for factor selection, two factors were extracted. The scree plot showed a much smaller decrease from the second to the third component than from the first to the second but still sufficient for the extraction of the second factor (Figure 3.8). Indeed, the extracted factors should explain at least 70% of the variance (Stevens, 2009), and the first factor explains 56.038%, the second one 16.790%, for a total of 72.828%. Finally, communalities (the proportions of common variance present in the variables) are all above .6 for this extraction (Table 3.16), which can be adequate even with small sample sizes (Field, 2018).

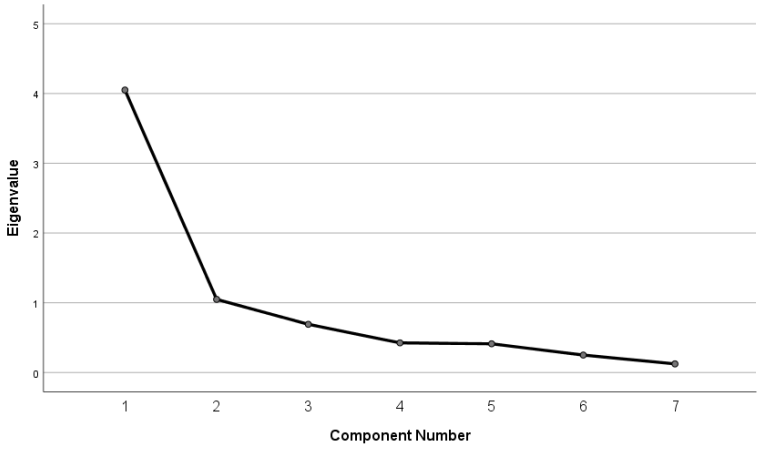


Figure 3.8. Scree plot for Q_A scales.
Two eigenvalues are above 1 and can be selected.

	Initial	Extraction
QA Scale 1 - Disorganization	1.000	.682
QA Scale 2 - Avoidance	1.000	.905
QA Scale 3 - Ambivalence	1.000	.644
QA Scale 4 - Phobicity	1.000	.625
QA Scale 5 - Depressivity	1.000	.859
QA Scale 6 - Somaticity	1.000	.669
QA Scale 7 - Obsessivity	1.000	.714

Table 3.16. Communalities for Q_A scales.
The scales have high communalities (all above .6).

The component matrix indicated high factor loadings (above .750) for the associated scales. For a sample size of 50, a factor loading needs to be .75 to be statistically significant but, practically, much less than that is sufficient (Hair et al., 2013). A value of .5 is usually enough, although it may increase to .7 for very small sample sizes (Howitt and Cramer, 2017). However, a varimax rotation was further applied, which produced factor loadings above .775 (Table 3.17). In particular, disorganization, ambivalence, phobicity, depressivity, somaticity, and obsessivity had high loadings on factor 1. Avoidance had high loading on factor 2. The small but still meaningful (>.3) (Field, 2018) secondary loading of depressivity on factor 2 will be discussed below. Finally, the reliability in terms of internal consistency was tested by calculating the Cronbach's alpha. This coefficient ranges between 0 and 1, and values above .7 are usually considered acceptable, although it depends on different factors, such as the number of variables considered (more variables tend to produce a larger alpha) (Hair et al., 2013; Field, 2018). In this case, the overall Cronbach's alpha is .866 and, for the scales that load on factor 1, it is .891.

	Component	
	1	2
QA Scale 1 - Disorganization	.776	.281
QA Scale 2 - Avoidance	.041	.950
QA Scale 3 - Ambivalence	.796	.102
QA Scale 4 - Phobicity	.788	-.062
QA Scale 5 - Depressivity	.840	391
QA Scale 6 - Somaticity	.808	-.126
QA Scale 7 - Obsessivity	.839	.103

Table 3.17. Rotated component matrix for Q_A scales.
A varimax rotation was performed to optimize factor loadings. After such a rotation, the components were more clearly defined. Factor 1 corresponds to disorganization, ambivalence, phobicity,

depressivity, somaticity, and obsessivity. Factor 2 corresponds to avoidance only. The loading of depressivity on its secondary factor (in light grey) will be discussed below.

3.3.2.2. Results from the analysis of Q_{CM}

As with the Q_A scales, for the Q_{CM} ones, the PCA was considered valid according to both the KMO and Bartlett's tests (Table 3.18). In particular, the KMO was .760, which is satisfactory.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.760
Bartlett's Test of Sphericity	Approx. Chi-Square	234.147
	df	21
	Sig.	.000

Table 3.18. Results of KMO and Bartlett's tests for Q_{CM} scales.
KMO sampling adequacy is fair according to Kaiser, and Bartlett's test of sphericity is significant (correlation matrix significantly different from identity). PCA is deemed valid.

Again, the Kaiser criterion for factor selection suggested extracting two factors. In this case, the scree plot showed a clearer difference between the second and third components, which confirms the adequacy of the two-factor extraction (Figure 3.9). Now, the variance explained by the first factor is 50.962%, and that explained by the second one is 24.217%, for a total of 75.179%. Communalities are all above .6, except for unreachability, which is, however, .595.

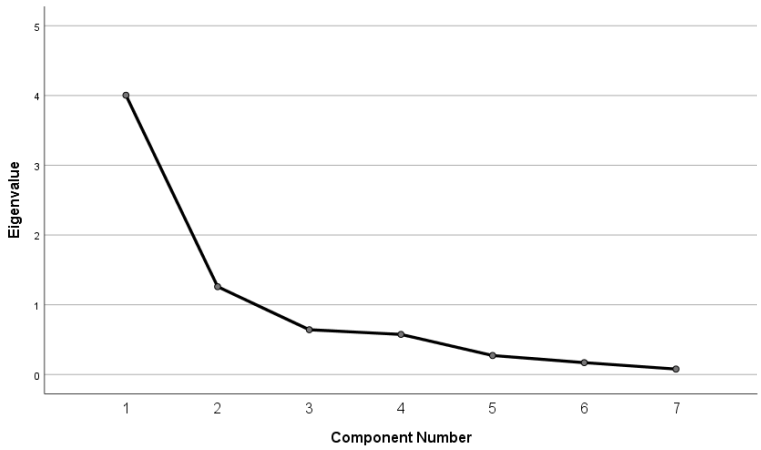


Figure 3.9. Scree plot for Q_{CM} scales.
Two eigenvalues are above 1 and can be selected.

The component matrix indicated high factor loadings (.750 or higher) for the associated scales except for one of them (unreachability, with .676), with three scales having some loading on their secondary factor. A varimax rotation confirmed a mixed configuration for four scales (Table 3.19). In particular, frightfulness, insensitivity, unresponsiveness, definition, and blame had high loadings on factor 1 (with a

minimum loading of .694 for blame). Limitation and unreachability had high loadings on factor 2 (with a minimum loading of .610 for unreachability). Frightfulness, unresponsiveness, unreachability, and blame showed smaller but meaningful secondary loadings (>.3) (Field, 2018), which will be discussed below. Finally, the reliability test in terms of internal consistency yielded a Cronbach's alpha of: (1) .866 for all scales; (2) .900 for the scales that load on factor 1; (3) .422 for the scales that load on factor 2 (the first two calculated by reversing scale 6 scores). The lower value of factor 2's alpha can be attributed to the scales' meaning, explained below.

	Component	
	1	2
QCM Scale 1 - Frightening	.872	.344
QCM Scale 2 - Insensitive	.890	-.115
QCM Scale 3 - Unresponsive	.764	.508
QCM Scale 4 - Limiting	-.131	.867
QCM Scale 5 - Unreachable	.471	.610
QCM Scale 6 - Defining	-.842	.058
QCM Scale 7 - Judgmental	.694	.421

Table 3.19. Rotated component matrix for Q_{CM} scales.
Factor 1 corresponds to frightfulness, insensitivity, unresponsiveness, definition, and blame. Factor 2 corresponds to limitation and unreachability. The loadings of frightfulness, unresponsiveness, unreachability, and blame on their secondary factor (in light grey) will be discussed below.

3.3.2.3. Results from the analysis of Q_{CF}

As with the Q_A and Q_{CM} scales, for the Q_{CF} ones, the PCA was considered valid according to both the KMO and Bartlett's tests (Table 3.20). In particular, the KMO was .683, which is still satisfactory.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.683
Bartlett's Test of Sphericity	Approx. Chi-Square	268.092
	df	21
	Sig.	.000

Table 3.20. Results of KMO and Bartlett's tests for Q_{CF} scales.
KMO sampling adequacy is sufficient according to Kaiser, and Bartlett's test of sphericity is significant (correlation matrix significantly different from identity). PCA is deemed valid.

As before, the Kaiser criterion for factor selection suggested extracting two factors but, in this case, the scree plot showed a larger difference between the second and third components, thereby strongly confirming the two-factor choice (Figure 3.10). In

this case, the variance explained by the first factor is 47.100%, and that explained by the second one is 32.213%, for a total of 79.313%. Communalities are all above .6.

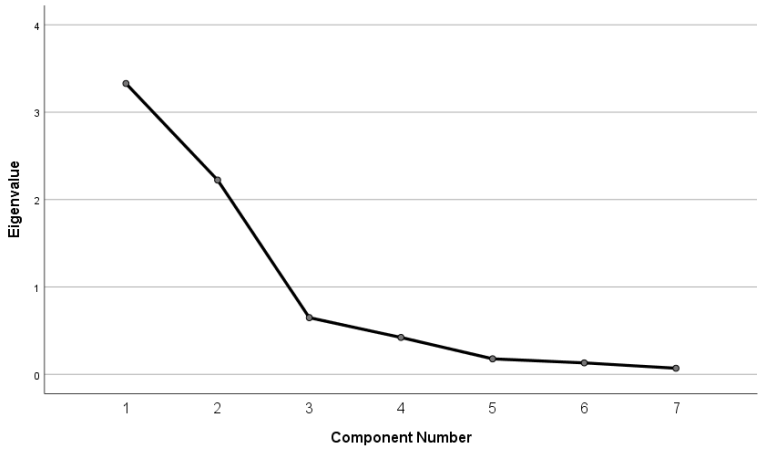


Figure 3.10. Scree plot for Q_{CF} scales.
Two eigenvalues are above 1 and can be selected.

The component matrix indicated high factor loadings (.750 or higher) for the associated scales except for limitation (.594), with this scale having almost the same loading on its secondary factor. A varimax rotation confirmed a mixed configuration for limitation (Table 3.21). In particular, frightfulness, unresponsiveness, unreachability, and blame had high loadings on factor 1 (with a minimum loading of .726 for unreachability). Insensitivity, limitation, and definition had high loadings on factor 2 (with a minimum loading of .684 for limitation). In this case, limitation and unreachability showed smaller but meaningful secondary loadings (>.3) (Field, 2018), which will be discussed below. Finally, the reliability test in terms of internal consistency yielded a Cronbach's alpha of: (1) .771 for all scales; (2) .889 for the scales that load on factor 1; (3) .805 for the scales that load on factor 2 (the first and third calculated by reversing scale 2 scores).

	Component	
	1	2
QCF Scale 1 - Frightening	.929	-.087
QCF Scale 2 - Insensitive	.290	-.902
QCF Scale 3 - Unresponsive	.908	-.122
QCF Scale 4 - Limiting	.473	.684
QCF Scale 5 - Unreachable	.726	306
QCF Scale 6 - Defining	.058	.925
QCF Scale 7 - Judgmental	.878	.043

Table 3.21. Rotated component matrix for Q_{CF} scales.

Factor 1 corresponds to frightfulness, unresponsiveness, unreachability, and blame. Factor 2 corresponds to insensitivity, limitation, and definition. However, the loading of limitation on its secondary factor is non-negligible (in light grey in the table). The loadings of limitation and unreachability on their secondary factor (in light grey) will be discussed below.

3.3.3. Discussion

The ACQ was developed to test the APT. After a conceptual analysis, the development of the self-report went from the initial item formulation to their repeated revision to the administration and, finally, the data analysis.

To compensate for the limited sample available, the items of the sub-questionnaires (Q_A, Q_{CM}, and Q_{CF}) were grouped into scales according to the theory (cf. Appendix B). As a result, Q_A consists of seven scales of attachment dimensions, and Q_{CM} and Q_{CF} each consist of seven scales of caregiving features. The scales were obtained by averaging the corresponding items and worked as new individual items. With sample size 51 and seven variables, a PCA was then feasible. A factor analysis was performed, and principal components were extracted. The theory was tested by checking its capability to interpret the factor loading distribution.

Importantly, the factorization was not meant to produce the minimum/optimal number of variables per component (the Cronbach's alpha, for example, was not used to eliminate variables and increase internal consistency as it is usually done (Field, 2018)). Given the reduced sample and the use of scales as variables, the purpose of the PCA was just to extract factors in order to test the explanation of the scales' loadings on them through the APT[20], thereby testing the theory. The results of the data analysis are now discussed for each questionnaire section.

3.3.3.1. Attachment section Q_A

The principal component analysis on Q_A produced a valid factorization – as attested by the KMO (.807) and Bartlett's (.000) tests. Two factors were extracted according to the Kaiser rule (eigenvalues greater than one). The scree plot moderately confirmed the two-factor extraction, but its adequacy was fully supported by the explained variance that reached a desirable 70% only by virtue of the second factor (factor 1 explains about 56%, factor 2 about 17%). The meaning of the variables' loadings on each factor will clear any possible remaining doubt.

APT Interpretation. Six variables/scales had (highest) loadings on factor 1, just one variable on factor two. In particular, factor 1 corresponds to (1) disorganization, (3)

[20] The APT interpretations of the loading distributions given in the following three sections rely on the descriptions of attachment dimensions and caregiving features presented in chapter 1 and their clinical implications.

ambivalence, (4) phobicity, (5) depressivity, (6) somaticity, and (7) obsessivity, while factor 2 corresponds to (2) avoidance (Table 3.17). Factor loadings are all above .75. Since all scales on factor 1 suggest some kind of threat in the relationship (when attachment is active) and the scale on factor 2 suggests emotional disconnection (when attachment is inactive), the meaning of this distribution appears clear. The two factors can be labeled as follows (Table 3.22):

(1) Threat perceived in the attachment relationship;
(2) Emotional disconnection in the attachment relationship (disconnection, for brevity).

Three remarks. First. This factorization correctly distinguishes between avoidance and ambivalence. Second. The attachment system always implies some form of threat, and, in fact, avoidance is also related to one (not to receive emotional comfort). However, the avoidant deals with this threat exactly by avoiding it – i.e. deactivating attachment and focusing on something else. As a result, avoidance appears not to be involved in the threat-factor. Third. Considering as non-negligible a loading above .3 (Field, 2018), depressivity has some involvement in the disconnection-factor. This is attributable to the self-reliance that belongs to the dimension (Bowlby, 1980). It is also worth noting that emotional connection is related to avoidance and depressivity in different ways. The avoidant does not seek connection (because they expect not to receive it), while the depressive seeks connection but feels unable to reach it.

	Dimension	Threat (factor 1)	Disconnection (factor 2)
1	Disorganization	To be harmed by who should protect	
2	Avoidance		By focusing on non-attachment activities
3	Ambivalence	Not to be physically attended to	
4	Phobicity	To be restricted / Not to be protected	
5	Depressivity	Not to be able to connect emotionally	By being self-reliant
6	Somaticity	To be intruded upon / Not to be defined	
7	Obsessivity	To break a rule and cause harm	

Table 3.22. Attachment dimensions and involved threat/disconnection according to the APT.
Q_A factorization produced two factors – threat and disconnection. The dimensions most involved (i.e. with highest loadings) on each component are highlighted by darker grey cells. Each dimension corresponds to some form of threat related to the relationship with the caregiver. For example, high disorganization corresponds to a caregiver that is themselves a possible source of harm, high somaticity corresponds to a caregiver that is excessively intrusive by imposing the definition of internal states. Avoidance appears not to be involved in threat because it implies dealing with such a threat by avoiding the relationship. If a threshold of .3 for the loadings is considered, there is also some involvement (non-negligible loading) of depressivity in its secondary component – (emotional) disconnection – (lighter grey cell), which is explained by the self-reliance related to the dimension (Bowlby, 1980).

Hence, the factorization of Q_A and its straightforward interpretation is fully compliant with the APT and provides a proof of concept for the conceptualization of the attachment dimensions (H_A).

Beyond classical statistics. It is notable that the above factor analysis suggests that the 6 dimensions that load on factor 1 should be considered as an expression of the same underlying factor and, therefore, equivalent to each other. This suggestion is further supported by the reliability of the instrument (α=.866). However, this can only hold at the highest level. The 6 scales have evident different meanings and cannot be the expression of any other common factor except the threat involved in attachment activation. To make a simple example, (1) disorganization and its dissociative manifestations, expressed by Q_A items such as *"In periods of great stress, I have felt the world around me as somehow unreal"*, (2) phobicity and its sense of constriction, expressed by items such as *"In any situation, it is important to ensure that you can move freely"*, and (3) somaticity and its need of compliance, expressed by items such as *"How others see me is important to me"* have very little in common with each other. These differences between the dimensions are clinically evident and relevant. Reducing them to the same underlying factor seems theoretically implausible and clinically inadequate. What is more, differences that go beyond the calculated factorization are also evident from the observation of the Q_A profiles that can be drawn by simply reporting the values of the scales on a bar-diagram. Below, such profiles are shown for the first four participants in the study (Figure 3.11). In these diagrams, patterns can be distinguished that carry meaningful information. It is not just a matter of the overall value of a factor but how this value is produced. Factor analysis tries to simplify by extracting underlying information, but, in this case, the most relevant information is discarded.

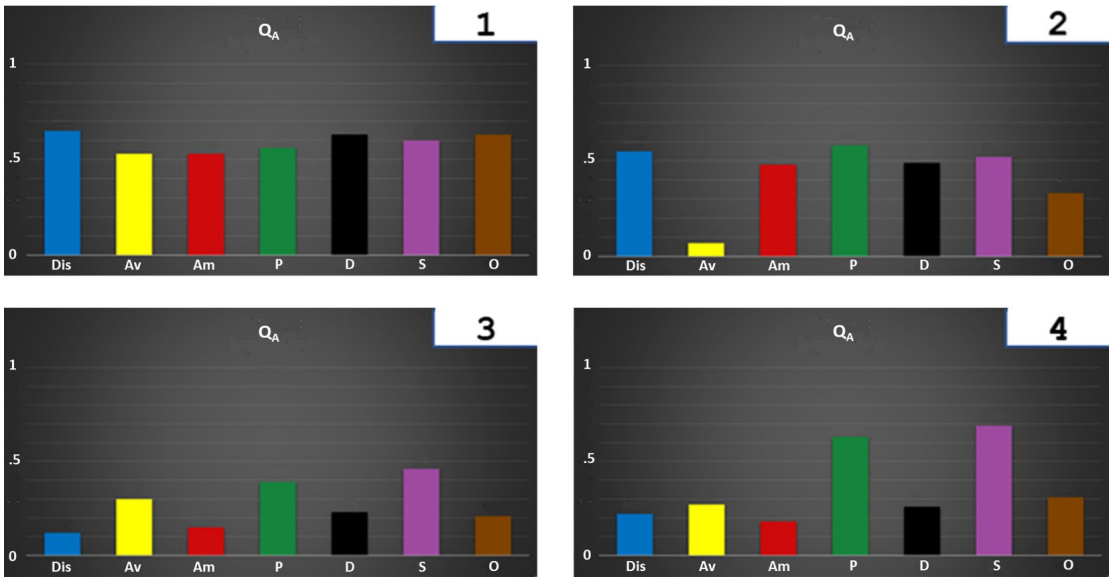


Figure 3.11. Q_A profiles for the first four subjects of the study.
The patterns generated by the different scales encode meaningful information that cannot be discarded.

This study suggests that the analysis of an attachment questionnaire should not exclusively rely on classical statistical methods such as factor analysis. A more powerful pattern recognizer is necessary. The information that a PCA can provide is certainly correct and useful but insufficient and potentially misleading. This small-scale study (7 variables, 51 participants) with its profiles provides a reduced model of a large-scale one (e.g. 125 variables, 900 participants). Administering the ACQ to a large sample can be expected to produce similar results: different dimensions undistinguished and meaningful patterns undetected. Therefore, such a large sample should be analyzed by a recognizer capable of detecting the patterns that carry attachment meaning as a clinician does.

3.3.3.2. Maternal caregiving section Q_{CM}

The PCA on Q_{CM} yielded a two-component factorization with satisfactory KMO (.760) and optimal Bartlett's test (.000). The extraction based on the Kaiser rule was clearer compared to the Q_A one and confirmed by the scree plot. The adequacy of the extraction was further supported by the explained variance (overall, a little over 75%): the first factor explains about 51%, the second one about 24%. The interpretation of the variables' loadings on the two factors is less straightforward but as meaningful as the one for Q_A.

APT Interpretation. Five variables/scales had the highest loadings on factor 1, and two on factor 2 (Table 3.19). More specifically, (1) frightfulness, (2) insensitivity, (3) unresponsiveness, (6) definition, and (7) blame loaded on factor 1, while (4) limitation and (5) unreachability loaded on factor 2. However, the situation is not as clear-cut as with Q_A. Five loadings are above .75, but blame has loading .694 and unreachability only .610. Moreover, considering a threshold of .3, four scales have non-negligible loadings on their secondary factor: frightfulness (.344), unresponsiveness (.508), blame (.421), and unreachability (.471). These four scales are somehow split between the two factors. The interpretation of the two extracted components needs to account for these mixed loadings too. In fact, they can be interpreted as follows. The scales that load on factor 1 suggest a conflict with the attachment figure, while the scales that load on factor 2 suggest suffering for the absence of the attachment figure (Table 3.23).

	Feature	Conflict (factor 1)	Suffering from absence (factor 2)
1	Frightfulness	The caregiver is harmful	The child cannot rely on the caregiver
2	Insensitivity	The caregiver is unloving	
3	Unresponsiveness	The caregiver does not attend	The child looks for the caregiver
4	Limitation		The child feels vulnerable
5	Unreachability	The caregiver is emotionally rejecting	The child feels lonely
6	Definition	The caregiver is a reference	
7	Blame	The caregiver punishes	The child does not understand

Table 3.23. Caregiving features and involved conflict/suffering from absence according to the APT. In regard to maternal caregiving, two components were extracted: conflict and suffering from the absence. The APT suggests that caregiving is provided through seven fundamental features that involve different aspects of the attachment relationship. With respect to the extracted components, only three features – limitation, insensitivity, and definition – can be considered to be circumscribed to only one component. The others have a mixed involvement.

Importantly, the emergence of these components is linked to the particular caregiver considered – the mother – and her influence, which was rated about 75% of the overall caregiving by the participants. Therefore, the explanation of the loading configuration is facilitated by considering the prototypical caregiving situation it refers to: a mother who is usually present as the only caregiver. For the other caregiver – the father – different components and a different loading configuration will emerge, which refer to a different prototypical caregiving situation. For the explanation, the two factors (with the scales that load on them) are considered in turn.

1. Conflict. The conflict with the caregiver implied by (1) frightfulness, (2) insensitivity, (3) unresponsiveness, and (7) blame is evident (Table 3.23). (6) Somaticity has a high negative loading, which requires inverse interpretation. Indeed, this dimension is all about compliance with the caregiver, and the higher it is, the less the conflict. When the caregiver is usually present – like in this case – (5) unreachability means that the caregiver rejects the child's attempts to connect emotionally, which implies some conflict. Finally, it is worth noting that (4) limitation does not involve conflict. The limiting caregiver restricts the child's exploration by sending the explicit or implicit message that the child either (1) needs to be protected (hyper-protection) or (2) suffers from some kind of serious issue (a health condition, for example), thereby inducing the child to stay close to them. In either case, the child does not perceive any conflict with the caregiver.

2. Suffering from the absence. The suffering implied in the absence of the caregiver is evident with respect to (3) unresponsiveness, (4) limitation, and (5) unreachability (Table 3.23). Concerning (1) frightfulness, the child suffers from the impossible contact with the caregiver and, in regard to (7) blame, from the distance felt from a caregiver

that imposes arbitrary and unexplained rules. Again, it is worth noting that (2) insensitivity does not involve suffering from the caregiver's absence since the child deactivates attachment, and (6) definition does not involve it because the caregiver is a present reference.

Overall, the APT can fully account for the factorization of Q_{CM}, thereby providing an initial confirmation of its conceptualization of the caregiving features (H_C) and their correspondence with the attachment dimensions (H_{CA}).

Beyond classical statistics. Finally, concerning the analysis of the caregiving features, the same considerations made for the attachment dimensions hold. Meaningful information is encoded in patterns of caregiving that a simple factorization cannot distinguish.

3.3.3.3. Paternal caregiving section Q_{CF}

Through the PCA on Q_{CF}, two factors were extracted. The KMO was satisfactory (.683), and Bartlett's test optimal (.000). The Kaiser rule and the scree plot identified the two factors very clearly and, in fact, the first one explains about 47% of the variance, and the second one 32%, for a total of 79%. The extraction proved to be adequate. Variables' loadings on the two factors can be meaningfully interpreted as in the Q_{CM} case.

APT Interpretation. Four variables/scales had the highest loadings on factor 1, and three on factor 2 (Table 3.21). More specifically, (1) frightfulness, (3) unresponsiveness, (5) unreachability, and (7) blame loaded on factor 1, while (2) insensitivity, (4) limitation, and (6) definition loaded on factor 2. The situation is similar to the one for Q_{CM} but more clear-cut. Five loadings are above .75, the other two not much less: unreachability has loading .726 and limitation .684. Considering a threshold of .3, only two scales have non-negligible loadings on their secondary factor: limitation (.473) and unreachability (.306). The split of these two scales between the two factors needs to be accounted for as well. In this case, all the loadings can be interpreted considering factor 1 as corresponding to the caregiver's roughness and factor 2 to the caregiver's function as a reference (Table 3.24).

	Feature	Roughness (factor 1)	Reference (factor 2)
1	Frightfulness	The caregiver is harmful	
2	Insensitivity		The caregiver is supposed to be loving
3	Unresponsiveness	The caregiver does not attend	
4	Limitation	The caregiver makes the world look dangerous	The caregiver is needed to feel safe
5	Unreachability	The caregiver is emotionally rejecting (often absent)	The caregiver is missed
6	Definition		The caregiver is a reference
7	Blame	The caregiver punishes	

Table 3.24. Caregiving features and involved roughness/reference according to the APT.
In regard to paternal caregiving, two components were extracted: roughness and reference. Five features can be considered to be circumscribed to only one component, and two – limitation and unreachability – as having a mixed involvement.

As with Q_{CM}, the emergence of the two components depended on the caregiver considered – the father – and his influence – rated about 25% of the overall caregiving. As in the mother case, the prototypical caregiving situation represented by this case – a father that is usually absent – can help explain the loading configuration. For the explanation, the two factors (with the scales that load on them) are considered in turn.

1. Roughness. The involvement of the (1) frightfulness, (3) unresponsiveness, (5) unreachability, and (7) blame scales on the roughness component is evident, especially considering a father that is often absent (Table 3.24). (4) Limitation can be involved by transmitting the idea of a dangerous world. A limiting father who is often away may use a rough attitude to convey this sense. Finally, with this respect, (2) insensitivity does not reasonably manifest itself much (its loading is .290), and (6) definition is not related to being rough.

2. Reference. The reference function implied in the (6) definition scale is evident (Table 3.24). Definition is all about being a reference and, in fact, its loading on this component is the highest (.925). (4) Limitation involves the reference to the caregiver as a protective figure. When the caregiver is not there, the child tends to feel vulnerable. (2) Insensitivity has a high negative loading, which needs to be interpreted inversely. The child tends to assume an often-absent father – who may have some positive interaction when there – to be very loving and keep them as an emotional reference. The reference involved in (4) unreachability concerns missing the caregiver. Finally, (1) frightfulness, (3) unresponsiveness, and (7) blame do not involve a caregiver as a reference (in the case of blame, rules are imposed).

The provided explanation shows that the APT can also fully account for the factorization of Q_{CF}, thereby providing further confirmation of its caregiving-attachment conceptualization.

Beyond classical statistics. Finally, the analysis of the paternal caregiving features requires the same approach as the analysis of the maternal ones. Meaningful information remains hidden after a factorization but can be read by a more powerful pattern recognizer.

3.3.3.4. A preliminary clinical validation of the APT

The study and its results can be summarized as follows. A PCA of the ACQ was conducted on a small sample by grouping items into scales. For Q_A, seven attachment scales were obtained, and, for Q_{CM} and Q_{CF}, seven caregiving scales. This allowed testing the APT capability to explain the analysis' results. The theory led to the following interpretations of the factorizations (Figure 3.12):

1. Q_A: the two factors extracted were interpreted as 'threat' and 'disconnection'. The loadings produce a clear-cut configuration, where six dimensions are related to threat and one to disconnection. The distribution of the seven dimensions reflects the threat-disconnection division that the theory suggests (Figure 3.12a).

2. Q_{CM}: the two factors extracted were interpreted as 'conflict' and 'suffering from the absence'. The loadings produce a mixed configuration corresponding to the prototypical context in which a mother is the primary caregiver present most of the time. This distribution of the seven caregiving features is consistent with their characteristics as described by the theory (Figure 3.12b).

3. Q_{CF}: the two factors extracted were interpreted as 'roughness' and 'reference'. The loadings produce a slightly mixed configuration corresponding to the prototypical context in which an often-absent father is the secondary caregiver. Again, this distribution of caregiving features is consistent with the theory (Figure 3.12b).

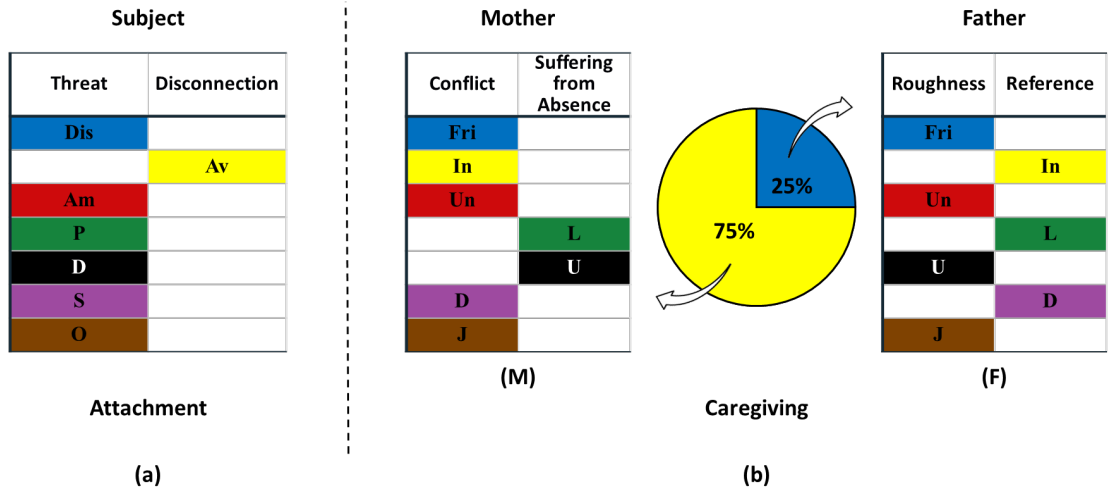


Figure 3.12. APT interpretation of data.
(a) The attachment factorization highlights two major characteristics of the relationship: being related to (1) several kinds of threat and (2) (emotional) disconnection. When the interaction is ongoing (attachment is active), some threat is involved, depending on the dimensions that underpin the interaction. On the other hand, when the interaction is cut (attachment is deactivated), disconnection is sustained. (b) The mother and father cases represent two different prototypical caregiving: (M) The mother is a primary caregiver who is often present (she takes 75% of caregiving time); (F) The father is a secondary caregiver who is often absent (he takes 25% of caregiving time). (M) In the mother case, the caregiving factorization highlights: (1) the possible conflict in the relationship but, at the same time, the compliance with the caregiver (inverse loading of definition) and (2) the suffering from the absence of a figure usually present. (F) In the father case, the caregiving factorization highlights: (1) the roughness of the relationship with an often-absent caregiver (short or inconsistent interaction, possibly harsh) and (2) the referential role played by a figure that may be more desired and positively imagined (inverse loading of insensitivity) than concretely experienced. These two factorizations very well depict two prototypical cases of caregiving.

The APT explanation of the ACQ factorization provides a first clinical validation of the theory – which, however, given the reduced sample size and the particular testing methodology, can be considered a proof of concept.

Conclusions

This chapter presented the Attachment-Caregiving Questionnaire (ACQ) – the clinical self-report that I developed to test the Attachment-Personality Theory (APT). Development and testing were carried out and here reported in this order:

(1) **Conceptualization**: Identification of the questionnaire main properties.
(2) **Realization**: Formulation of the questionnaire items.
(3) **Study**: Testing of the theory.

(1) Two kinds of attachment-related self-reports – the adult attachment and personal meaning questionnaires – were carefully reviewed and considered as a possible basis for the development of the ACQ.

Adult attachment questionnaires. The Standard Attachment Theory (SAT) conceptualization of adult attachment assessment was discussed, examining some of the most relevant adult attachment questionnaires. These instruments rely on what the subjects state (language content) to assess their attachment style. In other words, they rely on the superficial level of '**what we say**', which – it is argued – cannot lead to an adequate assessment of attachment. According to the APT, attachment knowledge is hierarchically organized, and the Internal Working Model (IWM) with its seven imprinted dimensions constitutes the deep foundation of such knowledge. This data structure is extremely resistant to change and exerts the most powerful influence on attachment phenomena. For these reasons, it can be considered the level of '**what we mean**' and should be the target of attachment assessment. The firmware level (what is meant) is mapped in so complex ways to the software level (what is said) that relying only on this superficial (conscious) level makes any measurement unreliable. In fact, the Adult Attachment Interview (AAI) aims to assess the state of mind with respect to attachment at a deeper (unconscious) level and relies on multiple sources of information – mostly language form rather than content. It is relevant (and not surprising) that measures provided by the adult self-reports and the AAI do not correlate. These instruments, as the self-reports developers say, actually assess different things. But – it is here maintained – the self-reports do not measure the f-IWM as the AAI is designed to do instead. As a result, the adult attachment questionnaires were not considered as a basis for the development of the ACQ.

Personal meaning questionnaires. The post-rationalist questionnaires that measure the Guidanian personal meaning organizations were examined. These self-reports have clinical value and work as personality inventories. However, they do not directly consider dimensions and are not discriminative enough. Therefore, they could not provide a valid basis for the development of the ACQ either.

The influence of attachment knowledge hierarchy and language on the assessment of adult attachment was discussed. This analysis suggested that the classical statistical method based on factorization – typically used in the development of a questionnaire – is actually insufficient, if not misleading, when not supported by a deeper scrutiny. According to this argument, factor analysis investigates the level of what is said in a way that cannot reach what is meant, and a more sophisticated pattern recognizer is necessary to reach such a level.

(2) The development of the ACQ was discussed in detail. Clinical work on the items led to a deeper understanding of the issues related to attachment assessment and confirmed the necessity of going beyond the level of language content. As a result, the ACQ was structured as a three-section clinical tool that collects information on: (1) The general condition of the subject (Q_D); (2) Their current attachment state as an adult (Q_A); and (3) Their caregiving experience as a child (Q_C), especially with the maternal (Q_{CM}) and paternal (Q_{CF}) figures. The data from these sections can be combined to go beyond the level of what is said and reach the one of what is meant. Indeed, the items form patterns that can be recognized – by a clinician or artificial intelligence – and reveal the content of the f-IWM.

(3) Finally, data were collected from 51 subjects, and a factor analysis could be performed by grouping items into scales. Following the theory, Q_A was analyzed by considering seven attachment scales, and Q_{CM} and Q_{CF} by considering seven caregiving scales. In all three cases, two factors were extracted. The discussion of the results proved that the factor loadings configuration could be explained by the APT and that the factor analysis provided useful but insufficient information. In other words, it was obtained both the first clinical confirmation of the APT and an indication that a more powerful pattern recognizer than a PCA is necessary to analyze data. It must be stressed that, given the preliminary nature of this work, deeper investigation is indispensable to further evaluate both these outcomes. A large-scale administration is currently under preparation.

The next chapter presents the Attachment Computational Model (ACM), designed to test the theory through an engineering approach.

Chapter 4

An Attachment Computational Model (ACM) of avoidance and ambivalence

Introduction

In this chapter, I present the **Attachment Computational Model** (ACM) – an Agent-Based Model (ABM) (Jennings, 1999; Bonabeau, 2002; Petters and Waters, 2015; Neal and Lawlor, 2016) that implements some key features of the Attachment-Personality Theory (APT) and represents, therefore, a test for it. The APT proposes to enhance the Standard Attachment Theory (SAT) (Cassidy and Shaver, 1999; 2008; 2016) through a cognitive-clinical approach that emphasizes the representational and dimensional nature of attachment. In fact, the review of previous attachment computational models (cf. Chapter 2) suggested that they might have suffered from a major issue: the reference to an inconvenient early formulation of the SAT that focuses on the behavioral and categorical[21] aspects involved in attachment (especially evident in infancy). Following the APT, as a step toward concrete modeling, an attachment module was outlined, of which the ACM represents a particular concretization. The module considers:

1. A general attachment relationship (any dyad, at any age);
2. Attachment as an intrinsic motivation and its involvement in the general motivational dynamics;
3. The implicit attachment knowledge – defined as the Internal Working Model (IWM) – as playing the role of set-goal for the attachment motivation;
4. The IWM as a firmware consisting of seven pieces of basic information – the attachment dimensions;
5. The origin of the f-IWM in specific caregiving features;

[21] Behavioral as opposed to representational and categorical as opposed to dimensional.

6. Imprinting as the mechanism of the f-IWM acquisition.

The APT embraces a vision of the mind as both an information processor and a control system (Bowlby, 1969/1982; Petters, 2019), and the attachment module is intended to be part of such a general cognitive architecture.

The ACM especially relies on the APT assumption that the f-IWM is imprinted to allow the best adaptation of the child to their caregiver by using its dimensions as set-goals to direct attachment activity. In other words, attachment works as a – representation-driven – multidimensional control system: (1) the currently perceived dimensional representation is compared to the corresponding imprinted one, and (2) the comparison is used to activate or deactivate attachment and generate an action that will make the next perception closer to the set-goal. Therefore, while previous models generally focused on the reproduction of behavioral patterns, the ACM focuses on the role of information in the generation of such patterns. Importantly, the attachment representation is multidimensional, and action is decided according to the salience of each dimension, which, in general, depends on the subject's sensitivity and the context. For example, an avoidant may not behave like an avoidant if their avoidance is not elicited. In a dangerous situation without their caregiver, their phobicity might be predominant and lead them to seek the caregiver. Similarly, an avoidant-ambivalent can behave as an avoidant or an ambivalent depending on what dimension is elicited.

In this perspective, behavior is the consequence of the current dimensional representations, which depend on the context but not necessarily in a straightforward fashion. In particular, a safe base pattern is not a matter of meters between the attacher and the caregiver but rather of how the attacher translates the context into representations. In practice, first, instead of looking for typical behavioral patterns, the underlying representations are sought. An avoidant is primarily one who knows that the caregiver is not going to connect emotionally, rather than one who explores x% of the time, let's say. An ambivalent is primarily one who knows that their caregiver is not going to attend to them, rather than one who expresses signaling or protest behaviors x% of the time. Nonetheless, testing the model requires to compare the generated behavioral patterns to those expected.

The ACM has been designed from scratch as a stand-alone model. Consequently, it has an essential structure and focuses on the most relevant aspects of attachment. In particular, here, the two fundamental dimensions of avoidance and ambivalence are modeled – as induced by the caregiver's insensitivity and unresponsiveness respectively. The attacher is assumed to be adapted to the caregiver. In other words, the attachment dimensions are considered as imprinted in previous interactions

according to the caregiving features. Consequently, for any given simulation, the dimension and corresponding feature are represented by parameters of the same value. They are considered to range between 0 and 1, and simulations are performed for increasing values (0.1 to 0.9 with step 0.1) to observe the different resulting patterns. As shown below, these patterns very well match what is expected from an avoidant or ambivalent dyad, thereby supporting the underlying theory.

4.1. Characterization of avoidance and ambivalence

According to the APT, attachment is first and foremost a dimensional, rather than a categorical, phenomenon. In particular, the four categories identified by the Strange Situation Procedure (SSP) (Ainsworth et al., 1978; Main and Solomon, 1990) and Adult Attachment Interview (AAI) (George et al., 1985; Main and Hesse, 1990; Hesse, 2016) can be described by three basic (relatively) independent dimensions: disorganization, avoidance, and ambivalence (cf. 1.4.1). These three dimensions can fully explain the range of attachment behaviors and internal states detectable through the SSP at around one year of age.

Attachment disorganization has been connected to the experience of a frightening caregiver (Main and Solomon, 1990; Lyons-Ruth and Jacobvitz, 2016). In the SSP, disorganized children typically express incoherent/contradictory behaviors that arise from the contrasting motivations of seeking care and, at the same time, defending from a threatening caregiver. Therefore, this dimension corresponds to a special and delicate condition. As with most previous models of attachment, the aim is here to model the other two dimensions.

Avoidance and ambivalence have been connected to the adequacy of the care received (Ainsworth et al., 1978; De Wolff and van Ijzendoorn, 1997). When such care is inadequate – in specific forms – attachment is either de-activated (avoidant case) or hyper-activated (ambivalent case), which is reflected in corresponding behaviors and internal states (Ainsworth et al., 1978; Parkes et al., 1993; Mikulincer et al., 2003; Mikulincer and Shaver, 2016). In particular:

(1) Avoidance. The avoidant deactivates attachment and is, consequently, unemotional ('cold') and caregiver-independent in their behavior. The child usually appears indifferent and does not seek comfort in the caregiver – they typically focus on exploration. More specifically, in the SSP, the avoidant child *"Focuses on toys or environment, and away from parent, whether present, departing, or returning. Explores toys, objects, and room throughout the procedure. Fails to cry on separation from parent. Actively avoids and ignores parent on reunion (i.e., by moving away, turning away, or leaning out of arms when picked up). Little or no proximity or contact*

seeking, distress, or expression of anger. Response to parent appears unemotional. Focuses on toys or environment throughout procedure." (Hesse, 2008, p.569). Therefore, the characteristics that can be considered to represent an avoidant are low activation of attachment (that will be referred to as low need to receive care) and high rates of exploration (low rates of attachment behaviors).

(2) Ambivalence. The ambivalent hyper-activates attachment and is, consequently, hyper-emotional and caregiver-dependent in their behavior. The child often appears worried about the caregiver's availability and seeks their presence – they typically not only focus on the caregiver but easily feel unattended to and protest. More specifically, in the SSP, the ambivalent child *"Focuses on parent throughout much or all of procedure; little or no focus on toys or environment. May be wary or distressed even prior to separation. Preoccupied with parent throughout procedure; may seem angry or passive. Fails to settle and take comfort in parent on reunion, and usually continues to focus on parent and cry. Signs of anger toward parent are mixed with efforts to make contact, or are markedly weak. Fails to return to exploration after reunion, as well as during separation and often preseparation as well (i.e., preoccupied by parent, does not explore)."* (Hesse, 2008, p.569). Therefore, the characteristics that can be considered to represent an ambivalent are high activation of attachment (that will be referred to as high need to receive care) and low rates of exploration (high rates of attachment behaviors).

The above descriptions are supported by expert ratings of a very large SSP sample (Fraley and Spieker, 2003) and also by objective measurements on video and audio recordings **(**Chow et al., 2018**;** Prince et al., 2021**)** as illustrated in Figure 4.1.

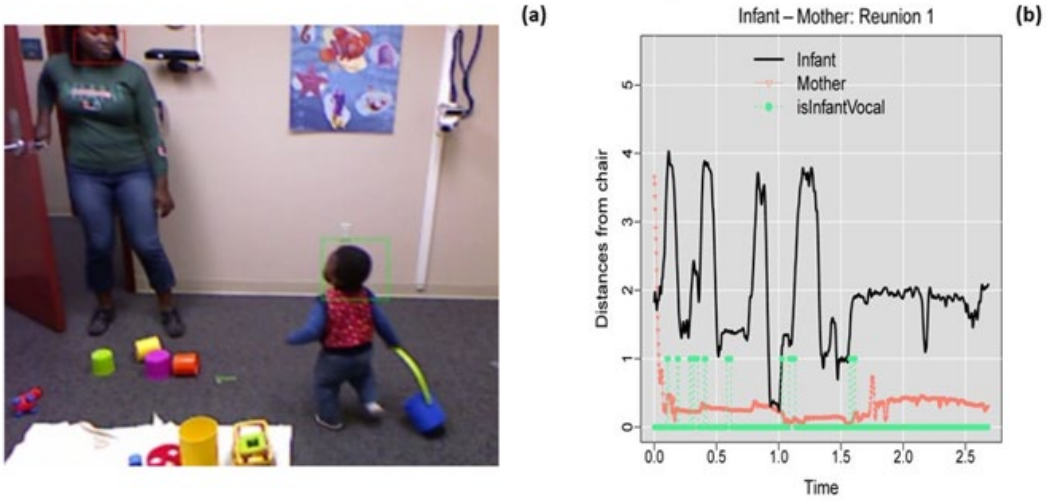


Figure 4.1. Example child and mother behavior in the SSP.

(a) An SSP room with a mother and her child (From Prince et al., 2021, fig. 1)[*]. The room is provided with a chair for the mother and toys for the infant. (b) Example data showing infant behavior patterns displayed during the SSP (from Chow et al., 2018, fig. 3)[**]. The graphs record the distances of infant (black) and mother (red) from the chair during a reunion episode. Note the oscillatory behavior of the child, repeatedly moving away from and then towards the mother. As will be shown below, oscillatory behavior is also a characteristic of our SSP-inspired model (Figures 4.9, 4.10).

According to the APT, although avoidant and ambivalent behaviors may often appear opposite, they do not correspond to opposite values of the same dimension. They correspond instead to two different dimensions – avoidance and ambivalence indeed – which cannot be induced by the same caregiving feature. The APT assumes the inducing features to be insensitivity and unresponsiveness respectively (cf. 1.4.1):

(1) Insensitivity. Avoidance is induced by an insensitive caregiver – i.e. a caregiver that does not offer the necessary emotional connection (i.e. love) to the child. Insensitivity and avoidance have an emotional nature. An insensitive caregiver does not activate their caregiving system when the child would need them to be sensitive/emotionally connected and, as a result, the child stops activating their attachment system: if the caregiver seems not to care (emotionally disconnected), it does not make any sense to ask for care.

(2) Unresponsiveness. Ambivalence is induced by an unresponsive caregiver – i.e. a caregiver that does not offer the necessary physical availability to the child. Unresponsiveness and ambivalence have a physical nature. An unresponsive caregiver does not activate their caregiving system when the child would need them to be available/physically there and, as a result, the child insists on activating their attachment system: if the caregiver seems to be often 'distracted by other matters' (physically unavailable), it makes perfect sense to remind them that their child needs care.

This hypothesis is consistent with the consideration that avoidance and ambivalence respectively evolved from the unwillingness and the inability of the parent to invest in their child (Chisholm, 1996; Chisholm and Sieff, 2014).

[*] Reprinted by permission from Elsevier: Infant Behavior and Development, *Continuous measurement of attachment behavior: A multimodal view of the strange situation procedure*, Prince et al., 2021, doi: https://doi.org/10.1016/j.infbeh.2021.101565**.**

[**] Reprinted by permission from Springer Nature: Psychometrika, *Representing Sudden Shifts in Intensive Dyadic Interaction Data Using Differential Equation Models with Regime Switching*, Chow, et al., 2018, doi: 10.1007/s11336-018-9605-1.

4.1.1. The expected patterns

An adequate attachment model needs to generate patterns that reproduce the quality of those outlined in the literature, and the above descriptions can be used as a reference. Considering exploration as the only alternative to attachment and caregiving, they suggest expecting monotonic trends for attachment, caregiving, and exploration for increasing levels of avoidance or ambivalence. In particular, for an attacher that expresses attachment by approaching the caregiver, the following trends can be considered:

a. Psychological need (i.e. attachment activation): The more the attacher is avoidant, the more they do not ask for care (low need); The more the attacher is ambivalent, the more they ask for care (high need).

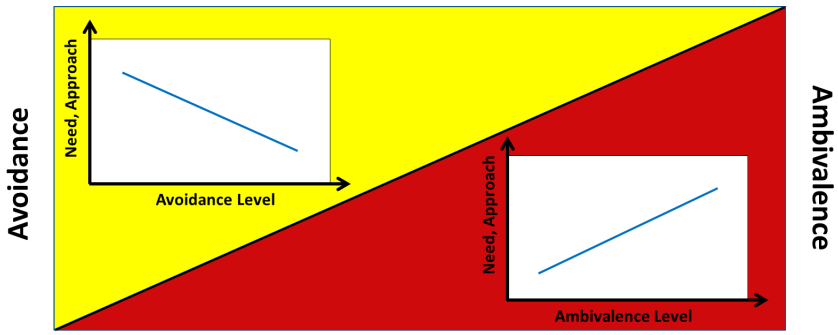
b. Behavioral dynamics: The more the attacher is avoidant, the less they approach (and the more they explore); The more the attacher is ambivalent, the more they approach (and the less they explore).

Similarly, for a caregiver who expresses caregiving by approaching the attacher:

a. Psychological need (i.e. caregiving activation): The more the caregiver is insensitive or unresponsive, the less they give care (low need).

b. Behavioral dynamics: The more the caregiver is insensitive or unresponsive, the less they approach (and the more they explore).

Considering indicative linear trends, these expectations can be graphically represented as follows (Figure 4.2).



(a) Attacher

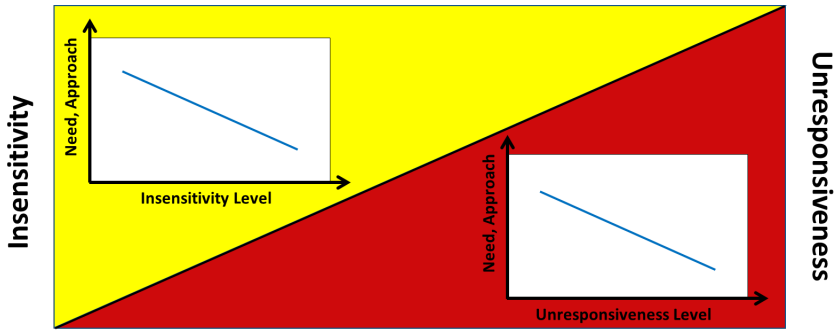


Figure 4.2. Expected trends of attacher's and caregiver's need and approach.
Following the literature, this figure represents indicative linear trends of need and approach: (a) in the attacher case, for avoidance (yellow side) and ambivalence (red side) and (b) in the caregiver case, for insensitivity (yellow side) and unresponsiveness (red side). Exploration always has the opposite trend.

4.2. A 2-dimensional agent-based model of attachment

The ACM is an agent-based model with two agents – an attacher and a caregiver. Although it can potentially represent any attachment dyad, since some parameters that describe the agents need to be particularized, the prototypical child-mother case is considered here. In the model, an environment populated by the two agents is iteratively simulated, making their attachment-relevant variables change according to rules compliant with the APT. The goal of this initial version is to test if a child and mother that behave according to the theory generate the expected avoidant and ambivalent patterns (as described above).

Each iteration step, n, marks a psychological event (such as taking care of the child) and, therefore, iterations beat a 'psychological time'. In other words, from one iteration to the other, the elapsed time can be different (for example, the time spent taking care of the child can be different in different interactions).

As previously noted, the child and mother each have two intrinsic motivations. The child is motivated by the attachment motivational system – that they direct toward the mother – and, coherently, the mother is motivated by the caregiving motivational system – that she directs toward the child. Both agents also have an exploration motivational system. Active motivations are expressed behaviorally through position changes: Attachment by approaching the mother, caregiving by approaching the child; and exploring by moving toward an object of interest (or in a random direction if no such object is detected).

The simulation environment is a 2D square 'lab', intended to resemble a typical SSP setting, that is empty except for the presence of a few objects in two opposite corners:

objects of interest for the child in the top corner and objects of interest for the mother in the bottom corner (Figure 4.3). The asymmetric relationship between child and mother is represented in terms of 'speed' – the distance that an agent can cover from an iteration to the other – and 'vision' – the distance from which an agent can detect an object interesting for them – by giving the caregiver three times the speed and vision of the child.

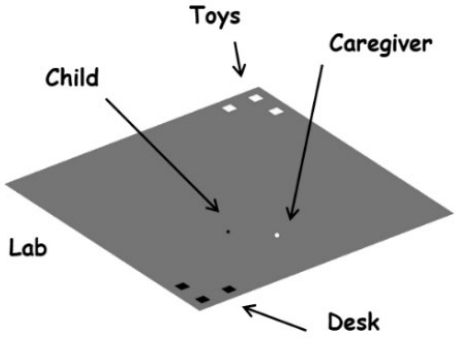


Figure 4.3. The agents and the simulation environment.
The lab (simulation environment) resembles a large square room, where a child (black dot) and a caregiver (white dot) are free to move. The lab has some objects of interest for the child (white squares at the top corner) (e.g. toys) and some objects of interest for the caregiver (black squares at the bottom corner) (e.g. a desk).

4.2.1. The rationale of the model

As discussed above, attachment has an evolutionary function, and its dimensions express the adaptation to corresponding caregiving features (cf. 1.4). In other words, the dimensionality of attachment suggests the independent acquisition of each dimensional level from the detection of a specific caregiving feature. In particular, avoidant and ambivalent levels are assumed to be independently acquired from the caregiver's insensitivity and unresponsiveness respectively.

Activation. Given their evolutionary role, each dimension will be elicited by a context recognized as having the corresponding adaptive value. For example, when the child will focus on signals related to emotional care (a loving look of the caregiver, for example), the avoidant dimension will come into play (and the child may respond with a happy smile). Therefore, although simultaneous elicitation of multiple dimensions cannot be excluded, it can reasonably be assumed that, in any given interaction session, only one dimension will be elicited. This is especially true of avoidance and ambivalence as they cannot be expressed simultaneously because they entail attachment deactivation and hyper-activation respectively (Mikulincer et al., 2003; Mikulincer and Shaver, 2016). Taking this into account, our attachment model

implements the two dimensions separately, and selects one or other dimension to be expressed in each simulation run. The underlying activation mechanism is usually not the focus of psychological investigation, which is more concerned with the characteristics of an ongoing session. Probably, this mechanism is subtle and involves elements of both the agents and the environment. In this work, a simplified version of it is proposed based on the assumption that, ceteris paribus, the higher the (stored) level of a dimension is in a child, the more they will be prone to activate it (Main et al., 1985; Maier et al., 2005; Gagliardi, 2021).

The whole module. Figure 4.4 provides a functional diagram representing the rationale of the model as a particularization of the outlined general attachment module (cf. 2.4). Avoidance and ambivalence are activated by the above-described mechanism, and the following processing realizes the tracking mechanism, multidimensional control, and action selection of the general module.

Each block of this diagram corresponds to the computational implementation detailed below. Adopting the child's perspective, as a preliminary step before the beginning of the simulation session (block 0), the dimension that determines the following interactions' type is activated (dimension activation rule below). Such interactions will be either avoidant (upper branch of the diagram) or ambivalent (lower branch of the diagram). An avoidant child will be highly sensitive to the caregiver's insensitivity and tend to activate avoidance, while an ambivalent one will be highly sensitive to the caregiver's unresponsiveness and tend to activate ambivalence. If avoidance is selected (switch toggled in upper position), the caregiving context is recognized as insensitive (block 1) by focusing on the caregiver's exploration rate (equations 4.6, 4.8). Then a non-zero avoidant drive (block 2) (equations 4.1, 4.2) is calculated and a need delivered to the avoidant action selection system (block 3) (avoidant selection rule below), which generates an avoidant action. On the other hand, if ambivalence is selected (switch toggled in lower position), the caregiving context is recognized as unresponsive (block 4) by focusing on the distance of the caregiver (equations 4.7, 4.9). Then a non-zero ambivalent drive (block 5) (equations 4.3, 4.4) is calculated and a need delivered to the ambivalent action selection system (block 6) (ambivalent selection rule below), which generates an ambivalent action. In both cases, the action produced will be either an approach to the caregiver (attachment) or an explorative move. This action will push the child toward the set-goal corresponding to the (stored) level of the activated dimension.

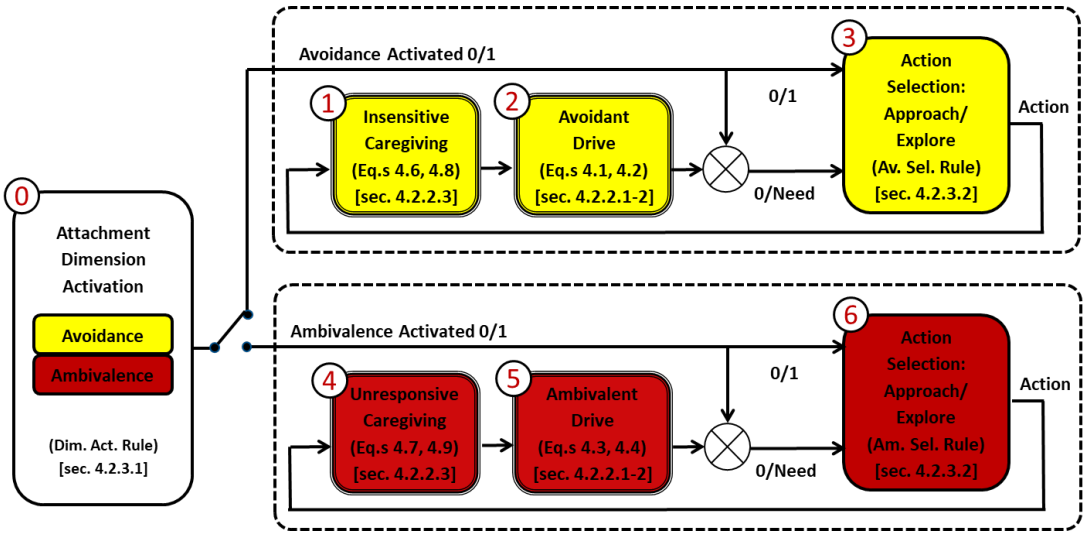


Figure 4.4. The rationale of the model.
The attacher activates a dimension, and corresponding interactions take place. The activation of avoidance or ambivalence determines the generation of avoidant or ambivalent actions, which push the attacher toward the set-goal corresponding to the (imprinted) level of the activated dimension.

To further clarify, the attachment interactions expressed by the model can be described as follows. Once a dimension is selected (block 0) and the simulation starts, at each iteration:

1. The child builds a current perception of dimensional level (i.e. a representation) from the caregiver's behavior. More specifically: In case of avoidance, the mother's exploration rate (behavioral variable) will affect the child's 'emotional separation' (psychological variable) (block 1); In case of ambivalence, the mother's distance (behavioral variable) will affect the child's 'perceived distance' (psychological variable) (block 4).

2. This current dimensional level and the other relevant variables and parameters induce some need for care in the child: Need for emotional care in case of avoidance (block 2); Need for physical care in case of ambivalence (block 5).

3. Finally, the child compares their current perception of dimensional level to their target one and takes an action – depending on the need level – that tends to make the next perception closer to the target. In other words: In case of avoidance, the emotional separation felt by the child will tend to their avoidant target (block 3); In case of ambivalence, the distance perceived by the child will tend to their ambivalent target (block 6). Attachment works as a control system with dimensional (i.e. representational) set-goals.

The caregiver behaves similarly, expressing psychological variables that are consistent with their own behavioral ones.

Model description. The overall system (Figure 4.4) can conveniently be thought of as consisting of a core (blocks 1, 2, 4, 5) and an interface (blocks 0, 3, 6), through which it interacts with the environment. Below, these parts are described in turn. As done above, the attachment system – which is the focus of this work – is primarily referred to (similar considerations hold for the caregiving system).

4.2.2. The attachment system's core

First, the core elements of the attachment model are described. Note that the terms 'need' and 'drive' will be used to refer to key variables without implying that they correspond to classical notions of need and drive in the literature on human motivation (see e.g. (Cofer and Appley, 1964)).

4.2.2.1. Drives

The core of the model is expressed in blocks 1-2 and 4-5 of Figure 4.4, which specify the activations of the different components of the attachment and caregiving systems. Specifically, two pairs of coupled equations are proposed for the activation of attacher avoidance, drive a_{av}, and caregiver insensitivity, drive c_{av} (block 2):

$$a_{av}[n+1] = (1 - A_v)K_{av}[n]/2 + C_{f,av}(1 - N_{G,av}(c_{av}[n], A_v))S_{Ea}[n] + c_{0a,av} \quad (4.1)$$

$$c_{av}[n+1] = (1 - I_n)K_{av}[n]/2 + C_{f,av}(1 - N_{R,av}(a_{av}[n], I_n))S_{Ec}[n] + c_{0c,av} \quad (4.2)$$

And two pairs of coupled equations are proposed for the activation of attacher ambivalence, drive a_{am}, and caregiver unresponsiveness, drive c_{am} (block 5):

$$a_{am}[n+1] = A_m K_{am}[n]/2 + C_{f,am} N_{G,am}(c_{am}[n], A_m) D_{Pa}[n] + c_{0a,am} \quad (4.3)$$

$$c_{am}[n+1] = (1 - U_n)K_{am}[n]/2 + C_{f,am}(1 - N_{R,am}(a_{am}[n], 1 - U_n))D_{Pc}[n] + c_{0c,am} \quad (4.4)$$

In these equations: (1) K is a measure of the elapsed psychological time since the child last received care; (2) N is the need signalled by the other agent that they require care (N_R), or wish to express caregiving (N_G); (3) S_E is a measure of the 'emotional separation' experienced by both agents; (4) D_P is the 'perceived distance' between the agents. Each of these elements are explained in more detail in the following subsections. (5) A_v is the level of the attacher's avoidance, and I_n is the level of the caregiver's insensitivity, while (6) A_m is the level of the attacher's ambivalence, and U_n is the level of the caregiver's unresponsiveness. These last four are control parameters set at the start and maintained fixed throughout the simulation run. A_v and A_m represent the dimensional levels imprinted in the attacher's brain. (7) $C_{f,av}$ and $C_{f,am}$ are coupling factors, which determine the weight of each agent's need on the other. (8) $c_{0a,av}$, $c_{0c,av}$, $c_{0a,am}$ and $c_{0c,am}$ are constants used for the initial setting of the system.

To assist the understanding of equations 4.1, 4.3, the following considerations from the child's perspective can be made (similar considerations hold for the caregiver, equations 4.2, 4.4). As time passes by (K increases), the child's need to receive care (N_R) will grow according to their drive (a) – which represents the psychological variables and parameters at play – and their level of avoidance or ambivalence (A_v or A_m) (N_R is parametrized by the dimensional level). K is the most influential factor – considering the passing of time by itself as a powerful elicitor of the need for care. The term is modulated by the dimensional level with an opposite effect in the avoidant and ambivalent cases: care requests are discouraged by avoidance and encouraged by ambivalence. The need felt by the caregiver (N_G) works as a signal for the child and influences their need. If more need to provide care is perceived, the avoidant child will tend to ignore their need, the ambivalent child to accentuate it. The drive is also influenced by the current dimensional representation (S_E or D_P). If the child perceives more emotional separation (higher S_E) or distance (higher D_P) from the caregiver, they will tend to feel more in need for care. S_E is a measure of emotional connection, and D_P is a measure of physical availability (in relation to the caregiver). Finally, the constant term (c_0) can be thought of as a structural setting, which affects the whole psychological functioning of the child. Therefore, other things being equal:

- The avoidant child (eq. 4.1) will feel a greater drive to receive care when: (i) its avoidance level, A_v, is smaller; (ii) the time with no emotional care, K, is longer; (iii) the need to provide care signaled by the caregiver, N_G, is smaller; and (iv) the perceived emotional separation, S_E, is greater. (A similar consideration holds for the insensitive caregiver in eq. 4.2.)

- The ambivalent child (eq. 4.3) will feel a greater drive to receive care when: (i) its ambivalence level, A_m, is greater; (ii) the time with no physical care, K, is longer; (iii) the need to provide care signaled by the caregiver, N_G, is greater; and (iv) the perceived distance, D_P, is greater (i.e. less availability). (A similar consideration holds for the unresponsive caregiver in eq. 4.4.)

4.2.2.2. Needs and elapsed time since care

Equations 4.1-4.4 refer to the activation of the child's attachment system as the child's need to receive care, N_R, and to the activation of the mother's caregiving system as her need to provide care, N_G. These are both defined according to the need function:

$$N(x,h) = \frac{x}{(x+h^x)} \qquad (4.5)$$

where x is the relevant drive (a or c) and h accounts for the dimension level, which equals the corresponding feature level (I_n or U_n) (Figure 4.5). This has the form of a

Hill function (Somvanshi and Venkatesh, 2013), commonly used to model saturation in biological systems. Note that it is assumed that each agent can perceive the other's drive level, and two pairs of equations, 4.1-4.2 and 4.3-4.4, are coupled in this way (see discussion below). The need equation, $N(x, h)$, is parametrized by the parameter h such that the steepness of the curve reduces with increasing h (Figure 4.5a). This reflects, for example, the fact that the more a child is avoidant (larger h), the less they feel a change in the need to be taken care of (for a given change of the situation). A phenomenon that is well represented by the avoidant child reaction to a separation in the SSP.

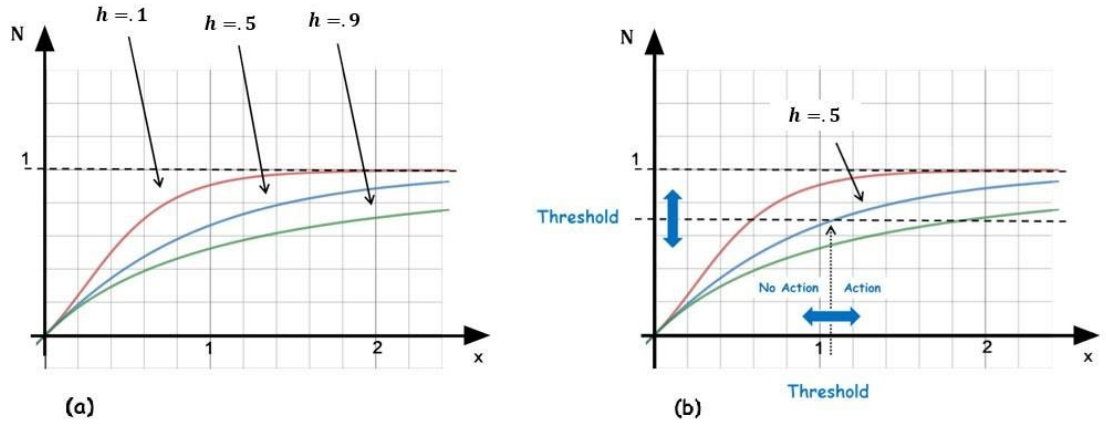


Figure 4.5. Calculation of the need function, N.
(a) Three different levels of parameter h are shown (0.1, 0.5, 0.9) to illustrate that an increasing h reduces the steepness of the curve in N according to value of drive x as per equation 4.5. (b) A threshold is set so that, when N is greater than the threshold, the agent can perform an attachment or caregiving behavior. Here, the case of $h = .5$ and corresponding threshold is shown.

K is the time passed with no provision of care, which relates to emotional care in the case of avoidance (K_{av}) and to physical care in the case of ambivalence (K_{am}). At each interaction n, this is equal to the number of iterations since care was last provided, considering care as provided when N_G exceeds its threshold. When K becomes zero, the need function N decays. The coefficient $1/2$ of K was set empirically and could be changed to account for context variations.

The modeled interaction between child and caregiver corresponds to the oscillation of the drives, a and c, and the needs, N_R and N_G, around a baseline as illustrated in Figure 4.6 for an example simulation run.

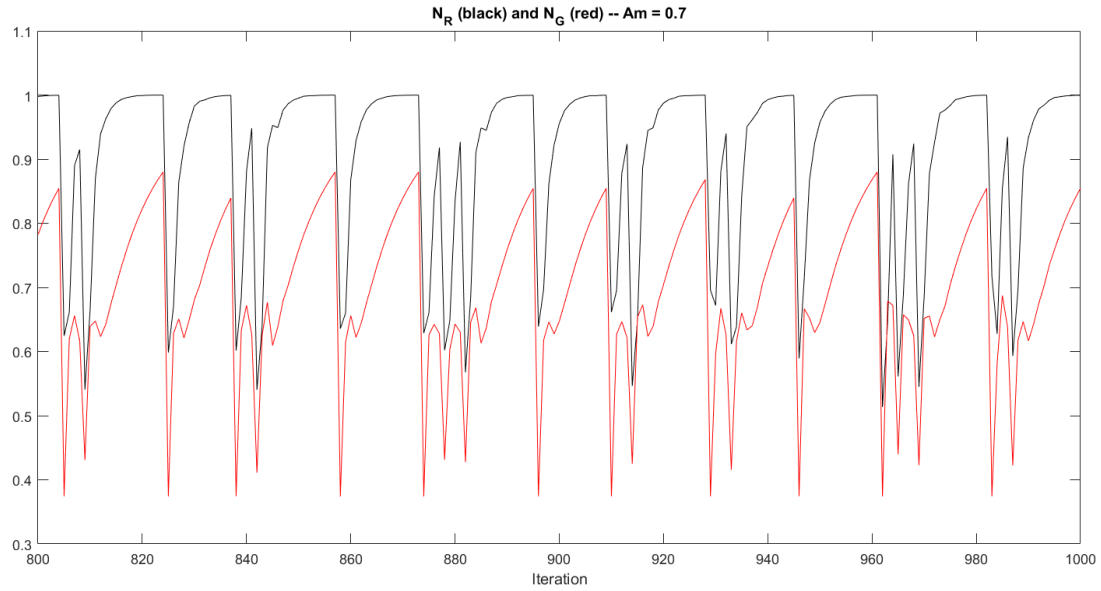


Figure 4.6. Oscillation of N_R and N_G.
For each dimension, N_R and N_G oscillate around a baseline. The graph represents the oscillation of N_R (in black) and N_G (in red) for ambivalence 0.7 over 200 iterations.

4.2.2.3. Perceptions of emotional and physical distance

At each iteration, the agents experience an 'emotional separation', S_E, and 'perceived distance', D_P, connected to contextual cues. More specifically: (1) In the avoidant case, the attacher experiences S_{Ea} and the caregiver S_{Ec}; (2) In the ambivalent case, the attacher experiences D_{Pa} and the caregiver D_{Pc}. The use of different variables is due to the different nature of the two dimensions and their link to different contextual cues, as discussed next.

Following the APT, the terms 'emotional separation' and 'perceived distance' reflect the assumption that avoidance is an emotional dimension and ambivalence is a physical dimension. S_E refers to the emotional connection and D_P to the physical availability perceived by the child in the relationship. These 'psychological variables' are connected to 'behavioral variables' measurable in the lab. In particular, for each dimension, a variable related to the caregiver's behavior provides a cue to the child to derive a dimensional level representing the current situation. The child will compare this level with the target one stored in their mind to drive their action. In this perspective, attachment works as a multidimensional control system.

To derive S_E and D_P, the following behavioral variables have been used:

- 'indifference' (i): defined as the percentage of iterations in which the caregiver explores, where N_{ex} is the number of such explorations:

$$i[n] = \frac{100\ N_{ex}[n]}{n} \quad (4.6)^{22}$$

- 'distancing' (d): defined as the distance between child and caregiver, where (x_a, y_a) and (x_c, y_c) are the positions in the lab of the attacher and the caregiver respectively:

$$d[n] = \sqrt{(x_a[n] - x_c[n])^2 + (y_a[n] - y_c[n])^2} \quad (4.7)$$

From them, each agent obtains S_E and D_P through an update rule of the form:

$$\begin{aligned} &Current\ Perception \\ &\quad = Previous\ Perception \\ &\quad + Step(Observed\ Deviation - Previous\ Deviation), \end{aligned}$$

with a noisy step size representing the natural uncertainty of the agent's perception. The particular expressions used are:

$$S_E[n] = S_E[n-1] + 2r[(i[n] - T_i) - (S_E[n-1] - T_E)] \quad (4.8)$$

$$D_P[n] = D_P[n-1] + 2r[(d[n] - T_d) - (D_P[n-1] - T_P)], \quad (4.9)$$

which update the previous values (first term) depending on the current indifference or distancing (second term), thereby going from observable variables (i, d) to mental ones (S_E, D_P) – as suggested by the APT. In these equations, $r \in [0,1]$ is a uniformly distributed random number, T_E, T_i, T_P, and T_d are the target values of S_E, i, D_P and d, respectively (as discussed below). The effectiveness of this formula can be clarified considering the following. The update needs to depend on the targets: for a new dimensional level to be adequate, it has to be consistent with the corresponding target. By referring the current behavioral gap from target ($i[n] - T_i$ or $d[n] - T_d$) to the previous psychological gap from target ($S_E[n-1] - T_E$ or $D_P[n-1] - T_P$), this expression ensures an adequate update. For example, considering the distance (eq. 4.9), if the new d is further from its target than the old D_P from its, then it makes sense that the new D_P increases. If d is closer, it makes sense that D_P decreases. The behavioral variable provides a consistent update of the psychological one.

4.2.3. The attachment system's interface

To describe how the system interacts with the environment requires the specification of blocks 0, 3, and 6, in Figure 4.4, which correspond to the dimension activation and

[22] Since the avoidant child and the insensitive caregiver are expected to show similar exploration rates, this equation has been used as a simplified form of $i[n] = \frac{100\ (N_{ex,c}[n] + N_{ex,a}[n])}{2n}$, which explicitly shows the influence of both agents on i. The two equations provide qualitatively identical results.

action selection rules. These are essential to close the loop with the environment via perception and behavior. Each of them is now examined.

4.2.3.1. Dimension activation rule

For any given simulation session, interactions can be either avoidant or ambivalent. The model implements a winner-take-all activation rule based on the evaluation of the softmax function (Bishop, 2006) of each dimensional level and selection of its maximum:

$$d_i,\ i = 1,2 \quad \textit{selected when} \quad s(d_i) = Max(s(d_1), s(d_2)), \quad \textit{where:}$$

$$d_1 = A_v \ \textit{(avoidance)}, d_2 = A_m \ \textit{(ambivalence)},$$

$$s(d_i) = \frac{e^{\beta(d_i + r_i)}}{\sum_{j=1,2} e^{\beta(d_j + r_j)}} \ \textit{(softmax function)},$$

$$r_1, r_2, \textit{ normally distributed random numbers.}$$

The random numbers r_i account for contextual noise, and the parameter β can be used to act on the influence of the dimensional levels' gap. A larger β tends to invert the effect of such a gap.

4.2.3.2. Action selection and behavior expression

For each agent, the system compares the current dimensional level to the target (stored) one and takes an action that tends to decrease the difference between the two. A decision is made depending on the need felt by the agents, which is determined by applying a threshold to the need function, N. Specifically, when N_R exceeds its threshold (T_R), the attacher needs care, and when N_G exceeds its threshold (T_G), the caregiver needs to provide care (Figure 4.5b). The thresholds are given by the following expression:

$$T = T_{bl} \pm \tau(1 + r) \qquad (4.10)$$

where: T_{bl} is a baseline value, τ is a constant, and $r \in [0,1]$ is a uniformly distributed random number (to account for possible fluctuations, given that T is a subjective/psychological variable). T is reduced (minus sign in the formula) when N decreases. This is intended to model the prudential tendency to readily reactivate attachment or caregiving when they are deactivated, as expected given their role for contingent survival. The constants were set empirically (see Simulations section).

According to the APT, the avoidant and ambivalent dyads differ for the goals they set for themselves.

- In the avoidant case, the agents have the same goals in terms of emotional separation (T_E). The more an agent is avoidant/insensitive (0.1 to 0.9), the larger the emotional separation they want to keep. In this model: $T_E = 100A_v = 100I_n$ (10 to 90) (Figure 4.7a).

- In the ambivalent case, the agents have opposite goals in terms of perceived distance (T_P). The more the attacher is ambivalent (0.1 to 0.9), the smaller the perceived distance they want to keep. The more the caregiver is unresponsive (0.1 to 0.9), the larger the perceived distance they want to keep. In this model: $T_P = 100(1 - A_m)$ (90 to 10) for the attacher and $T_P = 100U_n$ for the caregiver (10 to 90) (Figure 4.7b).

The target emotional separation (T_E) and perceived distance (T_P) respectively represent the psychological values of emotional separation (S_E) and perceived distance (D_P) that maximize the subject's comfort. For the child and the caregiver, such targets vary according to the level of avoidance or ambivalence.

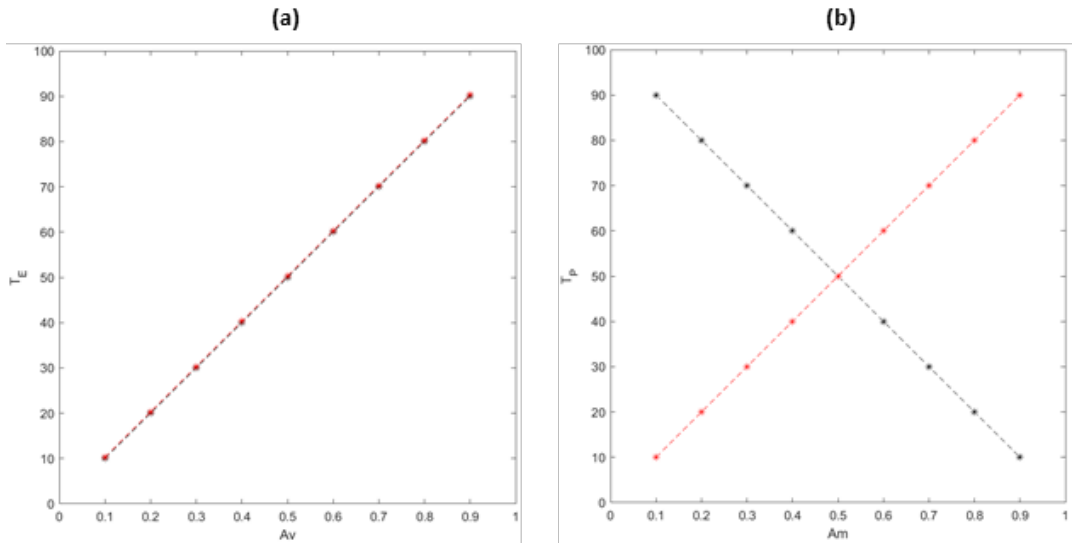


Figure 4.7. S_E and D_P targets.
(a) Emotional separation and (b) perceived distance targets (black for the attacher, red for the caregiver).

In general, the targets in the mind of the agents (T_E, T_P) will correspond to targets observable in the context of interaction (T_i, T_d). In the case of this elementary squared environment, the following simple linear relationships were used: $T_i = 1.1T_E$ (for the avoidant attacher and insensitive caregiver), $T_d = 0.24T_P$ (for the ambivalent and unresponsive caregiver) (distances between 2.4 and 21.6).

The action selection mechanism is implemented for the movement in the lab based on the agents' needs and targets. The child needs to decide whether to approach – a

manifestation of the need to receive care, i.e. attachment – or explore. The caregiver needs to decide whether to approach – a manifestation of the need to provide care to the child, i.e. caregiving – or explore. For each agent, approaching is a movement toward the other agent, while exploring is a movement toward an object of interest or random (when no object is found). Each move is a change in position that cannot exceed the agent's speed.

Given the need N and its threshold T, the implemented decision rule is (Figure 4.8):

- if $N < T$ (the agent feels no need), if $S_E < k_E T_E$ (in the avoidant case) / $D_P < k_P T_P$ (in the ambivalent case), then explore;
- if $N > T$ (the agent feels a need), if $S_E > k_E T_E$ (in the avoidant case) / $D_P > k_P T_P$ (in the ambivalent case), then approach.

Need is need to receive care in the case of the child and need to provide care in the case of the caregiver; S_E (the current emotional separation) is compared in the avoidant case, D_P (the current perceived distance) is compared in the ambivalent case; T_E and T_P are respectively the target emotional separation and perceived distance for the agent; k_E and k_P are constants (see Simulations section).

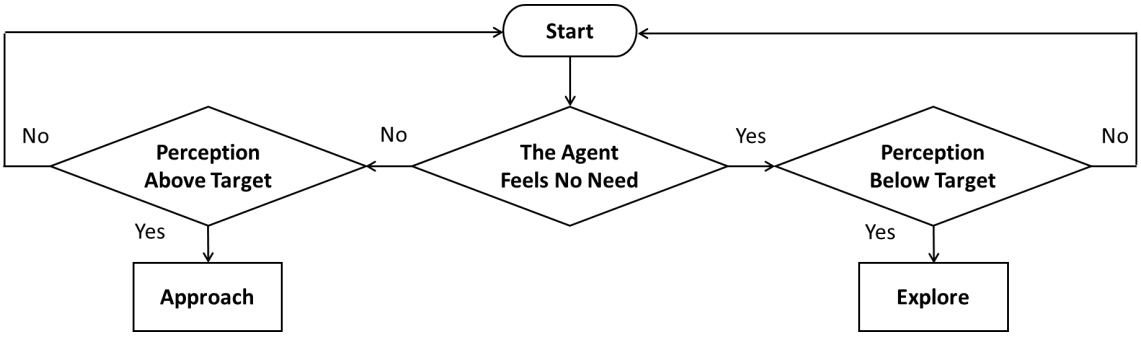


Figure 4.8. Action selection rule.

The system acts as a multi-dimensional controller. It compares current dimensional levels to target ones and takes actions that tend to decrease the difference between the two.

Approach and exploration. An agent's travel toward a target, i.e. the other agent (approach) or an object of interest (exploration), can be described as follows:

$$x[n+1] = x[n] + \Delta x[n]$$

$$y[n+1] = y[n] + \Delta y[n]$$

When the target's position (x_t, y_t) is beyond the agent's speed limit, the update is calculated according to such a limit and the angle identified by the target:

$$\Delta x[n] = speed \cdot \cos(angle)$$

$$\Delta y[n] = speed \cdot sin(angle)$$

where: $angle = \cos^{-1}(\sqrt{(x - x_t)^2}/d_t) = \sin^{-1}(\sqrt{(y - y_t)^2}/d_t)$, d_t distance to the target. When the target is below the speed limit, the agent moves to a random position whose coordinates differ no more than 0.5 from those of the target. If the agent wants to explore and objects of interest are in sight, exploration is made toward the nearest one. After an object has been explored, it loses its attraction for a certain number of iterations. If no interesting object is found, exploration is a move in a random direction.

4.3. Simulations[23]

For all simulations, the lab size S was set to 30 (lab coordinates 1 to S, actual size $S - 1$). Moreover, the following was chosen: (1) For the child: speed $L/9$ and vision $L/3$; (2) For the mother: speed $L/3$ and vision $L/1$; given $L = \sqrt{2}S$. Each agent has 3 objects of interest, which lose their status for 7 iterations after being explored.

The simulations of avoidant and ambivalent interactions were performed separately, considering 9 values for each dimension – $A_v = 0.1, 0.2, \ldots, 0.9$, $A_m = 0.1, 0.2, \ldots, 0.9$. A higher value corresponds to a stronger acquisition of the dimension. Constant values for the system were set as follows:

- In equations 4.1-4.2: $C_{f,av} = 4$, $c_{0a,av} = 0.49$, $c_{0c,av} = 0.5$;
- In equations 4.3-4.4: $C_{f,am} = 2$, $c_{0a,am} = 0.2$, $c_{0c,am} = 0.5$;
- In equation 4.10: $T_{bl} = 0.75$, $\tau = 0.08$;
- In the action selection rule: $k_E = 1.01$, $k_P = 1.1$.

A sensitivity analysis (cf. Appendix C) demonstrates that coupling the equations this way improves the system's performance (i.e. $C_{f,av} = 4$ vs. $C_{f,av} = 0$ and $C_{f,am} = 2$ vs. $C_{f,am} = 0$). Initial conditions were set equal in all simulations ($K = 0$, $N = 0.75$, $S_E = 50$, $D_p = 50$, $i = 55$, $d = 12$). In particular, the agents start from the same given positions in the central part of the lab (child $(9,15)$, mother $(21,15)$).

In each simulation, the agents are considered adapted to each other. In other words, the acquisition of the attachment dimensions in the child's mind is assumed to have already been induced by the caregiver ($A_v = I_n$, $A_m = U_n$). The interactions that follow the dimensional acquisition are simulated, and the corresponding attachment

[23] The model was implemented in MATLAB (the code is available on https://github.com/marc-gglrd/AC_Lab). In this version (AC_Lab 1.0), a dimension is activated when the program is launched (i.e. no activation rule is coded). The settings reported here correspond to those in the code.

patterns are assessed. Such patterns are expected to reproduce the quality of those outlined in attachment literature (as described above) (Ainsworth et al., 1978; Hesse, 2008), in terms of both internal states (need in this model) and behaviors (approach and exploration). In particular, while the avoidant child is relationship-independent (low in approach and high in exploration), the ambivalent child is relationship-dependent (high in approach and low in exploration). Although these characteristics may seem to belong to the same dimension, it will be shown how they are consistent with a two-dimensional phenomenon, as the APT suggests.

4.3.1. Results

Simulations' results are presented in terms of states and behaviors of the agents for different levels of attachment dimension. The case of avoidance (A_v) and ambivalence (A_m) are considered in turn. The attachment dimensions are the only referred to since the corresponding caregiving feature (insensitivity (I_n) or unresponsiveness (U_n) respectively) has the same value.

4.3.1.1. Behavioral patterns

First, are reported here relevant behavioral details concerning the simulations for representative levels of avoidance and ambivalence: (a) extremely low ($A_v = 0.1$, $A_m = 0.1$), (b) mid ($A_v = 0.5, A_m = 0.4$), and (c) extremely high ($A_v = 0.9, A_m = 0.9$) (Figures 4.9, 4.10). The focus is on the trajectories followed by the agents in the lab, the child's trajectory relative to the caregiver ($(x_a - x_c, y_a - y_c)$), and the distance between the agents[24].

Avoidance (and insensitivity).

- $A_v = 0.1$ (Figure 4.9a). The agents are 'anti-avoidant' and manifest high activation of attachment and caregiving (need). As a result, they stick to each other (high approach, low exploration). Interestingly, they tend to gravitate around the objects of interest for the caregiver, who leads the interactions (4.9a-left). This pattern is emphasized by a very concentrated relative trajectory (4.9b-center) and low distances (4.9a-right).

- $A_v = 0.5$ (Figure 4.9b). The agents appear secure, having an activation of attachment and caregiving (need) that results in a functional balance between approach and exploration. The child approaches moderately and tends to move around their objects of interest (exploration), while occasionally taken care of by the caregiver (4.9b-left). The appreciable proportion of exploration

[24] References made here to need, approach, and exploration levels can be checked in the following section concerning their trends.

results in a relative trajectory toward the top-right corner (4.9b-center) and fairly high distances (4.9b-right).

- $A_v = 0.9$ (Figure 4.9c). The agents appear (extremely) avoidant and manifest a very low activation of attachment and caregiving (need). As a result, they stick around their objects of interest or move randomly (exploration), and their trajectories are highly independent, as a sign of rare approach (4.9c-left). The autonomous exploration results in a spread relative trajectory (4.9c-center) and, again, relatively high distances (4.9c-right), which are, however, limited by the size of the lab and random moves.

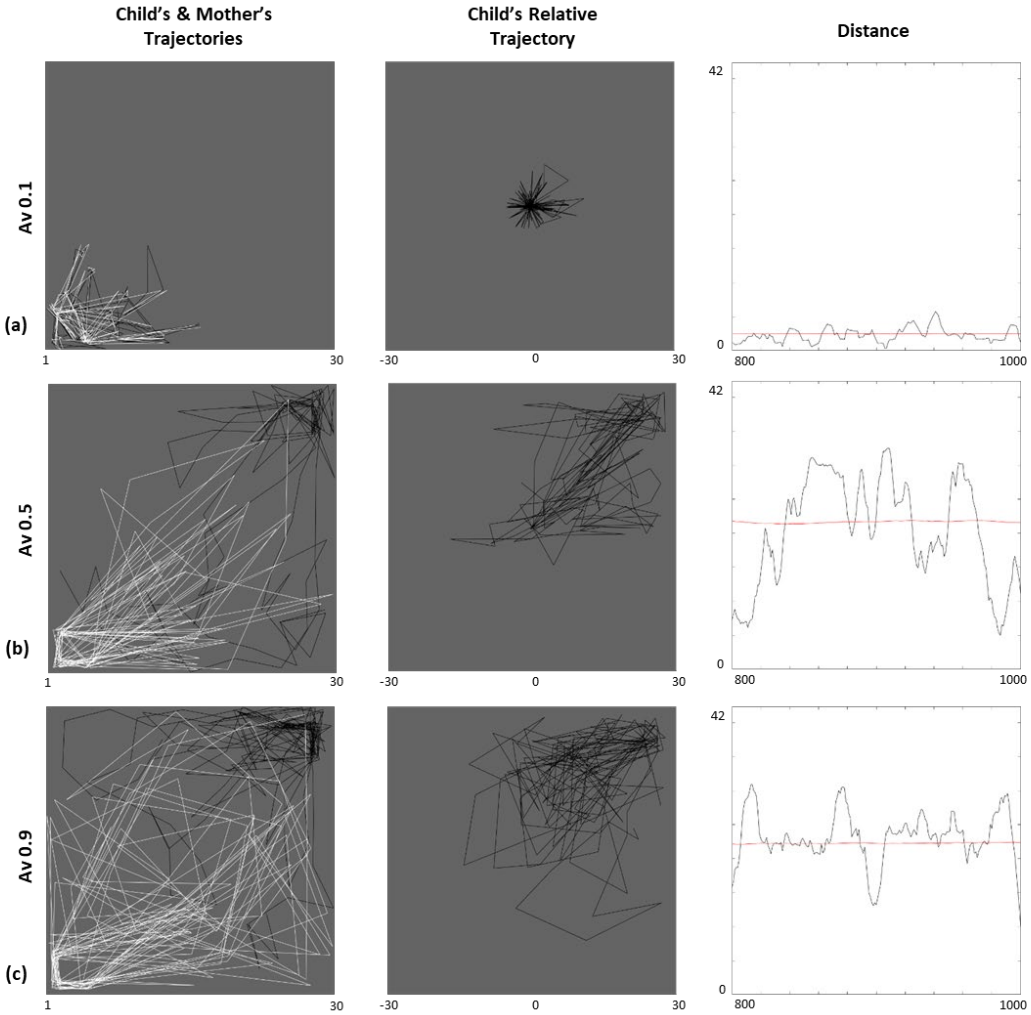


Figure 4.9. Behavior of avoidant dyads for different dimensional levels.
Three avoidant levels represent the (a) 'anti-avoidant' ($A_v = 0.1$), (b) secure ($A_v = 0.5$), and (c) (extremely) avoidant ($A_v = 0.9$) cases in terms of the agents' trajectories (black for the child, white for the mother), child's trajectory relative to mother, and distances (smoothed with a moving filter). In the left-column pictures, the objects of interest for child and mother are located in the top-right and bottom-left corners respectively. All graphs refer to iterations 800-1000 (the last 200 of the simulations).

Ambivalence (and unresponsiveness).

- $A_m = 0.1$ (Figure 4.10a). The agents are 'anti-ambivalent': the child manifests high activation of exploration, and the caregiver of caregiving (need). As a result, the caregiver chases the child, and they tend to gravitate around the objects of interest for the child (4.10a-left). Consistently, the relative trajectory is very concentrated (4.10a-center), and distances are very little (4.10a-right).

- $A_m = 0.4$ (Figure 4.10b). Similarly to the avoidant case (although with more approaches from the caregiver), the agents appear secure and have a functional activation of attachment and caregiving (need). The child again approaches moderately and tends to move around their objects of interest (exploration), while attended to by the caregiver (4.10b-left). The good proportion of exploration results in a relative trajectory on the right-top side (4.10b-center) and mid distances (4.10b-right).

- $A_m = 0.9$ (Figure 4.10c). The agents appear (extremely) ambivalent: the child manifests very high activation of attachment, and the caregiver very low of caregiving (need). As a result, the child chases the caregiver, and the dyad tends to move around the caregiver's objects of interest (4.10c-left). The exploration of the caregiver followed by the child makes the relative trajectory shift toward the bottom-left side (4.10c-center), and the high approach of the child limits the distances (4.10c-right).

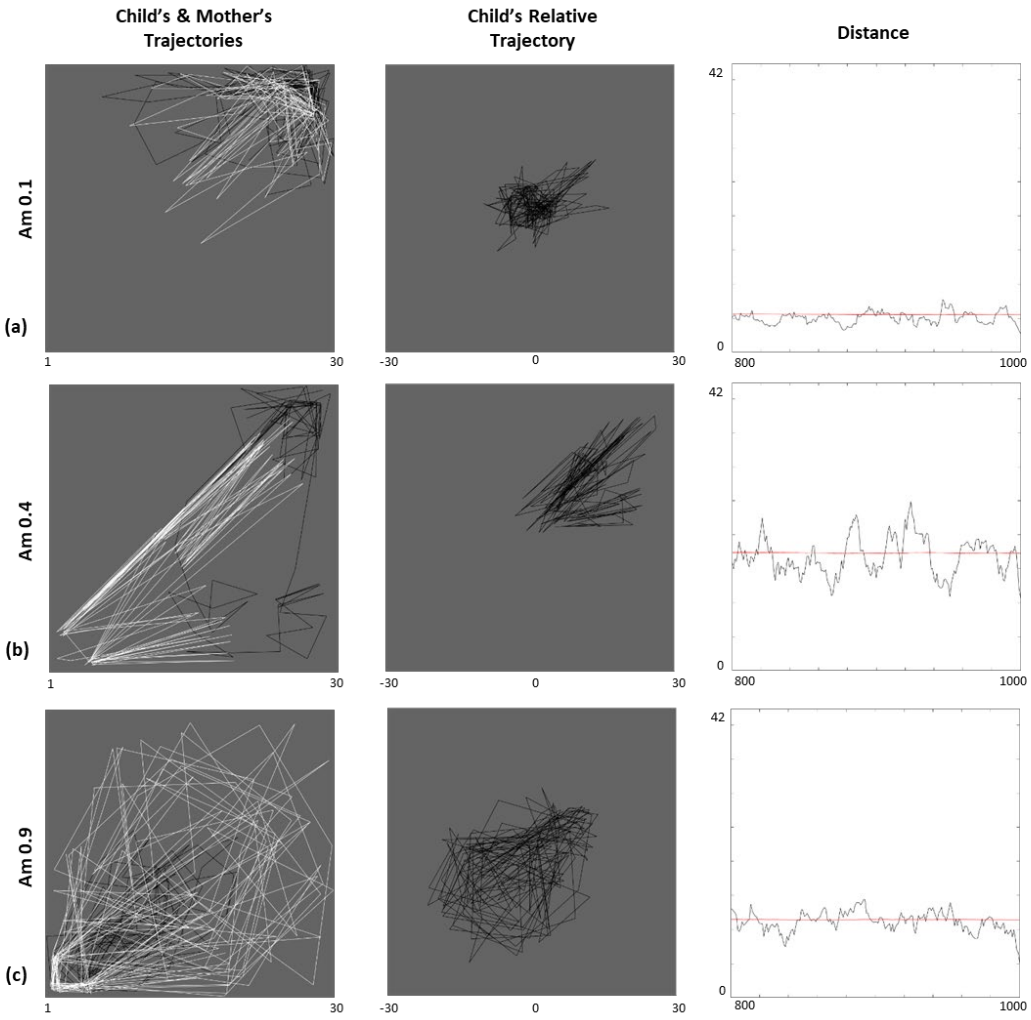


Figure 4.10. Behavior of ambivalent dyads for different dimensional levels.
Three ambivalent levels represent the (a) 'anti-ambivalent' ($A_m = 0.1$), (b) secure ($A_m = 0.4$), and (c) (extremely) ambivalent ($A_m = 0.9$) cases in terms of the agents' trajectories (black for the child, white for the mother), child's trajectory relative to mother, and distances (smoothed with a moving filter). In the left-column pictures, the objects of interest for child and mother are located in the top-right and bottom-left corners respectively. All graphs refer to iterations 800-1000 (the last 200 of the simulations).

The avoidant and ambivalent dyads in the lab. Below (Figure 4.11), the trajectories taken by the child (in black) and mother (in white) in the most avoidant (Figure 4.9c-left) and ambivalent (Figure 4.10c-left) cases are compared. (a) The avoidant child and insensitive caregiver feel very little need (to receive and provide care respectively) and move independently. Their paths concentrate where their objects of interest are located. (b) The ambivalent child feels very much in need (to receive care), while the unresponsive caregiver very little (to provide care). As a result, the child appears to insistently chase the caregiver, gravitating around the caregiver's objects of interest. These patterns capture the essence of avoidance and ambivalence as described in the literature.

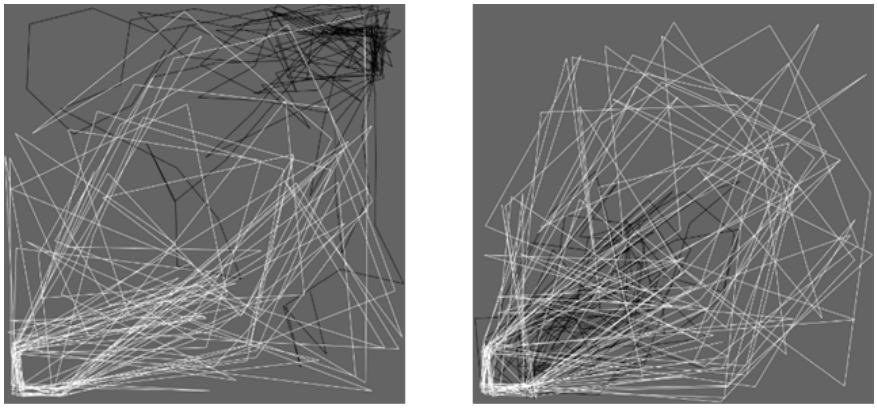


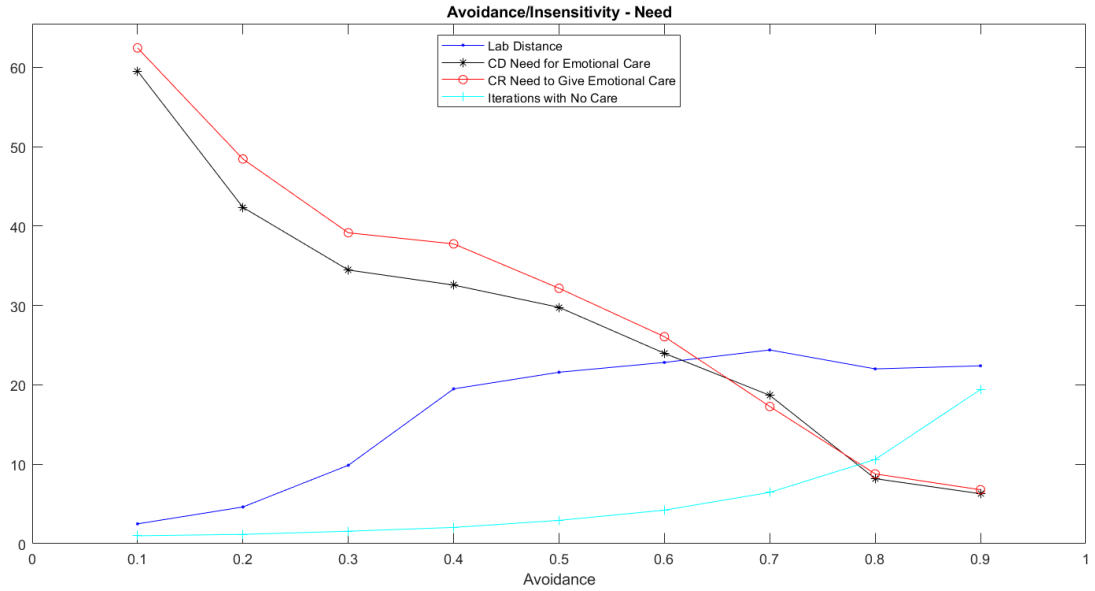
Figure 4.11. Avoidant and ambivalent dyads in action.
Trajectories (black for the child, white for the mother) followed by the extremely avoidant (a) and ambivalent (b) dyads (dimensional level 0.9, iterations 800-1000).

4.3.1.2. Trends of need and action

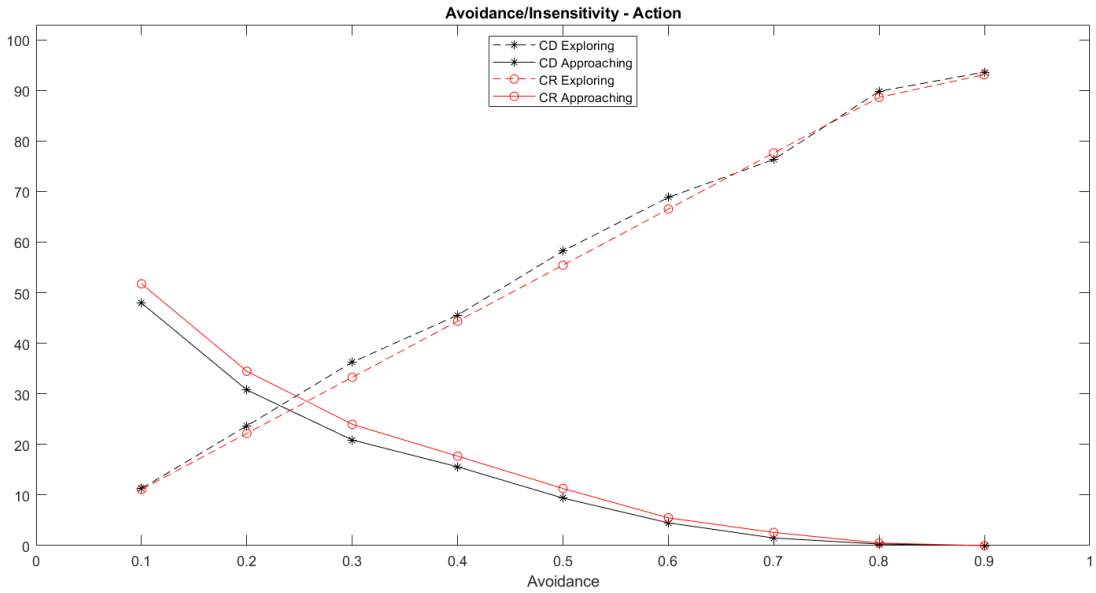
The percentage values over 1000 iterations are reported for the following variables: (A) The need N – child's need to receive care (N_R) and caregiver's need to give care (N_G). (B) Explorative and approaching behaviors. Also, the mean values over 1000 iterations are reported for the distance between the two agents in the lab and the number of iterations with no provision of care.

The results obtained for avoidance/insensitivity and ambivalence/unresponsiveness are discussed considering the curves in their progression from left to right, i.e. for increasing dimensional values (black is used for the child, red for the mother).

Avoidance (and insensitivity). In the case of avoidance, simulations produce a clear, and almost linear, decrease of both the need to receive care and the need to give care (Figure 4.12a). In other words: the more the child is avoidant, the less they need to be taken care of; the more the caregiver is insensitive, the less they need to provide care to the child. In the less avoidant case, values are around 60% and, in the most avoidant one, just above 5%. Coherently, simulations yield a sharp increase in exploration (dashed curves) and decrease in approaching (solid curves) (Figure 4.12b). The former goes from a little over 10% to almost 95%, and the latter from about 50% to zero. All these trends reflect what is expected from an avoidant dyad. Accordingly, the number of iterations with no provision of care rises (cyan curve) (Figure 4.12a). On the other hand, the distance remains practically steady after a first increase, which can be explained by the limited size of the room where the agents move and random explorations (blue curve) (Figure 4.12a).



(a)

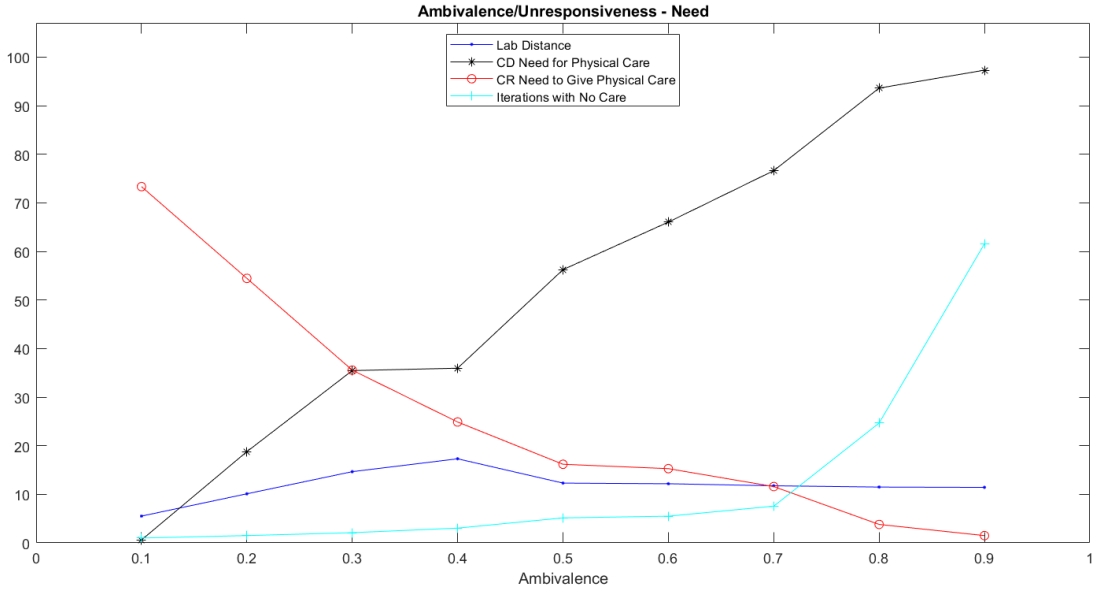


(b)

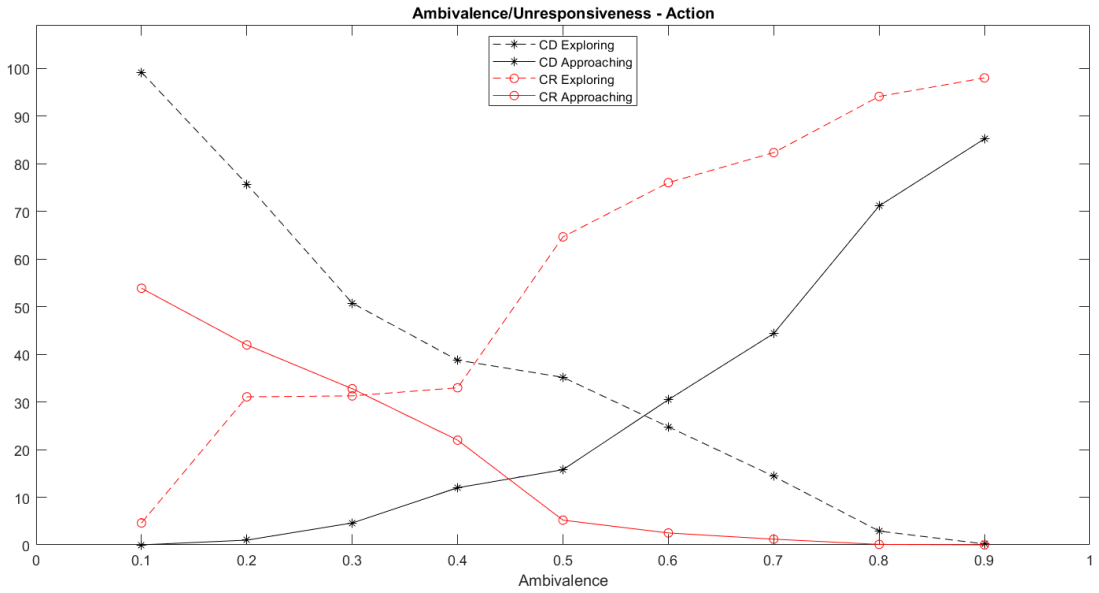
Figure 4.12. Avoidant case: Need and action.
The graphs represent characteristics for the child (black curves) and the caregiver (red curves) for levels of avoidance (A_v) and insensitivity (I_n) ranging between 0.1 and 0.9 (with step 0.1). The blue curve represents the distance measured in the lab between the child and the caregiver. The cyan curve represents the number of iterations without caregiving. In particular, as A_v and I_n increase, it is shown that: (a) The needs to receive care (felt by the child) and give care (felt by the caregiver) decrease. (b) The child and the caregiver both increase their exploration (dashed curves) while they decrease their approaches. All these phenomena are entirely consistent with what attachment studies describe.

Ambivalence (and unresponsiveness). In the case of ambivalence, the simulated needs to receive and give care have opposite trends: while the former increases

sharply, the latter decreases (Figure 4.13a). The most non-ambivalent children show no need for care. Such a need rises and keeps soaring toward the most ambivalent case – to almost 100%. On the other hand, from the extremely responsive caregiver to the extremely unresponsive one, the decline in the need to give care is more moderate – roughly, from a little above 70% to practically zero. Explorations and approaches are coherent with the needs (Figure 4.13b). The more the child becomes ambivalent, the more they approach the caregiver and the less they explore. Conversely, the more the caregiver becomes unresponsive, the more they explore and the less they approach the child. All these trends match those expected from an ambivalent dyad. Accordingly, the number of iterations in which the caregiver is unresponsive becomes higher as the child becomes more ambivalent (cyan curve) (Figure 4.13a). Interestingly, the distance between the agents seems to remain quite stable despite the significant change of the agents' attitudes, which indicates that such attitudes compensate each other in terms of distance (blue curve) (Figure 4.13a). In fact, the simulation of the most ambivalent case shows that the child constantly chases the caregiver.



(a)



(b)

Figure 4.13. Ambivalent case: Need and action.
The graphs represent characteristics for the child (black curves) and the caregiver (red curves) for levels of ambivalence (A_m) and unresponsiveness (U_n) ranging between 0.1 and 0.9 (with step 0.1). The blue curve represents the distance measured in the lab between the child and the caregiver. The cyan curve represents the number of iterations without caregiving. In particular, as A_m and U_n increase, it is shown that: (a) The need for care (felt by the child) increases while the need to give care (felt by the caregiver) decreases. (b) The child increases their approaches and decreases their exploration (dashed curve), while the caregiver increases their exploration (dashed curve) and decreases their approaches. All these phenomena are entirely consistent with what attachment studies describe.

4.3.1.3. Simulated vs expected trends

As discussed above, the literature provides qualitative indications about what is to be expected in the avoidant and ambivalent cases – in terms of internal states and observable behaviors (cf. 4.1.1, Figure 4.2). The compliance of the obtained results with such expectations is confirmed by the comparison of simulated need, approach, and exploration trends (solid) with the expected trends (dashed) (in black for the child, in red for the caregiver) (Figure 4.14). Both in the avoidant (Figure 4.14a, b, c) and ambivalent (Figure 4.14d, e, f) cases, the simulated trends match those expected. It must be noted that the expected trends are indicated by lines only for convenience – since the actual functions connecting dimensional level and need, approach, and exploration are unknown. The issue of obtaining a quantitative match between simulation results and available data is discussed below (cf. 4.4.2).

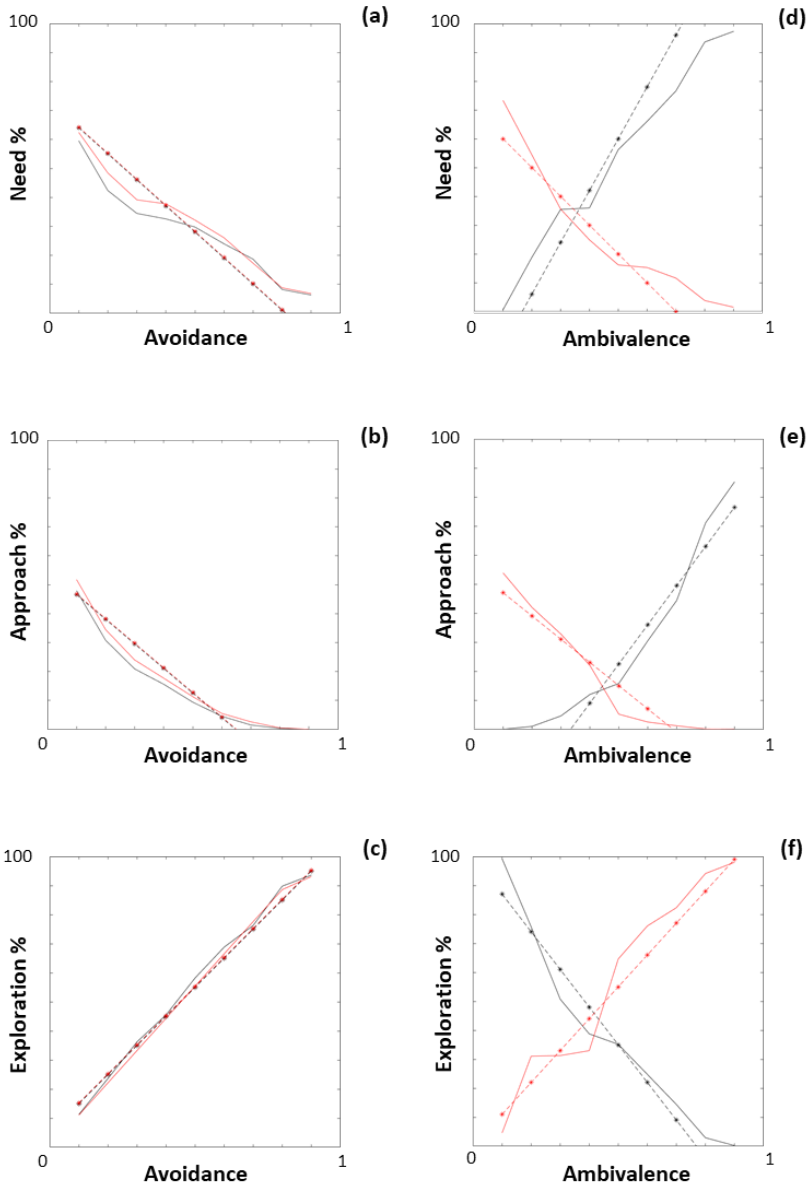


Figure 4.14. Need, approach, and exploration trends: simulated vs expected.
The graphs represent the simulated need, approach, and exploration trends (solid) compared to the expected ones (dashed) (in black for the child, in red for the caregiver) in the avoidant (a, b, c) and ambivalent (d, e, f) cases. All simulated trends match those expected.

4.4. Discussion

Attachment is a complex psychological phenomenon whose theory has been evolving for many decades, not only enormously widening its corpus but also refining its fundamental concepts and adopting different perspectives (Fitton, 2012; Sutton, 2019). Consequently, capturing a convenient theoretical picture of attachment on which to build a computational model has become increasingly difficult.

Previous computational models. Overall, previous models have provided remarkable contributions and also a valuable basis for the presented one. However, they generally rely on the early SAT and adopt a (1) behavioral (as opposed to representational) and (2) categorical (as opposed to dimensional) perspective, which – it has been argued (cf. 2.2.2) – may have set the following two significant limitations to their effectiveness.

(1) **Behavioral perspective.** The SAT conceptualizes attachment primarily as a secure-base phenomenon and proximity as its set-goal (Bowlby, 1969/1982; 1988). On the other hand, according to the APT, attachment has a representational nature expressed by its f-IWM, whose imprinted pieces of information (i.e. the attachment dimensions) drive action. They work as the set-goals of the system from which proximity derives. If a model does not explicitly use representations to drive behavior, the generated patterns can be expected not to adequately match those observed.

(2) **Categorical perspective.** Following the SSP categorical tradition, most previous attachment models focus on the caregiver's responsiveness as the only feature that induces the acquisition of avoidance and ambivalence, which are consequently seen as two opposite manifestations of the same dimension (Ainsworth et al., 1978). In contrast, the APT proposes that avoidance and ambivalence correspond to two different dimensions induced by two corresponding caregiving features. If a model does not implement attachment dimensionality, some relevant mismatch with reality can be expected to arise.

The contribution of the ACM can now be discussed in more detail, suggesting its limitations and possible developments.

4.4.1. Contribution

According to the APT, attachment is fundamental socio-psychological information that belongs to different dimensions. The presented ACM was built coherently with these assumptions as a two-dimensional ABM of attachment that reproduces the avoidant and ambivalent patterns observable in a child-mother dyad. The consistency of the simulations with attachment data supports the validity of the adopted theoretical perspective and can be considered a proof of concept – which suggests further testing with the generalization to a higher number of attachment dimensions. The model overcomes the limitations of a behavioral-categorical perspective by considering (1) attachment as a representational controller (2) based on two dimensions induced by two corresponding caregiving features.

Psychological and behavioral variables. In the ACM, psychological variables – in the mind of the agents – and behavioral variables – observable in the lab – are distinguished. From the basic setting of two autonomous dot-like agents moving in a limited space, two measurable features that can be interpreted by the child as cues for the construction of psychological representations (i.e. dimensional levels) are selected:

(1) In the avoidant case, the caregiver's indifference (i) – the proportion of explorations of the caregiver (behavioral) – is considered. From this measure of the caregiver's insensitive attitude, the child extracts a level of emotional separation (S_E) (psychological). The idea is that a mother's decision to explore can be seen by the child as a sign of her active rejection – evolutionarily, a sign of her unwillingness to invest in her offspring (Chisholm, 1996; Chisholm and Sieff, 2014).

(2) In the ambivalent case, the caregiver's distancing (d) – the distance between the caregiver and the child (behavioral) – is considered. From this measure of the caregiver's unresponsive attitude, the child extracts a level of perceived distance (D_P) (psychological). The idea is that a mother's distance can be seen by the child as a sign of her impossibility to attend in case of need – evolutionarily, a sign of her inability to invest in her offspring (Chisholm, 1996; Chisholm and Sieff, 2014).

Therefore, from two behavioral variables (in the lab), two corresponding psychological variables (in the mind) are derived (eq.s 4.8, 4.9) – through a formula that is expected to depend on the agents and interaction context. The attacher uses these psychological variables to be compared with the corresponding imprinted set-goals (T_E, T_P). Therefore, attachment works as a multidimensional-representational controller (representations are compared to drive action).

Motivational dynamics. In the model, the agents are driven by intrinsic motivations – the child by attachment and exploration, the mother by caregiving and exploration. Moreover, each agent's need is influenced by the other's (coupled eq.s 4.1-4.2 and 4.3-4.4), thereby creating an intertwined dynamics between the motivational systems. In this respect, a relevant role is played by the time spent without giving/receiving care – implemented by an iteration counter (K) – which determines cycles of attachment and caregiving activations alternated by exploration. In fact, the interplay between attachment and exploration is central to the infant's attachment patterns (Bowlby, 1969/1982; Ainsworth et al., 1978; Hesse, 2008). The implementation of a motivational dynamics requires an action selection mechanism for the agents. In the basic case of just two motivations and actions per agent, such a

mechanism can be implemented through a simple decision rule. If more elements came into play, a more sophisticated activation mechanism would be necessary.

Results. Simulations show that the ACM reproduces the quality expected by real avoidant and ambivalent relationships. Increasing the dimensional levels, children go from being 'anti-avoidant' or 'anti-ambivalent' to secure to highly avoidant or ambivalent (Figures 4.9, 4.10). The ACM covers a broader range of cases compared to the standard theory (Ainsworth et al., 1978; Main and Solomon, 1990; Hesse, 2008), suggesting that extremely low dimensional levels ($A_v = 0.1,\ A_m = 0.1$) may correspond to rare instantiations of dysfunctional conditions – such as particular cases of compulsive dependence or self-reliance (Bowlby, 1973; Fonagy et al., 2002; Beck et al., 2015) – usually not considered for attachment classification. On the other hand, mid-levels ($A_v = 0.5, A_m = 0.4$) correspond to secure attachment, which is taken as the healthy standard, reflected in an optimal balance between attachment and exploration. Finally, the highest dimensional levels ($A_v = 0.9,\ A_m = 0.9$) strikingly represent the quality of the extreme avoidant and ambivalent relationships. The essence of these patterns is visually emphasized by the child's and mother's trajectories in the lab (Figure 4.11), which reflect the independence of the avoidant dyad and the ambivalent attacher's over-involvement in the relationship related to their mother's lack of care (Hesse, 2008; Mikulincer and Shaver, 2016). The avoidant child and insensitive caregiver feel very little need (to receive and provide care respectively), while the ambivalent child feels very much in need (to receive care), and the unresponsive caregiver very little (to provide care). As a result, the avoidant child and insensitive caregiver move independently, while the ambivalent child appears to chase the unresponsive caregiver. The adherence of the ACM to attachment phenomena is further illustrated by the agents' need as a function of the imprinted dimensional level (Figures 4.12a, 4.13a) and by the corresponding approach and exploration rates (Figures 4.12b, 4.13b). When the level raises, the attacher's need for care decreases in the case of avoidance and increases in the case of ambivalence. At the same time, the avoidant explorations and the ambivalent approaches surge. Attacher's and caregiver's curves show matching trends, which entirely correspond to those expected (Figure 4.14).

The compliance of the ACM – in terms of need, approach, and exploration trends – with the expected attachment patterns demonstrates that such patterns can be generated by different dimensions. In other words, these outcomes do not need to be produced by opposite levels of the same dimension, as assumed by the early SAT, but they can involve different areas of the relationship. Interestingly, for each dimension, a specific configuration of agents' goals needs to be considered. In particular, the high rate of child's exploration in the avoidant case is the consequence of similar goals of

high emotional separations. On the other hand, the high rate of child's approaches in the ambivalent case is the consequence of opposite goals in terms of perceived distance.

Finally, it should be noted that, in the presented model, the drive-equations' terms $c_{0a,av}$, $c_{0c,av}$, $c_{0a,am}$, $c_{0c,am}$ were kept constant for simplicity. However, the form of such equations suggests that those terms are to be expected to depend on the dimensional levels A_v and A_m. Indeed, when K is zero (i.e. care is provided), the equations become:

$$a_{av}[n+1] = C_{f,av}(1 - N_{G,av})S_{Ea}[n] + c_{0a,av} \quad (1')$$

$$c_{av}[n+1] = C_{f,av}(1 - N_{R,av})S_{Ec}[n] + c_{0c,av} \quad (2')$$

$$a_{am}[n+1] = C_{f,am}N_{G,am}D_{Pa}[n] + c_{0a,am} \quad (3')$$

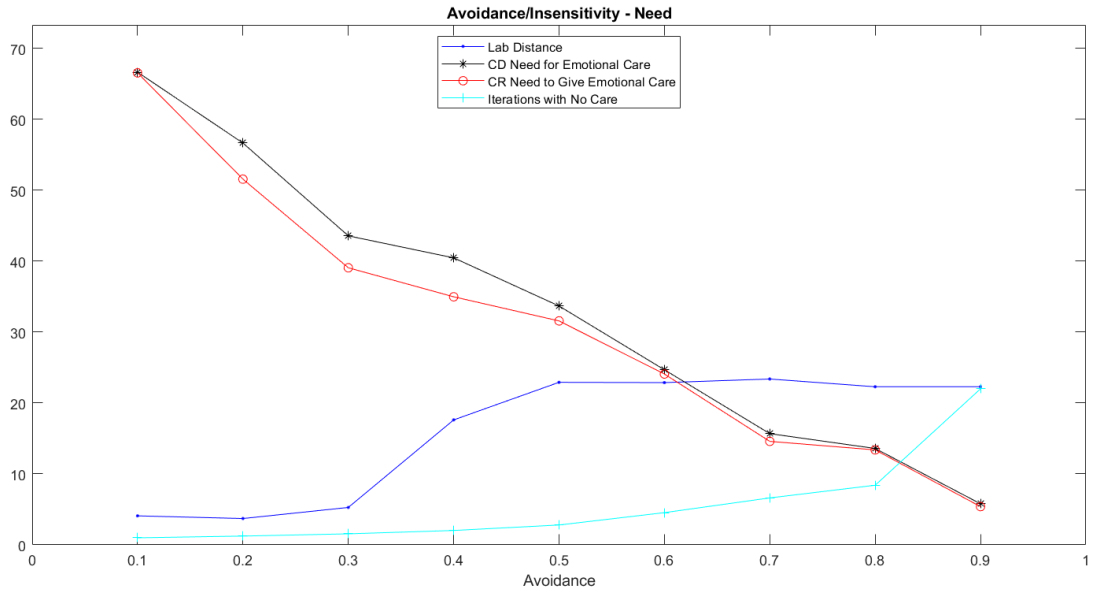
$$c_{am}[n+1] = C_{f,am}(1 - N_{R,am})D_{Pc}[n] + c_{0c,am} \quad (4')$$

and, all other things being equal (i.e. N, S_E, D_P), the drives will drop differently for different levels of avoidance and ambivalence. The drop will be greater for a more avoidant child (smaller $c_{0a,av}$) and smaller for a more ambivalent child (greater $c_{0a,am}$). Therefore, choosing appropriately variable coefficients can be expected to further improve modeling performance. In fact, in the avoidant case, the following simple linear relationships:

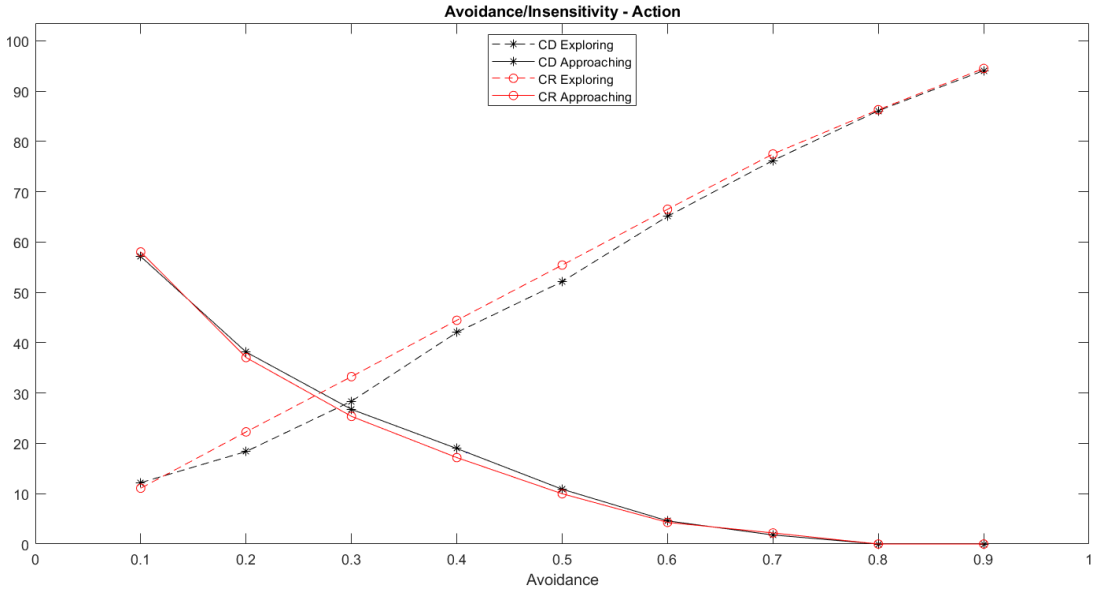
$$c_{0a,av} = -0.30A_v + 0.60$$

$$c_{0c,av} = -0.30A_v + 0.59$$

– that implement the predicted kind of variability – enhance the system's capacity to reproduce avoidance, as proven by the corresponding augmented range of needs, approaches, and explorations (Figure 4.15) compared to the above-illustrated case of constant $c_{0a,av}$ and $c_{0c,av}$ (Figure 4.12).



(a)



(b)

Figure 4.15. Avoidant case. Enhanced performance for variable $c_{0a,av}$ and $c_{0c,av}$ in terms of (a) needs and (b) action (approaches and explorations).

In conclusion, the presented basic version of the ACM provides first computational support to the representational and dimensional nature of attachment proposed by the APT, suggesting it to be a convenient theoretical standpoint for attachment computational modeling. Adopting this perspective should help solve some fundamental limitations inherent to the behavioral-categorical one. This model also confirms the adequacy of the ABMs for the investigation of attachment (Petters and Waters, 2015).

4.4.2. Limitations and future work

I finally discuss some limitations of the presented model, which encourage future work and improvement. The APT itself suggests multiple possible upgrades of the model.

(1) **APT testing.** The ACM aims to computationally implement the APT through an ABM with no other constraints than compliance with the theory. As a result, its design is peculiar, and the system expresses a non-linear dynamics that is not trivial to study. A programmed next step is to develop a simplified continuous model – relying on the discrete version presented here – to study its full dynamics through the tools of dynamical systems theory (Thelen and Smith, 1994; Coleman and Watson, 2000; Fraley and Brumbaugh, 2004; van Geert, 2019). Moreover, many parameters of the current version could be investigated, and the performed sensitivity analysis (cf. Appendix C) represents an example of such an investigation. This effort can be extended in future work.

(2) **Physicality and motivational expression.** Despite the advantages in terms of simplicity, a relevant limitation of the ACM is being a 2D-ABM with dot-like agents. Attacher and caregiver have no physicality and, therefore, a very limited capability to express attachment, caregiving, and exploration behaviors – which can, in reality, assume numerous and sophisticated forms (Bowlby, 1969/1982; Ainsworth et al., 1978; Bartholomew and Horowitz, 1991; Main and Hesse, 1992; Crittenden, 2008; Lyons-Ruth and Jacobvitz, 2008; Mikulincer and Shaver, 2016). In particular, bodily and emotional expressions are fundamental for the formation and maintenance of an attachment relationship. However, in the current ACM, motivations can only be expressed by movements in the lab (i.e. approaching and exploring), which should, therefore, be intended as general behaviors, representing one of the many possible attachment, caregiving, or explorative behaviors (such as crying, looking at the other, visually inspecting or manipulating an object). A more evolved version of the ACM – with a physicality that implements additional actions – could significantly improve adherence to reality. Such an upgrade could be a 3D-ABM or a robotic model.

(3) **Motivational dynamics.** Attachment relationships are part of our life, which, of course, can involve any motivation. This ACM only considers exploration as a non-attachment and non-caregiving motivational system. A more detailed model of attachment should implement a higher number of situations and corresponding motivations. Interesting cases to model would be dysfunctional child-mother interactions with, for example, inversion of attachment (where child and mother invert their motivational systems) or dominant/submissive behaviors (where the child uses the ranking motivational system) (Hennighausen and Lyons Ruth, 2005; Crittenden, 2008; Lyons-Ruth and Jacobvitz, 2008; Liotti, 2011).

(4) **Quantitative match.** As discussed above, the match between the ACM simulations and real attachment patterns is to be considered in qualitative terms. Such patterns can manifest themselves in various and complex ways, and quantitative measures – e.g. frequency of approaching, crying, looking – can vary depending on multiple variables, including the familiarity of the environment and the physiological state of the subject. As Ainsworth et al. (1978) remarked, even an infant and their caregiver can behave quite differently at home and in the lab, although following the same underlying pattern recognizable to an expert eye. In its current implementation, the ACM is too essential to match a real context closely enough to allow for a full quantitative comparison. As a result of the limited motivational expression, simulated approach and exploration rates are expected to be higher than the ones in real situations. Although the qualitative representation of the phenomena (Ainsworth et al., 1978, pp.59-63; Hesse, 2008, pp.568-569) is very well maintained throughout the whole 0-to-1 range of dimensional levels, the quantitative match can be improved. For instance, some side values seem too extreme to provide a quantitative match with real attachment situations (rates of over 90% of attachment behaviors appear to be generally implausible, for example) (Ainsworth et al., 1978, pp.99,126,133). An upgraded version of the model – where multiple motivational behaviors are implemented – should be able to narrow the quantitative gap. It is also worth noting that the considered 0-to-1 dimensional range could be rescaled to better match in quantitative terms the represented phenomena. For example, values between 0.3 and 0.7 could be the ones representing most, if not all, cases in a given real context.

(5) **Learning.** Both the SAT and the APT recognize learning as essential to attachment. The infant has to learn the identity of their caregiver as well as the attachment pattern that best works with them (Bowlby, 1969/1982; Ainsworth and Bell, 1970; Main and Solomon, 1990). However, with this respect, the SAT and the APT significantly diverge. On the one hand, although Bowlby (1969/1982) first suggested attachment to be allowed by imprinting – a specific learning mechanism that confers its stability – the SAT progressively emphasized the possibility of change, and the common implicit assumption became that attachment is learnt through reinforcement (Cittern, 2016; Petters and Beaudoin, 2017; Talevich, 2017). Possible stability over time is usually justified by the consolidation of habits rather than any particular learning mechanism. On the other hand, the APT proposes that imprinting is the specific mechanism that informs any attachment acquisition (cf. 1.4.3), both the identity of the caregiver and the f-IWM. This perspective allows for the explanation of attachment stability while, at the same time, admitting the possibility of change. Accordingly, the ACM should be enhanced by implementing the imprinting of avoidance and ambivalence, as suggested in the outlined attachment module (cf. 2.4.4).

(6) **Dimensionality.** The SAT considers only three attachment dimensions – disorganization, avoidance, and ambivalence (α-dimensions). However, the APT proposes that four additional ones need to be considered – phobicity, depressivity, somaticity, and obsessivity (β-dimensions). Therefore, the presented two-dimensional model should be extended through the implementation of other dimensions. Since, according to the APT, attachment dimensions correspond to lab variables that need to be detected by the attacher, this extension requires an adequate model structure (i.e. environment and agent characteristics). For example, to implement disorganization, signs of a threat from the caregiver need to be visible. To implement depressivity, the emotional unreachability of the caregiver needs to be signaled. A feature detection requires the existence of a structure that implements it (e.g. a sign of threat, a signal of unreachability) and, in general, an enhancement of the current model. However, as shown in the next chapter, phobicity can be implemented with no structural enrichment.

(7) **Architectural integration.** The presented ACM is the first implementation of an APT-informed attachment module (cf. 2.4) meant to be part of a general cognitive architecture such as the CogAff (Petters and Waters, 2015; Petters and Beaudoin, 2017) or the DAC (Verschure, 2012; Verschure et al., 2014). In particular, attachment phenomena have already been implemented on the CogAff, which is suitable for agent-based modeling. The integration in this architecture would allow the ACM to interact with other modules and extend the testability of the APT, in particular, to more clinically relevant phenomena, considering that the theory proposes the causal connection between attachment and psychopathology (cf. 1.4.2). Indeed, a mental condition that has an attachment etiology always involves a broad range of cognitive and affective activities, which could be supported by a general architecture.

Conclusions

Attachment is as essential to our socio-psychological life as it is difficult to conceptualize and model. This work relies on an enhanced version of the Standard Attachment Theory (SAT) – the Attachment-Personality Theory (APT) – that proposes a novel framework suitable for computational modeling. Attachment is conceptualized as a – representation-driven – multidimensional control system: seven imprinted attachment dimensions set the representational goals of the system.

To test this framework, in this chapter, I presented a two-dimensional Attachment Computational Model (ACM) that simulates avoidant and ambivalent interactions according to the APT. A child-mother dyad is represented by two agents in a limited environment who act either according to their avoidant-insensitive or ambivalent-

unresponsive representations. Avoidance and ambivalence are seen as two different dimensions induced by two specific caregiving features, and not as the opposite expressions of a single feature as suggested by the early SAT. For increasing values of avoidance and ambivalence, simulations match what is expected. In particular, the avoidant child feels less and less need to receive care and increases their exploration rate, while the ambivalent child feels more and more in need of attachment and increases their approach rate. At the same time, the caregiver shows a specular behavior. In other words, the ACM reproduces the quality of avoidant and ambivalent interactions as described in the literature, thereby supporting the APT representational and dimensional perspective of attachment.

In the next chapter, the ACM is extended to the implementation of phobicity, a dimension theorized by the APT but not by the SAT.

Chapter 5

Extension of the ACM to phobicity

Introduction

The **Attachment Computational Model** (ACM) presented in the previous chapter simulates avoidance and ambivalence. Here, to further test the APT, the model is extended to a third dimension – phobicity – which the Standard Attachment Theory (SAT) does not consider as such. The choice of this dimension is dictated by the properties of the current basic version of the ACM, which only allows for the representation of a limited number of attachment dimensions and caregiving features. The implementation of dimensions and features requires an adequate model structure (i.e. environment and agents characteristics). Disorganization, depressivity, somaticity, and obsessivity cannot be supported by the structure of the current ACM. On the other hand, the APT definition of phobicity concerns the caregiver's task of regulating the child's balance between attachment and exploration. This feature can be manifested in different ways but is usually expressed by the caregiver's tendency to offer protection, which induces a corresponding child's tendency to feel vulnerable in their absence. These tendencies can be well represented by the current ACM. It is worth noting that, besides a sense of vulnerability when far from the caregiver, the phobic tends to feel a sense of constriction when close to them. However, in this first implementation, constriction is ignored, assuming that typically the phobic child does not act when feeling constricted. Therefore, I simulated phobic interactions through protection and vulnerability. In particular, the limiting caregiver will be hyper-protective, and the phobic child will easily feel vulnerable. Both protection and vulnerability are connected to the distance between the agents. Larger distance is interpreted (1) by the child as lower protection (offered by the caregiver) and (2) by the caregiver as higher vulnerability (felt by the child). Thus, as with ambivalence, distance is considered, but, in this case, it is interpreted differently. The connection of relevant variables and parameters generates two coupled equations similar to the ambivalent and avoidant ones. However, specific targets distinguish this case. The

agents have consistent needs: the more they are phobic/limiting, the more they perceive vulnerability and seek proximity: the vulnerable child feels the need to be protected, while the protective caregiver feels the need to protect. Simulations meet the expectations. When phobicity is high, the agents tend to stick together, when it is low, they tend to be independent. These results are again consistent with the APT representational and dimensional view of attachment.

5.1. Characterization of phobicity

According to the APT, phobicity is the subjective measure of the limitation in exploration imposed by the caregiver (cf. 1.4.2.1). The most common way for a caregiver to limit their child's exploration is being hyper-protective – and this is the case that will be considered here. Given that only the APT considers phobicity as an attachment dimension, the SAT does not describe it (as such). However, the post-rationalist clinical accounts concerning the phobic personal meaning organization (Guidano and Liotti, 1983; Guidano, 1987; 1991; Picardi et al., 2004; Guidano, 2007; Nardi and Bellantuono, 2008) provide a detailed and operationalizable characterization of phobic patterns.

Phobicity and limitation. The phobic feels vulnerable and hyper-activates attachment to remain in psychological proximity of their caregiver. In other words, they want to feel their caregiver can protect them. Symmetrically, the hyper-protective caregiver feels the attacher is vulnerable and hyper-activates caregiving to remain in their phycological proximity. Psychological proximity usually means feeling capable of reaching the other if necessary. In the case of a child-mother dyad, it can easily correspond to physical proximity. Concisely, in Guidano's words: *"Despite their diversity, the invariant aspect characterizing patterns of parental attachment consists of an indirect inhibition of the infant's autonomous exploratory behavior […] The infant feels protected from the environment, perceived as dangerous, only when in close physical contact with a caregiver"* (Guidano, 1991, p.41).

5.1.1. The expected patterns

As with avoidance and ambivalence, the above descriptions can be used as a reference. They suggest expecting monotonic trends for attachment, caregiving, and distance variables (for increasing levels of phobicity). In particular, if: (1) Exploration is the only alternative to attachment and caregiving; and (2) Agents express attachment and caregiving by approaching the other; then, the following variables and trends can be considered:

a. Psychological need (i.e. attachment/caregiving activation): The more the child is phobic, the more they ask for protection (high need to receive care), and the more the caregiver is limiting, the more they offer protection (high need to provide care).

b. Behavioral dynamics: (1) The more the child is phobic and the caregiver is limiting, the more they tend to be close to each other. This condition must be accompanied by consistent approach and exploration behaviors. (2) In general, the more the child is phobic and the caregiver is limiting, the more their approach rates could be expected to increase and their exploration rates to decrease. However, as discussed below, this effect depends on the context where the interactions occur (in this case, especially the lab size). The ACM will take the distance between the agents as a measure of vulnerability and, therefore, a target for the agents. In particular, a decreasing distance (for increasing phobicity and limitation) will be an agents' objective. Approach and exploration rates will derive from it.

Again, considering indicative linear trends, these expectations can be graphically represented as follows (Figure 5.1).

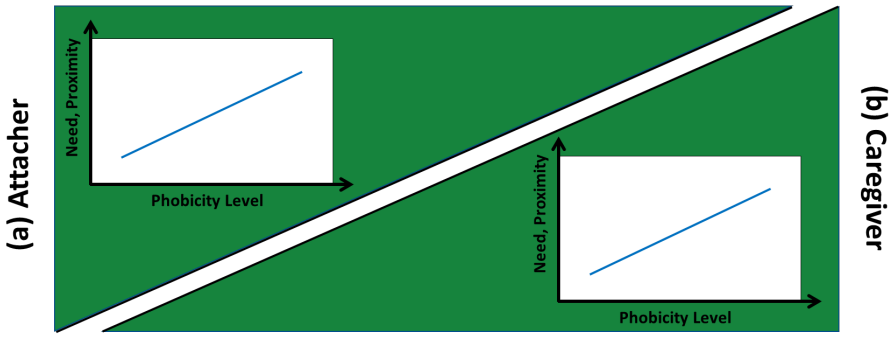


Figure 5.1. Expected trends of attacher's and caregiver's needs and related behaviors.
For phobicity-limitation, considering (1) exploration as the only alternative to attachment and caregiving and (2) approaching the other as the only expression of attachment and caregiving, the literature indicates that need and psychological proximity have monotonic trends (for increasing levels of the dimension/feature). Approach and exploration trends are expected to be consistent with them, depending on the interaction context. Further details remain, however, unspecified. This figure represents indicative linear trends of need and distance for (a) attacher and (b) caregiver. As shown below, in this case, approach and exploration trends will not be monotonic over the entire dimensional interval.

5.2. A 3-dimensional agent-based model of attachment

The ACM – first devised to test the APT framework in regard to avoidance and ambivalence – can be extended to phobicity following the same steps. The extension

is here illustrated by taking the design characteristics of the two-dimensional model (cf. 4.2) as a basis for the addition of the third dimension. Therefore, such characteristics are briefly summarized in two points.

(1) The reproduced scenario is a limited space – a virtual environment that is referred to as 'lab' – where two agents – attacher and caregiver – can interact through a basic bi-motivational dynamic: the attacher can either attach or explore, the caregiver can either give care or explore (Figure 4.3). It resembles a large room where an attacher-caregiver dyad can interact and reminds of an SSP-lab. Objects of interest for the two agents are placed at opposite corners of the lab. Importantly, the only way to express attachment or caregiving is by approaching the other agent, and the only way to express exploration is to move toward an object of interest (or randomly if none is available). The attacher is considered to be a child and the caregiver their mother, but similar considerations hold for any dyad.

(2) The attachment dimensions (for this ACM, avoidance, ambivalence, and phobicity) are considered together with the caregiving features from which they derive (insensitivity, unresponsiveness, and limitation respectively). The attacher is assumed to have adapted to their caregiver. For the considered dyad, it means that the child has learnt from their mother her caregiving style – i.e. the child has acquired the attachment dimensions that correspond to the mother's caregiving features (dimension and corresponding feature have the same value). After this has happened, the dyad is observed while interacting in the lab.

5.2.1. The rationale of the model

Since each dimension can be considered to be elicited separately (cf. 4.2.1), the rationale of the three-dimensional ACM is analogous to the two-dimensional one. Therefore, the two-submodule functional diagram (Figure 4.4) can be extended by simply upgrading the selection mechanism to include the new dimension and adding a corresponding submodule (Figure 5.2).

For the phobic case, each block corresponds to the computational implementation detailed below. Adopting the child's perspective, the simulation session begins by activating the dimension that determines the following interactions' type (block 0). Such interactions will be either avoidant (upper branch of the diagram), ambivalent (mid branch of the diagram), or phobic (lower branch of the diagram). The activation mechanism remains unchanged but is applied to three dimensions rather than two (cf. 4.2.3.1). If phobicity is selected (switch toggled in lower position), the caregiving context is recognized as limiting (block 7) by focusing on the distance of the caregiver in a phobic perspective (equations 5.3, 5.4). Then a non-zero phobic drive (block 8)

(equations 5.1, 5.2) is calculated and a need delivered to the phobic action selection system (block 9) (phobic selection rule below), which generates a phobic action. The action produced will be either an approach to the caregiver (attachment) or an explorative move. This action will push the child toward the set-goal corresponding to their (stored/imprinted) level of phobicity.

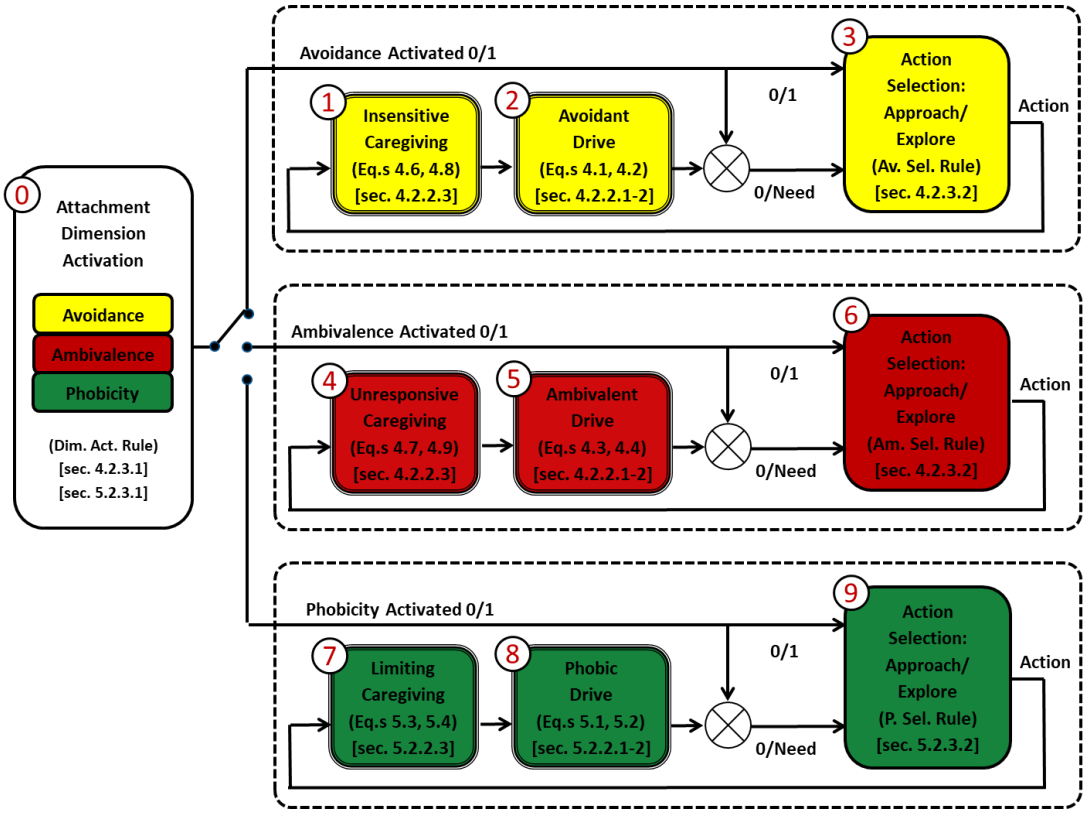


Figure 5.2. The rationale of the extended model.
The diagram represents how the extended ACM works. The attacher activates a dimension, and corresponding interactions take place. The activation of avoidance, ambivalence, or phobicity determines the generation of avoidant, ambivalent, or phobic actions, which push the attacher toward the set-goal corresponding to the (imprinted) level of the activated dimension.

In the following two sections, the core and interface of the phobic submodule are discussed along the same lines as for the avoidant and ambivalent submodules covered before (cf. 4.2.2, 4.2.3). These sections integrate the corresponding ones in chapter 4, and consistently, the next simulations section will also integrate the one in that chapter (cf. 4.3).

5.2.2. The attachment system's core

The core of the model is extended by blocks 7-8 of Figure 5.2, which generate a phobic need.

5.2.2.1. Drives

As for the avoidant and ambivalent submodules (cf. 4.2.2.1), two pairs of coupled equations are proposed for the activation of attacher phobicity, drive a_p, and caregiver limitation, drive c_p (block 8):

$$a_p[n+1] = P_h K_p[n]/2 + C_{f,p} N_{G,p}\big(c_p[n], 1 - P_h\big) V_a[n] + c_{0a,p} \quad (5.1)$$

$$c_p[n+1] = L_i K_p[n]\ /2 + C_{f,p} N_{R,p}\big(a_p[n], 1 - L_i\big) V_c[n] + c_{0c,p} \quad (5.2)$$

And similarly, in these equations: (1) K measures the psychological time passed since the child last received care (i.e. protection); (2) N is the need signalled by the other agent that they require protection (N_R), or wish to protect (N_G); (3) V is the attacher's vulnerability perceived by the agents. (4) P_h is the level of the attacher's phobicity, and L_i is the level of the caregiver's limitation, which work as fixed control parameters. P_h represents the dimensional level imprinted in the attacher's brain. (5) $C_{f,p}$ is a coupling factor, which determines the weight of each agent's need on the other. (6) $c_{0a,p}$, and $c_{0c,p}$ are constants used for the initial setting of the system.

To assist the understanding of equation 5.1, the following considerations from the child's perspective can be made (similar considerations hold for the caregiver, equation 5.2). As time passes by (K increases), the child's need to receive care (N_R) will grow according to their drive (a) – which represents the psychological variables and parameters at play – and their level of phobicity (P_h) (N_R is parametrized by the dimensional level). K is the most influential factor – considering the passing of time by itself as a powerful elicitor of the need for care. The term is modulated by the dimensional level: care requests are encouraged by phobicity. The need felt by the caregiver (N_G) works as a signal for the child and influences their need. If more need to provide care is perceived, the phobic child will tend to accentuate their need. The drive is also influenced by the current dimensional representation (V). If the child perceives themselves more vulnerable (higher V), they will tend to feel more in need for care. Finally, the constant term (c_0) can be thought of as a structural setting, which affects the whole psychological functioning of the child.

Therefore, other things being equal, equation 5.1 considers that the phobic child will feel a greater drive to receive care when: (i) its phobicity level, P_h, (ii) the time spent with no protection, K, (iii) the need to provide protection signaled by the caregiver, N_G, and (iv) the perceived vulnerability, V, are greater. (A similar consideration holds for the limiting caregiver in eq. 5.2.)

5.2.2.2. Needs and elapsed time since care

In equations 5.1-5.2, N_R is the need to receive care felt by the child, and N_G is the need to give care felt by the mother. In the phobic case, care is protection. As with avoidance and ambivalence (cf. 4.2.2.2), the need is function $N(x,h) = x/(x + h^x)$, where: the variable x is the drive (a_p or c_p), and the parameter h accounts for the level of phobicity/limitation (P_h or L_i). N realizes the coupling between the two equations. In accordance with the APT, the needs felt by the agents are considered as functions of the drives. The greater the drives, the greater the correspondent need.

K is the counter of iterations with no provided protection, given that protection is considered provided when N_G exceeds its threshold. Again, when K becomes zero, N decays. The coefficient $1/2$ of K was set empirically and could be changed to account for context variations.

5.2.2.3. Perceptions of emotional and physical distance

At each iteration, the agents experience a 'vulnerability', V – more specifically, the attacher experiences V_a and the caregiver V_c. These are the dimensional levels derived by the agents from the current situation. In particular: (1) V_a is the child's vulnerability, i.e. the degree to which the child feels vulnerable; (2) V_c is the caregiver's vulnerability, i.e. the degree to which the caregiver perceives the child as vulnerable.

As with avoidance and ambivalence (cf. 4.2.2.3), vulnerability is a 'psychological variable' connected to a 'behavioral variable' measurable in the lab. In this case, as in the ambivalent one, the behavioral variable is the distance between the agents. But this time, it is interpreted in a phobic, and not ambivalent, way. The vulnerabilities represent how child and mother perceive the situation with respect to phobicity-limitation, thereby representing their current state of mind. In particular, the caregiver's distance provides a cue to the child to derive a current level of 'phobicity'. The child will compare this level with the target one stored in their mind to drive their action, making attachment work as a multidimensional control system.

As a variable from which to derive a phobic perception, the distance between the agents is termed 'distancing':

$$d[n] = \sqrt{(x_a[n] - x_c[n])^2 + (y_a[n] - y_c[n])^2} \qquad (5.3)$$

(where (x_a, y_a) and (x_c, y_c) are the positions in the lab of the attacher and the caregiver respectively). The derivation of the psychological variable vulnerability is performed through the usual formula (cf. 4.2.2.3, eq.s 4.8, 4.9):

$$V[n] = V[n-1] + 2r[(d[n] - T_d) - (V[n-1] - T_V)] \qquad (5.4)$$

where $r \in [0,1]$ is a uniformly distributed random number, T_V and T_d are the target values of V and d, respectively (as discussed below).

5.2.3. The attachment system's interface

Having specified the phobic submodule's core, its interface – consisting of the dimension activation and action selection rules (blocks 0 and 9 in Figure 5.2) – can now be outlined. Such an interface is essential to close the loop with the environment via perception and behavior.

5.2.3.1. Dimension activation rule

An interaction session always starts by selecting the dimension that characterizes it – either avoidance, ambivalence, or phobicity. For the 3-dimensional ACM, the activation rule is the same as in the case of the 2-dimensional one (cf. 4.2.3.1) – a softmax maximum winner-take-all selection – with the addition of a third dimension to be considered.

5.2.3.2. Action selection and behavior expression

As with avoidance and ambivalence (cf. 4.2.3.2), the system compares the current dimensional level to the target (stored) one and acts to decrease the difference between the two. The decision is made according to the need felt by the agents, which depends on its threshold. Specifically, when N_R exceeds its threshold (T_R), the attacher needs protection, and when N_G exceeds its threshold (T_G), the caregiver needs to protect. The threshold has the same expression and works in the same way as for the other dimensions: $T = T_{bl} \pm \tau(1 + r)$, where: T_{bl} is a baseline value, τ is a constant, and $r \in [0,1]$ is a uniformly distributed random number (that accounts for subjective/ psychological variations). T is reduced (minus sign in the formula) when N decreases. The constants were set empirically (see Simulations section).

According to the APT, the phobic dyads differ from the avoidant and ambivalent ones for the goals they set for themselves. In the phobic case, the agents have the same goals in terms of vulnerability (V). The more an agent is phobic/limiting (0.1 to 0.9), the smaller the vulnerability they want to keep. In this model: $T_V = 100(1 - P_h) = 100(100 - L_i)$ (90 to 10) (Figure 5.3).

The target vulnerability (T_V) represents the psychological value of vulnerability that maximizes the subject's comfort. For the child and the caregiver, such targets vary according to the level of phobicity. In the phobic case (as in the avoidant one), the two agents have the same targets (but with an opposite trend compared to avoidance): the higher the phobicity/limitation, the higher the sensitivity toward vulnerability and, consequently, the lower the vulnerability target.

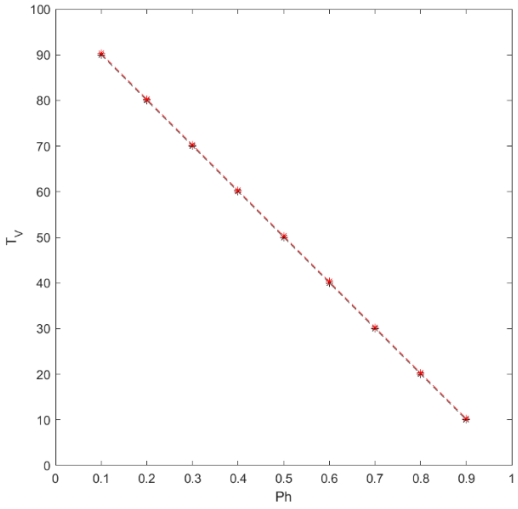


Figure 5.3. V targets.
Vulnerability targets (black for the attacher, red for the caregiver).

Again, the mental targets (T_V) will correspond to contextual ones (T_d). In the phobic case (as in the ambivalent one), the following relationship was used: $T_d = 0.24T_V$ (both for the child and caregiver) (distances between 2.4 and 21.6).

For all dimensions, the action selection rule is the same (cf. 4.2.3.2). If the agent is in need, they approach if their current representation is beyond their target. If the agent is not in need, they explore if their current representation is below their target. These actions tend to maintain the agent on target. More specifically, given the need N and its threshold T, the implemented decision rule is:

- if $N < T$ (the agent feels no need), if $V < k_V T_V$, then explore;
- if $N > T$ (the agent feels a need), if $V > k_V T_V$, then approach.

Need is need to be protected in the case of the child and need to protect in the case of the caregiver; V is the current vulnerability; T_V is the target vulnerability; k_V is a constant (see Simulations section). Approach and exploration have the same characteristics for every dimension.

In conclusion, following the APT, the attacher (1) builds mental representations connected to objective contextual cues, (2) compare such representations to target ones imprinted in their minds, and (3) acts in order to reduce the difference between the two. Attachment is a multidimensional representational controller.

5.3. Simulations

In the phobic case, compared to the avoidant and ambivalent ones (cf. 4.3), there was no change in terms of lab structure. Simulations were also run considering the same

dimensional values – $P_h = 0.1, 0.2, \ldots, 0.9$. A higher value corresponds to a stronger acquisition of the dimension. The only peculiarities concern the setting of the following constant values for the system:

- In equations 5.1-5.2: $C_{f,p} = 1.5$, $c_{0a,p} = 0.47$, $c_{0c,p} = 0.50$;
- In the action selection rule: $k_V = 1.01$.

Initial conditions were also set equal in all simulations as before ($V = 50$).

The child is considered to be adapted to the caregiver by means of past interactions in which the child got imprinted a phobic value that corresponds to the caregiver's limiting one. Therefore, in each simulation, the value of phobicity and limitation are assumed to be identical ($P_h = L_i$). Simulations concern the interactions and emerging patterns that follow adaptation. Such patterns are expected to reproduce the quality of those outlined in the literature (as described above) (Guidano, 1991; 2007), in terms of both internal states (need in this model) and behaviors (distance). Approach and exploration rates are expected to be consistent with the distance objective for any given context. A small space, for example, may not require high approach rates to maintain proximity, a large one may not require high exploration rates to maintain distance. The phobic child is relationship-dependent and expresses their dependency primarily by keeping proximity.

5.3.1. Results

For avoidance and ambivalence (cf. 4.3.1), simulations' results were presented in terms of states and behaviors of the agents for different levels of attachment dimension. The same is done here for phobicity. And similarly, the attachment dimension (P_h) is the only referred to.

5.3.1.1. Behavioral patterns

In this section, relevant behavioral details are reported, concerning the simulations for representative levels of phobicity: (a) extremely low ($P_h = 0.1$), (b) mid ($P_h = 0.5$), and (c) extremely high ($P_h = 0.9$) (Figure 5.4). The considered aspects are the trajectories followed by the agents in the lab, the child's trajectory relative to the caregiver ($(x_a - x_c, y_a - y_c)$), and the distance between the agents[25].

[25] References made here to need, approach, and exploration levels can be checked in the following section concerning their trends.

Phobicity (and limitation).

- $P_h = 0.1$ (Figure 5.4a). The agents are 'anti-phobic' and manifest very low activation of attachment and caregiving (need). Consistently, they keep very distant from each other (5.4a-left). Interestingly, they tend to stay in their objects of interest's area and approach very rarely, but their exploration is also infrequent (5.4a-center). Indeed, although the very low need enables explorative moves, being distant makes such movements unnecessary, resulting in maintaining the same distance for prolonged periods. This pattern – of 'still exploration' – is emphasized by a thin relative trajectory toward the top-right corner (5.4a-right).
- $P_h = 0.5$ (Figure 5.4b). The agents appear secure, driven by activations of attachment and caregiving (need) that generate a functional balance between approach and exploration. Consistently, they maintain a mid-distance between each other (5.4b-left). They tend to move around their objects of interest or randomly (high exploration), but their trajectories merge, as a sign of reciprocal approach (5.4b-center). The prevalence of exploration results in a relative trajectory in the center-top-right area (5.4b-right).
- $P_h = 0.9$ (Figure 5.4c). The agents appear (extremely) phobic and manifest a very high activation of attachment and caregiving (need). Consistently, they stay in very close proximity (5.4c-left). As a result, their trajectories overlap completely – interestingly, where the caregiver's objects are located, thereby stressing the caregiver's lead of the interactions and the child's renounce of exploration (5.4c-center). This pattern is emphasized by a relative trajectory concentrated in the center (5.4c-right).

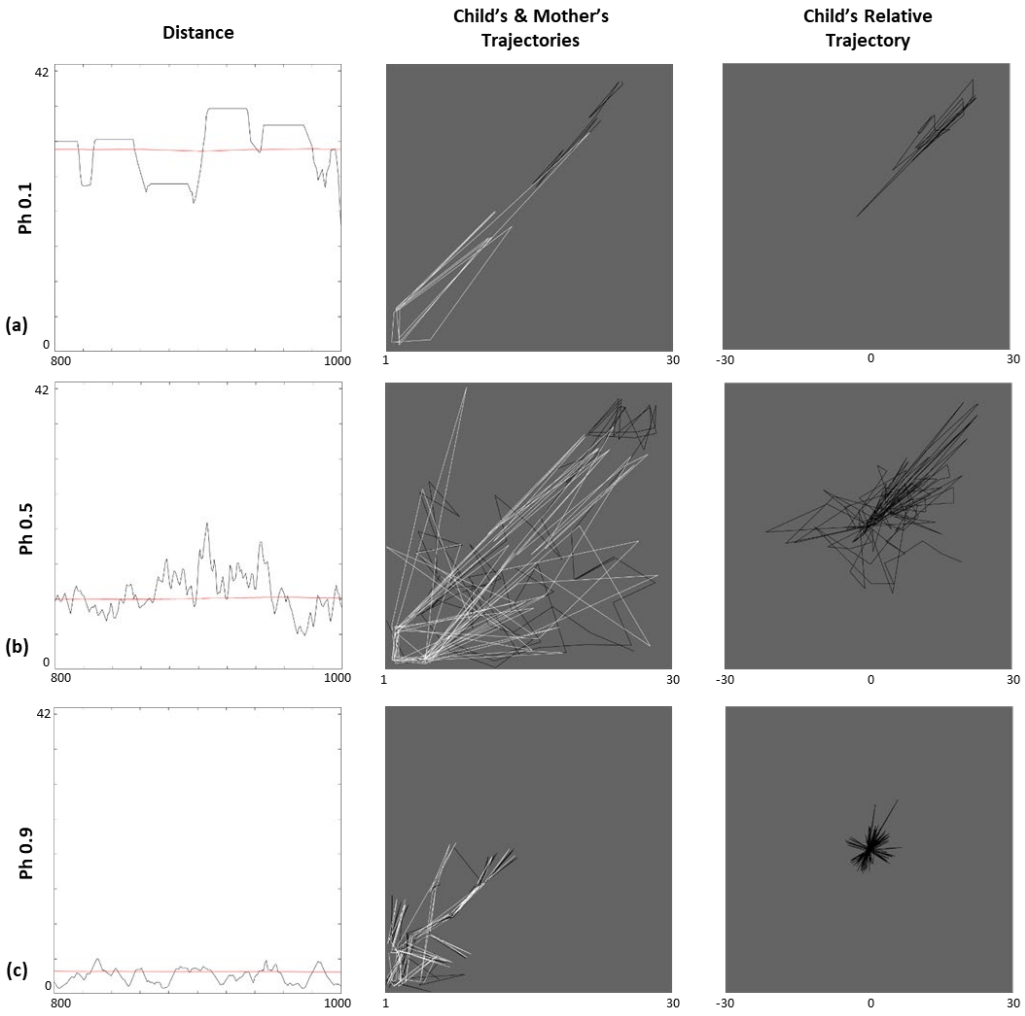


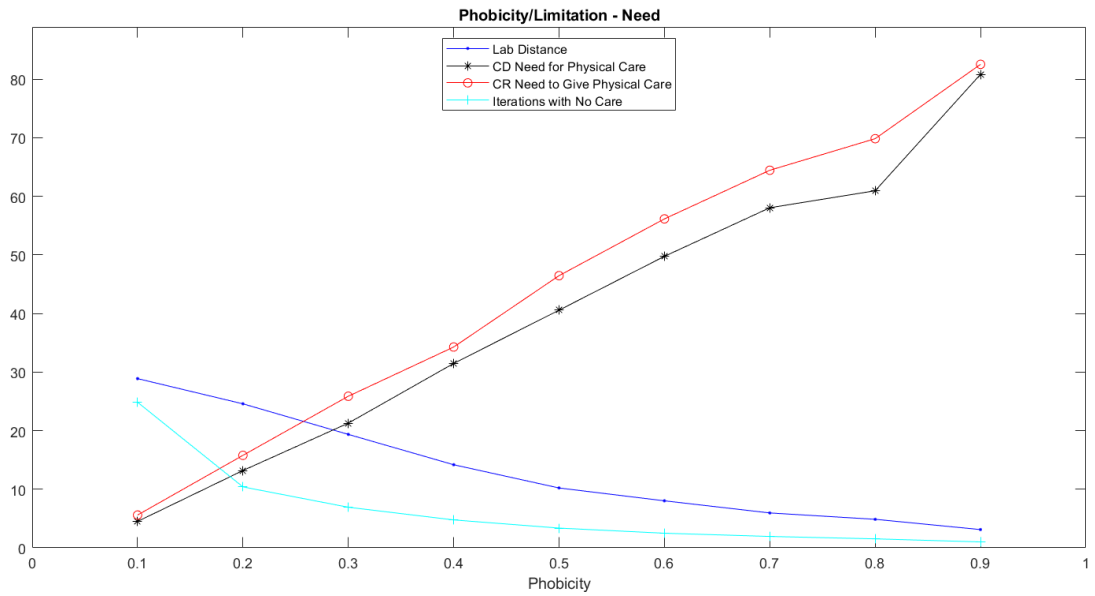
Figure 5.4. Behavior of phobic dyads for different dimensional levels.
Three phobic levels represent the (a) 'anti-phobic' ($P_h = 0.1$), (b) 'secure' ($P_h = 0.5$), and (c) (extremely) phobic ($P_h = 0.9$) cases in terms of the agents' trajectories (black for the child, white for the mother), child's trajectory relative to mother, and distances (smoothed with a moving filter). In the central-column pictures, the objects of interest for child and mother are located in the top-right and bottom-left corners respectively. All graphs refer to iterations 800-1000 (the last 200 of the simulations).

5.3.1.2. Trends of need and action

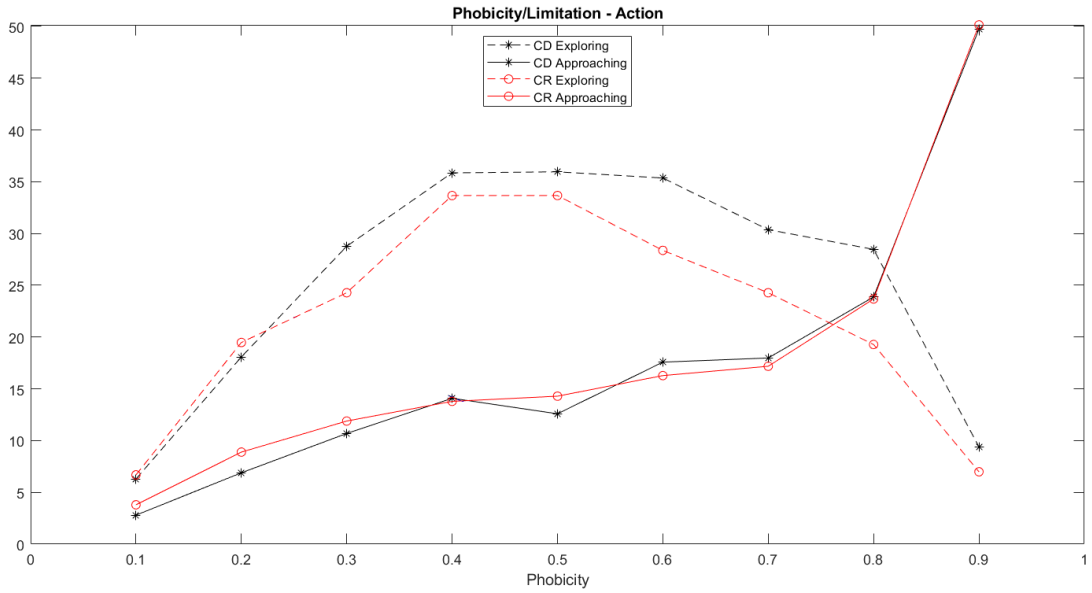
For phobicity, the same variables and conditions as with avoidance and ambivalence are considered. More specifically, the percentage values over 1000 iterations are reported for the following variables: (A) The need N – child's need to be protected (N_R) and caregiver's need to protect (N_G). (B) Explorative and approaching behaviors. Also, the mean values over 1000 iterations are reported for the distance between the two agents in the lab and the number of iterations with no provision of care.

Results are discussed considering increasing levels of phobicity/limitation (namely looking at the graphs from left to right) and reported by referring only to phobicity (black is used for the child, red for the mother).

Phobicity and limitation. Simulations yield a clear, and almost linear, increase of both the need to be protected and the need to protect (Figure 5.5a). In other words: the more the child is phobic, the more they need protection from the caregiver; the more the caregiver is limiting, the more they need to protect the child. In the less phobic case, the mean values are around 5% and, in the most phobic one, above 80%. Turning to explorations (dashed curves) and approaches (solid curves) (Figure 5.5b), the situation is different. Only from 0.5 on, explorations decrease and approaches increase monotonically (roughly, explorations 36% to 9% and 34% to 7%, and approaches 13% to 50% and 14% to 50%, for child and caregiver respectively). Below 0.5, there is an ascending monotonic trend for both. As discussed shortly, approaches and explorations are significantly affected by the context. Nonetheless, in this configuration, simulations generate a decreasing trend in terms of distance (blue curve) (Figure 5.5a), which here declines almost linearly (from a little below 29 to around 3). Therefore, the need and distance trends entirely reflect what is expected from a phobic dyad, and those of approach and exploration are consistent with them and the context. Accordingly, the number of iterations with no provision of protection declines (cyan curve) (Figure 5.5a).



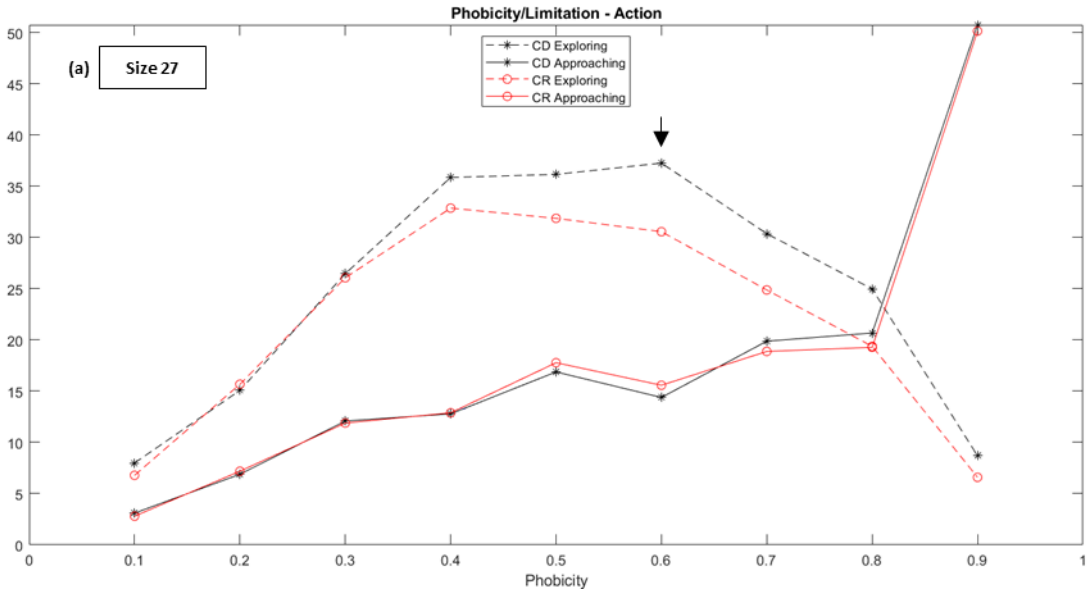
(a)

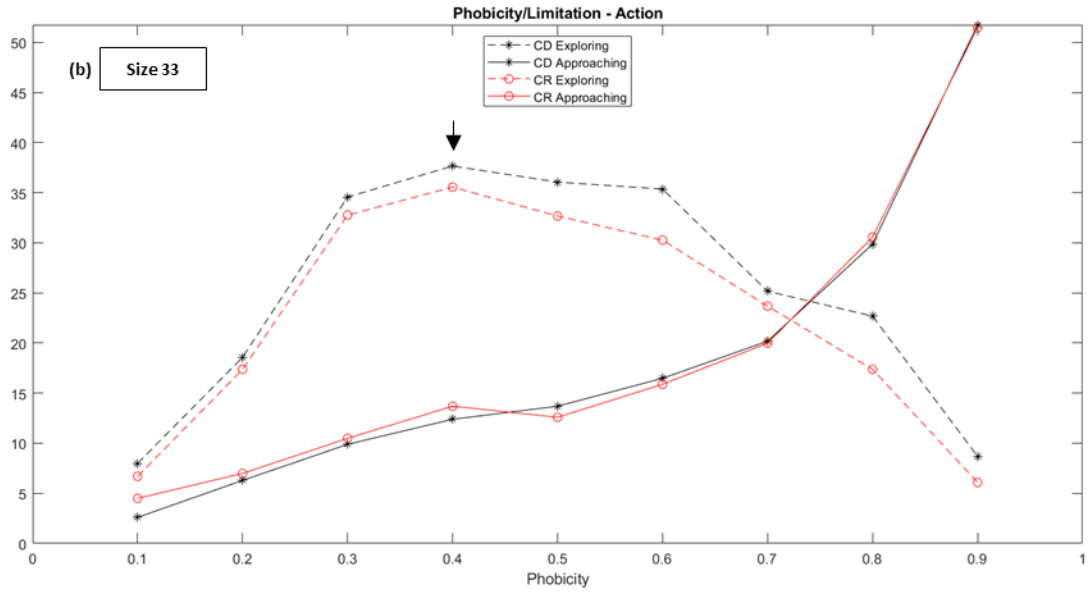


(b)

Figure 5.5. Phobic case: Need and action.
The graphs represent characteristics for the child (black curves) and the caregiver (red curves) for values of phobicity (P_h) and limitation (L_i) ranging between 0.1 and 0.9 (with step 0.1). The blue curve represents the distance between the child and the caregiver. The cyan curve represents the number of iterations without caregiving, i.e. provision of protection. In particular, as P_h and L_i increase: it is shown that: (a) The need for protection (felt by the child) and the need to protect (felt by the caregiver) increase. (b) In general, exploration (dashed curves) and approaches do not have a monotonic trend. From phobicity 0.1 to 0.4, they both increase. On the other hand, from phobicity 0.5 on, the child and the caregiver decrease their exploration while they increase their approaches. These trends produce a constant decline of distance, which is the necessarily expected behavioral pattern. These phenomena are entirely consistent with what the literature describes.

Context effect. As stressed above, although the distance shows the necessary monotonic reduction over the entire range of phobicity levels, approach and exploration trends are not monotonic as one might expect. They do not need to since phobicity is about distance. For any set of given distancing targets, they can change depending on the context, especially the space available, to produce the necessary outcome. For instance, compared to the above-discussed reference case (lab size 30) where the peak of child's explorations is at 0.5, a 10% decrease of the lab size (from 30 to 27) moves the peak right to 0.6 (Figure 5.6a), while a 10% increase of the lab size (from 30 to 33) moves it left to 0.4 (Figure 5.6b). An increase of a little over 20% (size 37) brings the peak further left to 0.3 (Figure 5.6c). Intuitively, enlarging the lab size allows for a rise in exploration. However, multiple other factors – such as speed and vision of the agents – will affect the balance that allows the decreasing distance trend to be maintained across the full range of phobicity levels.


Phobicity/Limitation - Action
(a)
Size 27
CD Exploring
CD Approaching
CR Exploring
CR Approaching
Phobicity


Phobicity/Limitation - Action
(b)
Size 33
CD Exploring
CD Approaching
CR Exploring
CR Approaching
Phobicity

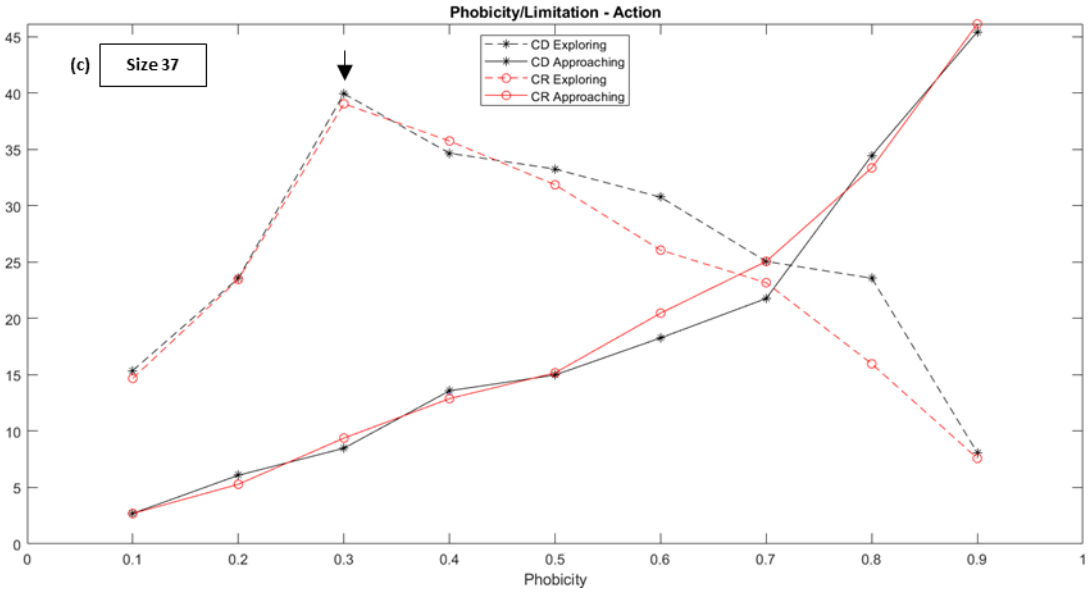

Phobicity/Limitation - Action
(c)
Size 37
CD Exploring
CD Approaching
CR Exploring
CR Approaching
Phobicity

Figure 5.6. Phobic approaches and explorations with reduced and augmented lab size.
Approach and exploration trends depend on the context. Compared to the standard case (size 30) (Figure 5.5b) – which shows a child's exploration peak at 0.5 – here, the lab size is (a) decreased by 10% (to 27), (b) increased by 10% (to 33), and (c) further by around 20% (to 37). In (a), the peak is at 0.6, in (b), at 0.4, and in (c) at 0.3. Increasing the lab size allows for more exploration when the agents want to. In all cases, need and distance trends remain the expected phobic ones.

5.3.1.3. Simulated vs expected trends

As with avoidance and ambivalence, the literature provides qualitative indications about what is to be expected in the phobic case – in terms of internal states and observable behaviors (cf. 5.1.1, Figure 5.1). The compliance of the obtained results with such expectations is confirmed by the comparison of simulated need, and distance trends (solid) with the expected trends (dashed) (in black for the child, in red for the caregiver) (Figure 5.7). Both for the need (Figure 5.7a) and distance (Figure 5.7b), the simulated trends match those expected. Again, it must be noted that the expected trends are indicated by lines only for convenience – since the actual functions connecting dimensional level and need and distance are unknown. The issue of obtaining a quantitative match between simulation results and available data was discussed above (cf. 4.4.2).

The compliance of the above results with what expected according to the literature (Figure 5.1) is confirmed by the comparison of simulated need and distance trends (solid) with the expected ones (dashed) (in black for the child, in red for the caregiver) (Figure 5.7). Both for the need (Figure 5.7a) and distance (Figure 5.7b), the simulated trends match those expected.

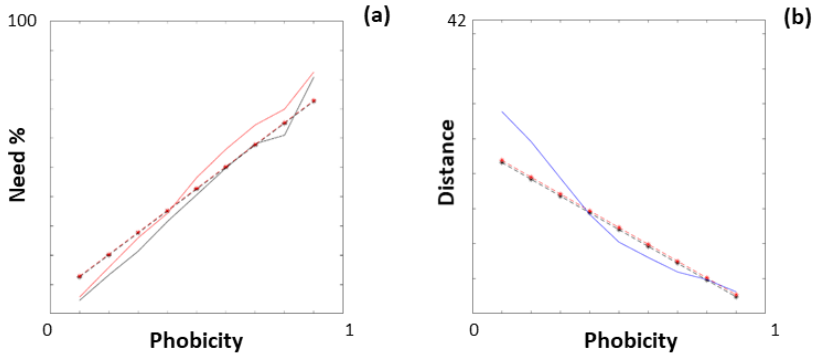


Figure 5.7. Need and distance trends: simulated vs expected.
The graphs represent the simulated need (a) and distance (b) trends (solid) compared to the expected ones (dashed) (in black for the child, in red for the caregiver) (distance in blue). The simulated trends match those expected.

5.4. Discussion

The avoidance-ambivalence ACM was here extended to represent phobicity. The model could support this dimension with no feature additions. Indeed, phobic interactions required the implementation of the vulnerability (as either felt by the child or perceived by the caregiver), which was assessed from the distance between the agents. In general, the model contribution, its limitations, and the future work suggested for the two-dimensional version remain unaltered for the three-dimensional one. However, some comprehensive considerations are here added.

5.4.1. Contribution

The three-dimensional ACM implements the APT representational and dimensional perspective considering avoidance, ambivalence, and phobicity. Consequently, attachment works as a representational controller over such dimensions. Simulations are compared with psychological data using the need felt by the agents and their behaviors with results that support the validity of the theory and can be considered a proof of concept.

Psychological and behavioral variables. For each dimension, the agents use a behavioral variable (observable in the lab) to build a psychological variable (in the mind), i.e. a dimension-related representation. The agents' psychological variables are the emotional separation (S_E), the perceived distance (D_P), and the (perceived) vulnerability (V), which are built from the behavioral variables indifference (i) – the proportion of caregiver's explorations – and distancing (d) – the distance between the agents. Focusing on attachment:

(1) The avoidant child sees the explorations of the caregiver as a cue of emotional rejection from which they derive their level of emotional separation.
(2) The ambivalent child sees the distance of the caregiver as a cue of physical unavailability from which they derive their level of perceived distance.
(3) The phobic child sees the distance of the caregiver as a cue of lack of protection from which they derive their level of vulnerability.

The relationships between behavioral and psychological variables (eq.s 4.8, 4.9, 5.4) are expected to depend on the interaction context and the dyad. They play the key role of creating the mental representations that, according to the APT, determine action by being compared with the corresponding stored ones (A_v, A_m, P_h). Consistently with this representational view, the same behavioral variable – here, the distance between the agents – can be interpreted in different ways depending on the situation. In this case, the distance is seen in terms of (1) availability when

ambivalence is active and (2) protection when phobicity is active. This differential interpretation corresponds to attributing a 'personal meaning' to events, which is crucial in determining real-life action (Guidano and Liotti, 1983; Guidano, 1987; 1991; Picardi et al., 2004; Guidano, 2007; Nardi and Bellantuono, 2008).

Approach, exploration, and distance. While in the avoidant and ambivalent cases, approach and exploration rates were to be considered to determine the compliance with the real behavioral patterns, in the phobic case, distance is the variable that determines such compliance. Overall, the need and distance curves characterize phobicity, and, as the results show, they comply with the phobic patterns described in the literature. As phobicity grows, the attacher feels more vulnerable without the caregiver – i.e. more in need of protection – and, consequently, keeps closer to them to be protected. Symmetrically, the caregiver becomes more protective – i.e. in need of providing protection – and, consequently, more limiting by keeping closer to the attacher. However, the behavioral compliance of the model is also supported by consistent approach and exploration rates. Closer proximity can be expected to correspond to a higher rate of approaches and a lower rate of explorations. But with this respect, the agents' targets and the context (e.g. the size of the lab) play a major role in affecting the actual rates of approaches and explorations needed to maintain the target distance (cf. 5.3.1.1, 5.3.1.2).

Three personality traits. The comparison of the simulations of the three implemented dimensions – avoidance, ambivalence, and phobicity – offers a snapshot of the implemented representational-dimensional theory. In particular, the child's and mother's trajectories suggest how the behavioral patterns observed in reality can be generated by the action of different dimensions (Figure 5.8).

- $A_v, A_m, P_h = 0.1$. The anti-avoidant, -ambivalent, and -phobic patterns (Figure 5.8a) represent extreme cases that seem to correspond to dysfunctional conditions not usually investigated in attachment research (cf. 4.4.1). In particular, the anti-phobic over-distancing appears as the phobic hyper-exploration described in the literature (Guidano, 1991; 2007), which can be seen as a regulation strategy where exploration is used to inhibit attachment (cf. 1.5.1.3, 2.4.3).
- $A_v, P_h = 0.5, A_m = 0.4$. The 'secure' patterns (Figure 5.8b) are similar to each other and correspond to a functional balance between attachment and caregiving. They are, however, characterized by the dimension they belong to in terms of approach, exploration, and distance.
- $A_v, A_m, P_h = 0.9$. The extremely avoidant, ambivalent, and phobic patterns (Figure 5.8c) show that these dimensions have very different characteristics.

> The emotional independence of avoidance generates high autonomous exploration, the ambivalent preoccupation for non-attendance generates the child's chase of the caregiver, and the phobic sense of vulnerability generates the reciprocal effort to maintain proximity. The APT explains how these behavioral characteristics derive from imprinted representations (Table 1.3) that forge one's personality (cf. Chapter 1).

Overall, given a dimension, the patterns from the lowest to the highest level show that any observable behavioral configurations can stem from a dimension activation. And similar configurations can be generated by different dimensions – i.e., similar patterns can result from very different reasons (e.g. $A_v = 0.1$ and $P = 0.9$). Following the APT, this suggests that, to correctly reproduce behavioral patterns, such dimensions need to be considered. In particular, the infant secure-base patterns generated by the activity of avoidance and ambivalence are not the opposite expressions of the same caregiving feature as the early SAT suggests. The child's trajectories relative to the mother represent such secure-base patterns (although the ACM mother constantly moves) and confirm the different dimensional nature of the dyad's functioning (Figure 5.9).

Attachment module and dimensional submodules. The ACM implements an APT-informed attachment module consisting of one submodule for each dimension (cf. 2.4, 4.2.1, 5.2.1). Three different attachment dimensions derive from three corresponding caregiving features. When a dimension is active – i.e. the attachment relationship is underpinned by such a meaning – then the corresponding internal states and action patterns unfold. If the emotional connection is salient in the current relational context, then the attacher's avoidance and the caregiver's insensitivity will be active and direct the interaction accordingly. In particular, the attachment control system will be driven by the goal set by avoidance. Similarly, if the availability of the caregiver is salient, then ambivalence will set the goal and, if the location of the caregiver in relation to danger is salient, then phobicity will. Developmental and clinical literature suggests that usually the attacher is considerably more sensitive to one or few dimensions (cf. 1.4.1, 1.4.2), which characterize the relationship. Therefore, overall attachment patterns are the result of the activation of multiple dimensions and should be more conveniently studied by considering the influence of each of them.

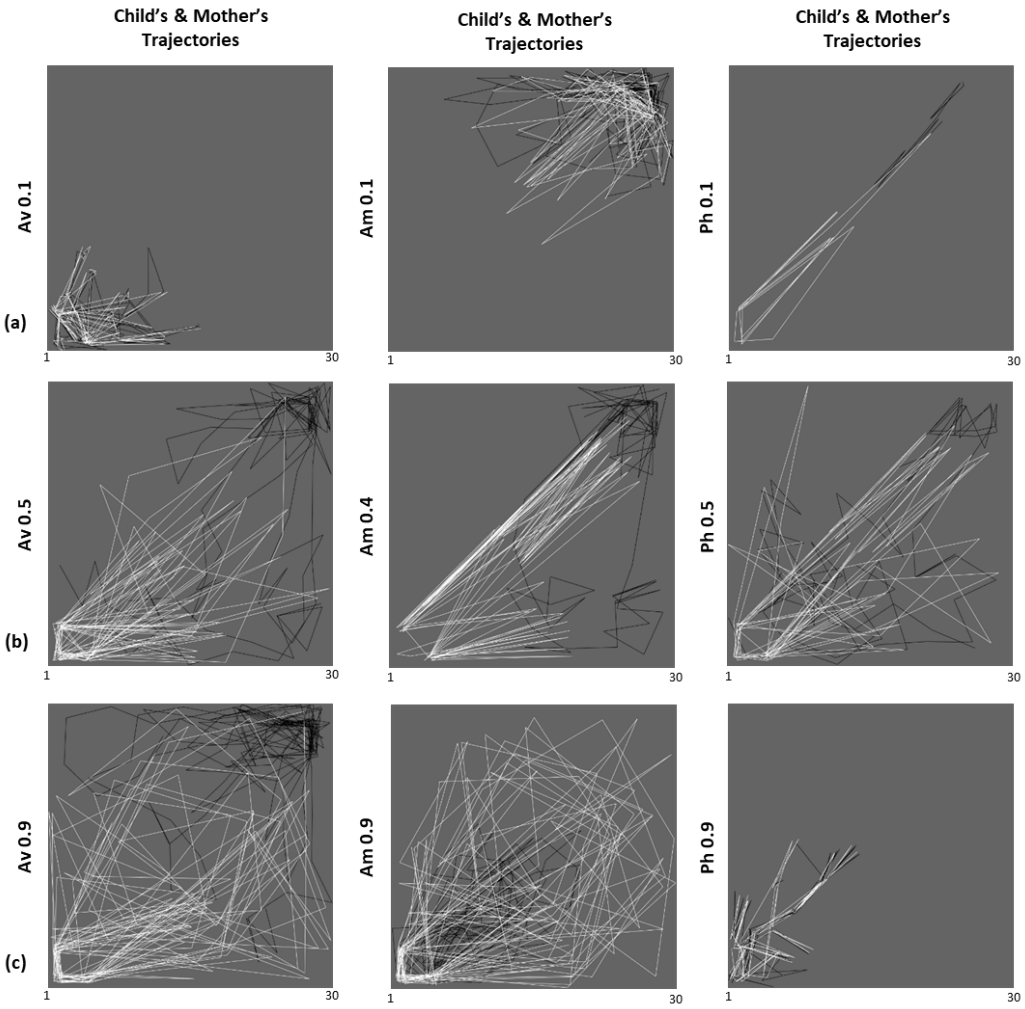


Figure 5.8. Three personality traits.

The picture compares the trajectories of avoidant (left column), ambivalent (central column), and phobic (right column) child and mother for (a) very low, (b) mid, and (c) very high dimensional levels. The stored dimensional representations represent personality traits and generate characteristic behavioral patterns.

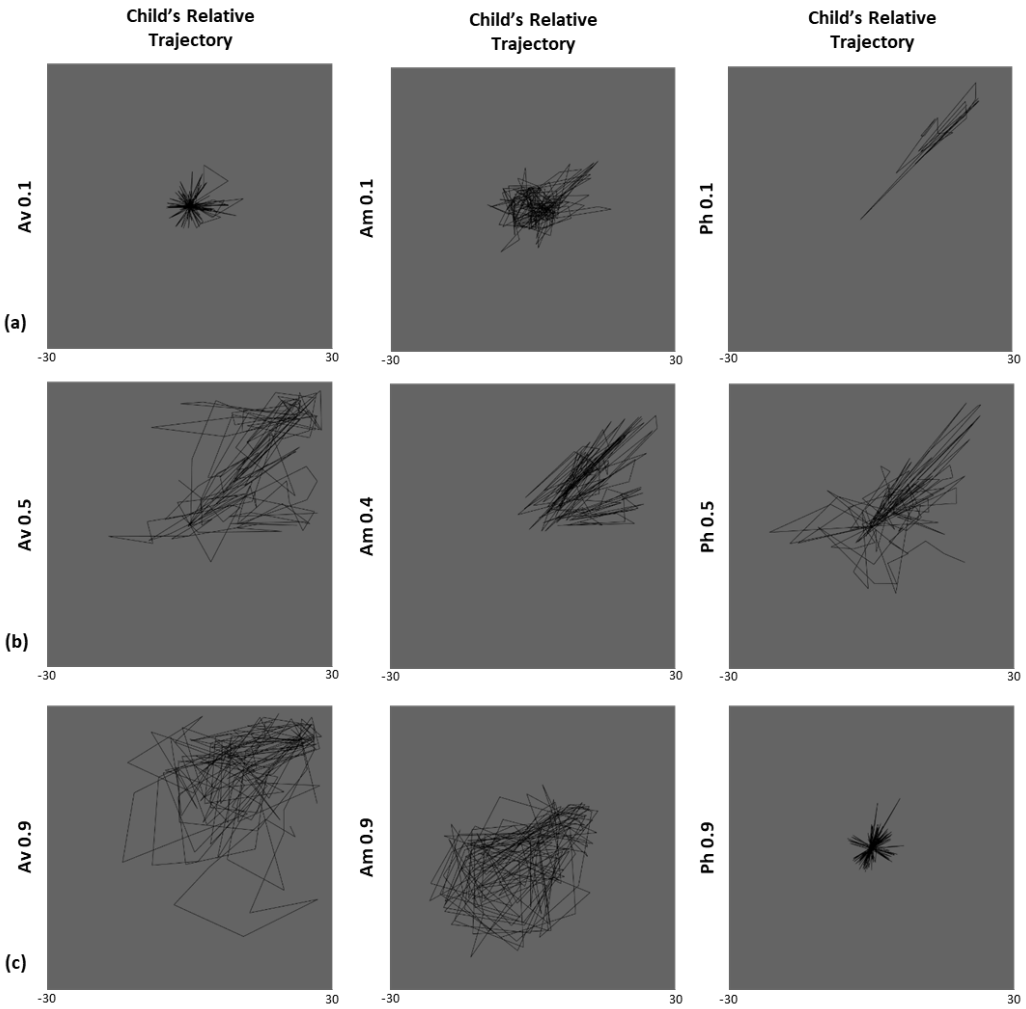


Figure 5.9. Secure-base patterns.
The picture compares the child's trajectories relative to mother in the avoidant (left column), ambivalent (central column), and phobic (right column) cases for (a) very low, (b) mid, and (c) very high dimensional levels. Although the mother moves, these trajectories represent the child's secure-base patterns and illustrate their dimensional dependence.

5.4.2. Limitations and future work

The discussion of limitations and future work for the two-dimensional ACM also holds for the three-dimensional one. However, in regard to phobicity, two additional considerations can be made. First, it is worth noting that the definition of phobicity entails a double sensitivity. The phobic not only tends to feel a sense of vulnerability when far from the caregiver but also a sense of constriction when close to them. In this first implementation, constriction was ignored, assuming that typically the phobic child does not act when feeling constricted. Therefore, the model could be extended to account for this case. Second, phobic interactions could only be supported by assessing vulnerability through the distance. No other variable seemed to be a valid proxy for the caregiver's capability to protect and the child's sense of vulnerability. An

upgraded version of the model could allow creating such representations from additional cues – as body language, for example.

Conclusions

The Attachment Computational Model (ACM) implements the Attachment-Personality Theory (APT), which enhances the Standard Attachment Theory (SAT) through a representational and dimensional perspective. The APT conceptualizes attachment as an information processor and control system. In particular, information about the attachment relationship over seven dimensions is detected and imprinted to be used as a set-goal to direct action. In other words, attachment works as a multidimensional representational controller. To test this conceptualization, three dimensions have been modeled by this first realization of the ACM: avoidance, ambivalence, and phobicity. In this chapter, I presented the implementation of phobicity by relying on the one of avoidance and ambivalence presented in the previous chapter. Overall, simulations are fully compliant with the APT representational and dimensional perspective, which is expected to overcome some relevant limitations inherent in the early SAT.

Conclusions

This research explored human nature and its extensibility to artificial agents. What makes us 'us'? While trying to give an answer to this question was certainly beyond the scope of this work, I believe that its subject – attachment – is an essential part of such an answer. If this is the case, then understanding attachment more deeply and implementing it on an artificial agent can significantly contribute to making a machine more human.

I presented the Attachment-Personality Theory (APT), a novel theoretical framework to understand human attachment, and provided its first empirical testing and proof of concept. The theory received confirmation from both a clinical test – through the Attachment-Caregiving Questionnaire (ACQ) (cf. Chapter 3) – and a computational one – through the Attachment Computational Model (ACM) (cf. Chapters 4, 5). Both the theory and its testing connect two disciplines that are usually considered not to have much in common: clinical psychology and engineering – the latter especially in the form of computational modeling. I conclude this work by remarking on the multiple and deep connections that I see between them and how I think this research can contribute to strengthening them.

1. A clinical theory suitable for computational modeling

This project built upon the well-established ground of attachment theory and, at the same time, challenged it. The APT is an enhancement of the Standard Attachment Theory (SAT) (Cassidy and Shaver, 1999; 2008; 2016) that adopts a cognitive-clinical approach. It focuses on the representational and dimensional nature of attachment and proposes new solutions to problems that the SAT seems not to find the resources to solve: (1) intergenerational transmission, (2) stability, and (3) psychopathology. This research was aimed at testing this theoretical framework both clinically and computationally.

The APT is fundamentally a clinical theory, which – besides Bowlbyan attachment theory (Bowlby, 1969/1982) – has been inspired by Liottian cognitive-evolutionary (Liotti et al., 2017) and Guidanian post-rationalist (Guidano, 1991) clinical approaches. As a result, it endorses evidence-based cognitive psychotherapy and is compatible with similarly-oriented psychoanalysis. Despite the value of clinical knowledge, such a resource seems very hardly translatable into computation. On the other hand, the

results and insights of computational modeling also usually appear difficult to make available to the clinician. This fact significantly impedes the scientific progression of clinical psychology and the compliance of computational modeling with clinical-psychological data. I believe that the particular perspective adopted by the APT can help reduce the distance between these disciplines. This work – especially through the implementation of the ACM (cf. Chapter 4, 5) – supported this idea and the APT's clinical-computational potential.

1.1. Why is clinical psychology important to computational modeling?

Informally, a theory can be thought of as a set of ready-made concepts and connections between them that can be applied to understand reality and act on it. In other words, theory drives action. If we want to reproduce human psychological characteristics on an artificial agent – a humanoid robot, for example – we need a theory of such characteristics. Human psychology is subtle and often hard to detect and measure. As a result, psychological theories usually have a lower degree of formalization compared to other sciences. Moreover, different psychologists focus on different aspects of the same phenomenon. Attachment theory, for instance, has mainly been developed by adopting a social or developmental perspective – although Bowlby was actually a clinician. Clearly, different perspectives offer different conceptual frameworks to the modeler – different ready-made concepts that represent to them different realities to model.

The APT conceptualizes attachment from a clinical perspective and focuses on its representational and dimensional nature. These aspects, rather than the behavioral and categorical ones that are typically evident in observational contexts – such as the Strange Situation Procedure (SSP) (Ainsworth et al., 1978; Main and Solomon, 1990) – emerge more easily in clinical settings. The clinician that utilizes the tools provided by the APT focuses on the motivational dynamics that underlies behavior and on the corresponding beliefs that drive it. Attachment is both an intrinsic motivation and the engine that allows us to gather the fundamental socio-psychological information that constitutes the core of our personality: The Internal Working Model (IWM) and its seven attachment dimensions. In computational terms, this perspective represents attachment as an information processor and multidimensional control system where seven pieces of imprinted data set the goals of action.

The computational implementation of attachment developed here focuses on these aspects rather than on those more evident to an external observer of attachment-caregiving exchanges. The secure-base dynamics that characterizes the first explorative attempts of an infant in the presence of their mother soon appeared clear

and drew attention to behavior and its classification. Following this early observational approach, until now, computational modelers have mostly focused on the behavioral and categorical aspects of attachment. However, according to the proposed perspective, behavior is primarily driven by implicit knowledge, and categories are produced by several dimensions. By utilizing the ready-made tool provided by the APT, three dimensions of attachment were modeled, thereby showing that the theory is operationalizable and can lead to simulations that are both compliant with observable patterns and beneficial to the understanding of the phenomenon. Therefore, this work substantiates the idea that clinical psychology – and in particular the APT – can offer a useful perspective to the computational modeler.

1.1. Why is computational modeling important to clinical psychology?

As Petters (2019) points out, Bowlbyan attachment theory was born with the requirement of gaining the 'scientific respectability' that the Freudian psychoanalysis based on untestable retrospective accounts could not warrant. Scientific respectability is now considered an essential condition for clinical psychology as well as attachment theory. However, although clinical psychology can count on solid scientific methods, computational modeling seems not to be part of them. I think that this should not be the case since the advantages that can be brought to the discipline are significant. In the words of Petters:

"A lot of clear thinking has to go into creating running simulations. For theories of psychological phenomena to be run on a computer requires in those theories precision and explicitness in description and a process of formalization which highlights possible logical flaws, inconsistencies, lacunae, hidden assumptions or unexpected complexities about the processes being modelled. In addition to this welcome rigor, the overall process promotes serendipitous discoveries because running simulation can produce unforeseen behaviour" (Petters, 2019, p.237).

Computational modeling poses much stricter constraints than those clinical psychological thinking usually needs to meet. For example, the dynamics involved in an avoidant relationship needs to be examined to its fine details. The time spent without receiving care has to be continuously monitored, a drop of need for care has to occur in precise circumstances, a rate of exploration has to rise in those circumstances, etc.. All the involved variables, parameters, and their relationships must be precisely defined. Random interventions must be accounted for as well. The outcome of such a minute thinking is twofold. The implemented theory undergoes a strict test and, at the same time, the provided representation of the simulated

phenomenon can bring to the attention aspects that usually are not considered by a clinician, thereby prompting revisions and new insights.

2. A clinical questionnaire suitable for artificial analysis

The bond between clinical psychology and computational modeling is not the only one endorsed by the APT. The theory is favorable to diverse Artificial Intelligence (AI) applications.

As a clinical theory, the APT called for some form of clinical testing. For this purpose, I developed the ACQ (cf. Chapter 3, Appendix A) – a self-report that works both as a clinical tool and a personality inventory. In accordance with the APT, the ACQ is designed to measure the f-IWM, i.e. the attachment implicit knowledge that constitutes the basis of our personality. This information was referred to as **'what we mean'**, to underline that it is what informs our 'personal meaning organizations' (Guidano, 1991). As a preliminary step for the development of the instrument, several of the most relevant SAT adult attachment questionnaires were reviewed (cf. 3.1.1.2), which aim at assessing the two dimensions avoidance and ambivalence. These self-reports all rely on the conscious statements given by the subjects through their ratings of the questionnaire items. Such language content was referred to as **'what we say'**. Usually, these tools are developed using factor analysis and have the same structure: two scales, whose items are meant, for each scale, to measure the same dimension (avoidance or ambivalence). However, there is reason to believe that these self-reports do not actually assess the implicit attachment knowledge. Or in other words, when it comes to attachment, what we say often differs from what we mean (cf. 3.1.3.1). It was argued that given the hierarchy of attachment knowledge and the ambiguous nature of language itself, the f-IWM cannot be assessed by only considering what we say. To express it through a brain-computer analogy, the minimal attachment knowledge hierarchy to be considered consists of firmware and software levels (cf. 3.1.3.2). The firmware (non-verbal knowledge, the IWM) is very hard to change and very influential. The software (verbal knowledge, language content), by contrast, is much easier to change and much less influential. Importantly, measures carried out through the Adult Attachment Interview (AAI) (George et al., 1985; Main and Hesse, 1990; Hesse, 2016) – the reference tool for the adult assessment of the state of mind with respect to attachment – do not correlate with those carried out by the adult attachment questionnaires. AAI and self-reports assess different things (cf. 3.1.3.2). In fact, the AAI is designed to catch the unconscious by relying on something that goes beyond language content: the coherence of speech. Since the ACQ – like the AAI – aims to measure the implicit attachment knowledge, its conceptualization had to take into account – especially in terms of structure (cf. 3.1.3.4) – that such

knowledge cannot be reached by relying on language content alone. The questionnaire was endowed with multiple sections and subsections that allow for the extrapolation of implicit information by finding meaningful answer patterns across different scales and sections – thereby going beyond the basic scales. In other words, the clinician can assess the f-IWM through a more complex pattern recognition. This cannot be done on a self-report based on the extraction of a minimal number of factors.

This argument was corroborated by the conducted statistical analysis (cf. 3.3.3.4). A Principal Component Analysis (PCA) performed on the ACQ scales provided preliminary support to the APT and confirmed the necessity of a more powerful analysis for an attachment questionnaire. The PCA works as an elementary pattern recognizer that provides useful but insufficient information. For example, the analysis of the attachment section of the ACQ (Q_A) suggested extracting two components: one related to 'threat' and the other to (emotional) 'disconnection'. Although this information is correct – i.e. entirely consistent with the theory – the two-factor distinction is not discriminative enough. The scales are theoretically and clinically so different that reducing them to two main factors appears inadequate. The only way to overcome this issue seems to use a more sophisticated pattern recognizer in order to analyze the ACQ as a clinician does. AI – in the form of a neural network, for example – was hypothesized as a viable and convenient solution. Combining APT and AI through the ACQ could not only provide a further test for the theory but also indicate new directions of development.

3. Limitations and future work

The most evident limitation of this research is venturing into uncharted territory. The APT is a novel theory and, although it is based on consolidated attachment and clinical traditions, it proposes an original perspective and hypotheses that had never been tested before. In accordance with the scientific blueprint of the theory, a long testing phase will be necessary.

With this respect, both the ACQ and the ACM were built from scratch. To the best of my knowledge, there is neither a clinical questionnaire with a similar design or purpose nor a similar computational model based on attachment dimensions. Moreover, a large sample should be used to analyze the ACQ through both the classical factor-based procedure and more advanced pattern recognition. Therefore, this research represents only a small fraction of the testing work that needs to be done. Overall, the multiple disciplines and aspects involved in this work suggest a

considerable number of applications and future work, for which I consider here some possible directions.

3.1. Further development of the APT

The APT is a clinical theory and, as such, it can be immediately applied to the understanding and treatment of mental disorders. Therefore, the most obvious suggestion for future work is to use the theory for clinical purposes and further develop it. Case studies in the clinical setting offer the chance for both getting new insights and testing the current formulation through direct feedback. But those from the literature can also provide valuable data. In any case, systematic clinical testing on large numbers of case studies is essential. The theory adopts concepts and provides tools – such as the ACQ – that can be used to measure its performance by applying formal methods of analysis.

3.2. Further analysis and application of the ACQ

As discussed above (cf. 3.3), the ACQ was statistically analyzed on a limited sample of 51 participants, which was not sufficient to perform a PCA of the entire set of items (Q_A consists of 125 items, while Q_{CM} and Q_{CF} of 83 each). According to the literature, such analysis would require at least 500 participants (Bandalos and Boehm-Kaufman, 2009; Rouquette and Falissard, 2011). However, since the PCA is expected to provide only superficial/partial information, the use of an artificial pattern recognizer was suggested instead (Duda et al., 2000; Bishop, 2006), which could simulate the work of a clinician.

Besides this, another exciting AI application can be considered for the developed clinical questionnaire, using Explainable Artificial Intelligence (XAI) (Gunning et al., 2019) – the very recent area of AI that tries to look inside the neural network 'black box' and explain how it actually works. The ACQ could be coupled with a network to develop an XAI system and a 'lab' of synthetic psychology (Braitenberg, 1984; Dawson, 2004; Prescott, 2015; Prescott and Camilleri, 2018), as illustrated below (Figure 1). In this application, after the questionnaire is administered to a human sample, a personality profile is obtained both through human processing (according to the APT) (upper part of the diagram) and through artificial processing (lower part of the diagram). The comparison between data coming from the two kinds of elaborations can allow for: (1) identifying the parts of the network that implement the attachment dimensions (to create a ‘bio-inspired’ neural network) (XAI) and (2) gaining further knowledge about attachment in humans (synthetic psychology). In other words, applying AI to the questionnaire can allow making sense of the neural network content and enhancing psychological knowledge.

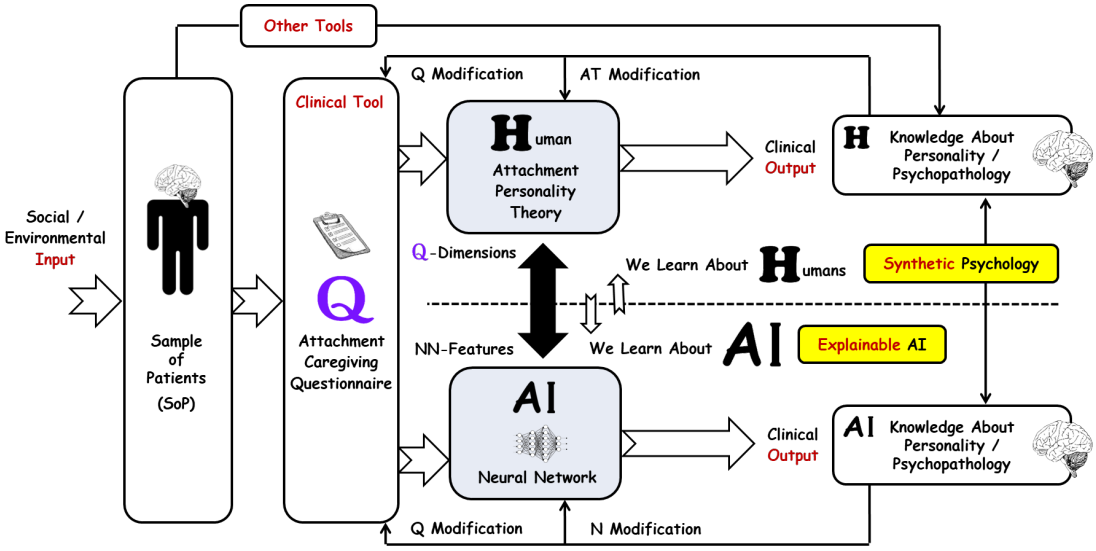


Figure 1. The Attachment-Caregiving Questionnaire in conjunction with an AI system.
The ACQ is administered and analyzed by both natural and artificial means. The result is a twofold advantage in terms of XAI and synthetic psychology.

This application represents a further possibility to tighten the connection between clinical psychology and engineering.

3.3. Extension of the modeling work

Following the APT, the ACM expresses the interactions between attacher and caregiver as driven by representation. In particular, the imprinted dimensions provide the goal of action. This conceptualization was applied to three of them and can be extended to the remaining four with the ultimate objective of integrating the ACM into a general cognitive architecture, as discussed above (cf. 4.4.2). These extensions further illustrate the relationship between clinical psychology and computational modeling.

3.3.1. Extension of the ACM to other dimensions

To implement the remaining dimensions – disorganization, depressivity, somaticity, and obsessivity – the current version of the ACM needs to be enhanced.

Disorganization. This dimension is defined as the subjective measure of how much the caregiver is frightening. It is conceptualized as deriving from the conflict between the two incompatible motivational systems of attachment and defense. The child is caught by the unsolvable dilemma of either looking for care or protecting themselves from a reference figure who is, at the same time, a caregiver and a threat. The consequence is the activation of the two incompatible systems. To simulate disorganization, the ACM needs to implement a caregiver-agent able to be threatening and a child-agent

able to act defensively – flee, for instance. Moreover, disoriented or contradictory actions need to be generated simultaneously or in a rapid sequence.

Depressivity. This dimension is defined as the subjective measure of how much the caregiver is emotionally unreachable. It is related to the emotional unresponsiveness of the caregiver – a feature that starts to be relevant when the child develops the capability of realizing they ask for emotional connection. Therefore, the simulation of depressivity needs an ACM enhancement that allows representing the request for emotional connection and its perceived rejection. This situation is most often related to the loss or prolonged absence of the caregiver. For example, the caregiver-agent should be able to leave the lab for a long time and possibly come back.

Somaticity. This dimension is defined as the subjective measure of how much the caregiver is defining in terms of internal states, such as emotions and thoughts. Since the current ACM does not support the representation of any internal states involved in somaticity, it cannot simulate this dimension. Moreover, somaticity is related to the respect of social standards, which implies the introduction of additional agents and feeling ashamed.

Obsessivity. This dimension is defined as the subjective measure of how much the caregiver is judgmental. As with somaticity, for an adequate simulation, obsessivity requires an ACM upgrade to represent related internal states. The caregiver's blame implies their adherence to a code of conduct and its imposition on the child. Therefore, the caregiver needs to distinguish between the child's right and wrong actions. At the same time, the child needs to feel guilty for a wrongdoing. For example, an area of the lab may be marked as forbidden to the child.

These kinds of interactions often involve the participation of the attachment module in a broader motivational dynamics, which would be facilitated by integrating it into a general cognitive architecture.

3.3.2. The ACM as part of a cognitive architecture

The attachment module implemented by the ACM is designed to be part of a general cognitive architecture (Figure 2). Such architecture can be conceptualized from different perspectives, and at least two of them can be considered: a clinical and computational one – which can help further demonstrates the relationship between clinical psychology and computational modeling.

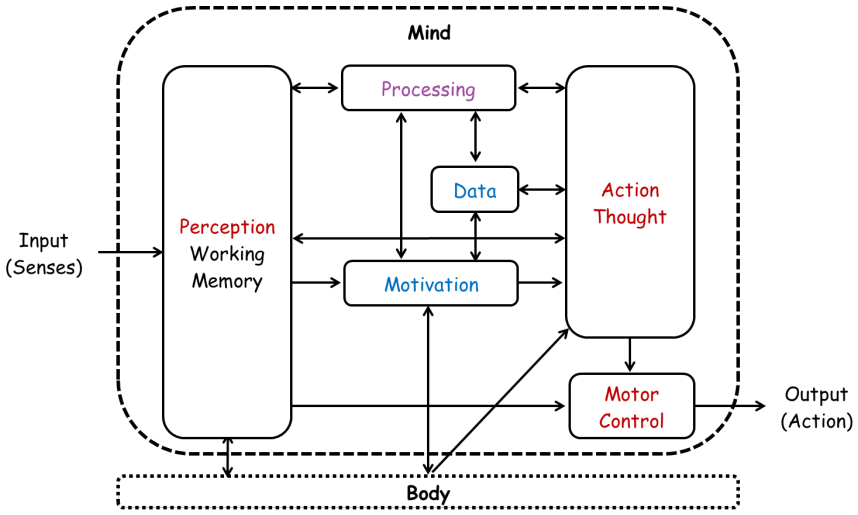
(a) A clinical architecture needs to outline the most clinically relevant modules – motivational and data systems – and their role in the general design of the mind, e.g. for the generation of conscious and unconscious thought (Carruthers, 2006) (Figure

2a). External signals enter the mind through the perception systems, i.e. the working memory (Baddeley, 2000), and the processing systems perform unconscious elaboration on the perceived information. The motivational systems drive action by considering multiple internal and external sources, with an important role played by the data systems, which store information. This is especially true in the case of attachment and its f-IWM. When a motivation is selected, a corresponding action is conceived of by the action thought systems and possibly implemented by the motor control systems. Importantly, according to this perspective, the brain is a massively modular system that basically works as an unconscious parallel machine through its processing systems. However, the working memory – our perceptual consciousness – allows for the implementation of conscious and serial thought by functioning as a common workspace where the processing systems can direct their outputs to be shared with each other.

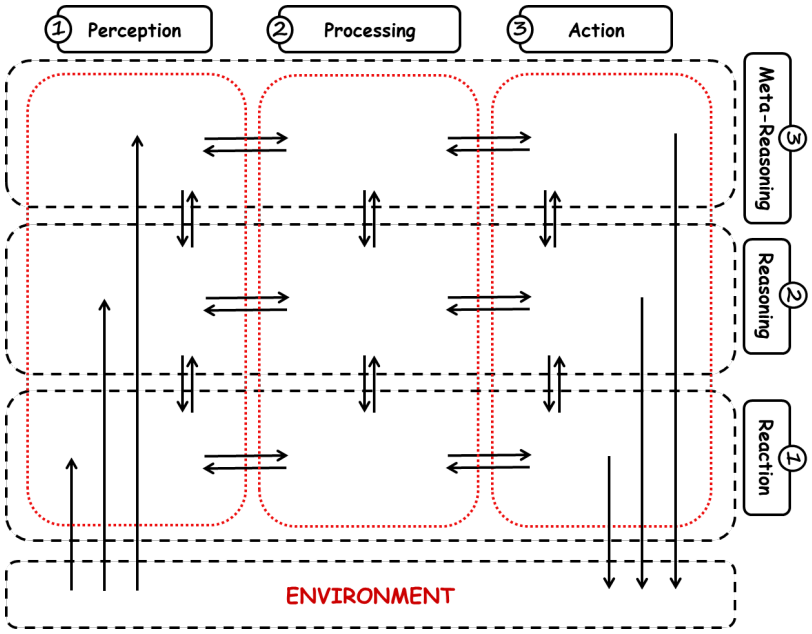
(b) A computational architecture needs to implement the structure and function of the mind as an information processor and control system (Bowlby, 1969/1982; Petters, 2019) (Figure 2b). Given its operative conception, a natural extension of the ACM is to integrate it into such an architecture. With this respect, a particularly suitable platform is the CogAff (Sloman, 2008) – a general-purpose architecture that can be effectively particularized for representing attachment phenomena, as the studies from Petters demonstrate (Petters and Waters, 2015; Petters and Beaudoin, 2017). The CogAff consists of three control layers that perform operations on three columns (perceptual, central processing, action):

1. Reactive layer: implements direct flow of information from perception to central processing to action generation;
2. Management: adds deliberative planning (look-ahead reasoning);
3. Meta-management: adds self-reflective reasoning.

The integration of an ACM into this architecture would allow it to be part of a broader designed-based research project, which investigates mental phenomena through an architectural approach (Petters and Beaudoin, 2017). According to this perspective, in order to deeply understand the functioning of our mind, it is essential to outline the architecture that supports it and run simulations accordingly. This is exactly what this work encourages.



(a) Clinical architecture of the mind.



(b) Computational architecture of the mind.

Figure 2. Clinical and computational architectures of the mind.
(a) A clinical architecture of the mind. It represents the most relevant modules to clinical-psychological phenomena (motivational and data systems) and the overall general design of the mind. In particular, it illustrates the generation of conscious and unconscious thought. (b) A computational architecture of the mind. It represents mental computation through 3 layers (reaction, reasoning, and meta-reasoning) and 3 columns (perception, processing, and action). The CogAff is an example of such an architecture that realizes cognitive and affective processing.

For both the clinical and computational architectures, the brain is a physical machine that implements a virtual one: the mind. To further narrow the gap between clinical psychology and computational modeling, the two architectures should also be more closely related.

4. Final remark

Through a cognitive-clinical approach, the APT proposes an original perspective on attachment, according to which representations acquired over multiple dimensions control its expression and forge our personality. As illustrated, its hypotheses are testable using various methods, especially clinical and computational. Moreover, the clinical applications of the APT are suitable for integration with artificial intelligence. This work intends to promote the bond between these disciplines.

Appendix A

The Attachment-Caregiving Questionnaire (ACQ)

Below, the ACQ is reported in an offline version. Items are designed to be given multiple-choice answers, which are not included here. See Chapter 3 for a detailed description of the questionnaire.

	ACQ – Attachment-Caregiving Questionnaire
	This questionnaire is anonymous. We collect the following data for research purposes only. Please, insert a code to identify your questionnaire (e.g. your initials followed by a number or a word).
	[Section 1] Q_D – General Data
	Q_{DP} – Personal Data
1	**Sex**
2	**Age**
3	**Weight** in Kg Please, insert your weight in Kg rounding to the nearest ten. For example, insert 65 if your weight is 65,3 Kg or 92 if your weight is 91,7 kg.
4	**Height** in cm Please, insert your height in cm – for example, 162 cm or 185 cm.
5	**Education** Please, select your highest achievement. (The indicated ages are merely illustrative)
6	**Occupation**
7	**Nationality**
8	**Native Language**
9	If not English native speaker: Please, rate your English level
10	If not English native speaker: What is your Native Language:
11	**Children** Have you ever had children?
12	In this case: How many?
13	In this case: How old were you when you had your first child?
14	In this case: How old were you when you had your last child? Please, if you only had one child, just select the corresponding item from the list.
15	In this case: Are they all living?
16	**Siblings** Do you have or did you have any siblings?
17	In this case: How many?
18	In this case: Of your siblings, how old is (or was) the youngest compared to you?

19	In this case: Of your siblings, how old is (or was) the oldest compared to you? Please, if you only have (or had) one sibling, just select the corresponding item from the list.
20	In this case: Are they all living?
	Q_{DG} – General condition
1	**Psychological Well-being** **Do you think you currently suffer from any form of psychological discomfort?**
2	In this case: Can you select one of the items on this list, if any, that can describe – at least partially – the core of your discomfort?
3	**Have you ever suffered from panic attacks?** A panic attack is an event of acute fear and physiological activation in which one fears for their health or even life.
4	**Have you ever suffered from depression?** Depression is a period of exceptionally negative mood and thoughts, in which one feels they have no way out, no hope.
5	**Have you ever suffered from an eating disorder (anorexia, bulimia, and/or obesity)?** Anorexia is voluntarily maintaining an insufficient diet which leads to having an extremely low weight (much lower than the norm expected by gender and age). Bulimia consists of having binges (eating a lot in a short time) and trying to compensate for them with subsequent physical activity, laxatives, vomiting, and/or fasting. Obesity is maintaining an extremely excessive weight (far above the norm expected by gender and age). Here, it is understood that these disorders are not caused by physical problems.
6	**Have you ever suffered from an obsessive-compulsive disorder?** An obsessive-compulsive disorder is characterized by obsessions and compulsions. Obsessions are intrusive (namely, that come involuntarily and unwanted) ideas of very unpleasant and disturbing things. Compulsions are acts (physical or mental) that are performed repeatedly (as rituals) to get rid of the aforementioned intrusive ideas.
7	**Have you ever suffered from a post-traumatic stress disorder?** An event is traumatic for us when we perceive it as seriously health-threatening or even lethal – for us or a loved one – and it makes us feel helpless in that situation. A post-traumatic stress disorder is the disturbing and lasting consequence of a traumatic event that cannot be overcome.
8	**Have you ever received a formal diagnosis from a mental health professional?** (if not currently, in the past)
9	In this case: What (main) diagnosis have you received? We indicate below a partial and simplified list of disorders often diagnosed. If possible, please indicate the one corresponding to the (main) condition you have been diagnosed with.
10	In this case: Have you been diagnosed with an additional condition besides the main one? We indicate below a partial and simplified list of disorders often diagnosed. If possible, please indicate the one corresponding to the additional condition you have been diagnosed with – if any. Otherwise, please select 'No Additional Condition'.
11	**Have you ever been helped by (at least) a psychotherapist?** By 'psychotherapist', we mean a mental health professional who supports you – discussing with you – in tackling issues that are problematic for you.
12	In this case: Could you please select one of the items on this list, if any, that can describe the principal reason for being helped?
13	In this case: How long have you used psychotherapy altogether?
14	In this case: How do you rate the result of this experience?
15	**Physical Well-being** **Do you currently suffer – or think to suffer – from any serious physical-health issue?**
16	In this case: Could you please indicate the main problem? We indicate below a partial and simplified list of physical issues. If possible, please indicate the one corresponding to your main problem.
17	**Other Issues** **Is there any other issue – concerning you, other people, or your relationship – that currently seriously worries you?**
18	In this case: Could you please select one of the items on this list, if any, that can describe this issue?
19	**Current level of stress** **Overall, in this period, how do you rate your level of stress/concern?**
	Q_{DS} – Specific issues
1	**Constrictions** **Are you currently limited or constricted by the presence of someone you care about or their needs?**
2	In this case: Who is this person to you (or who are these people)? For example, mother, father, partner, sibling, friend, etc..

3	**Losses** **Have you recently suffered the loss of someone you cared much about, or do you have reason to believe you might lose them in the near future?** By 'loss' we mean passing away or a definitive separation.
4	In this case: Who is this person to you (or who are these people)? For example, mother, father, partner, sibling, friend, etc..
5	**Expectations** **Is there 'anyone' who is currently placing important expectations on you?** This 'anyone' can also be more than one person, or a social group, and even the whole of society.
6	In this case: Who is it that makes you feel this pressure? For example, mother, father, partner, office manager, sibling, my group of friends, society in general, etc..
7	**Care for loved ones** **Have you ever – for a period of your life – taken care of a loved one who suffered from a serious or even deadly health condition?** This experience may also have occurred to you more than once – for different periods, with different loved ones.
8	In this case: Who was this person to you (or who were these people)? For example, mother, father, partner, sibling, friend etc..
9	In this case: How long, overall, have you had this experience as a caregiver? If such an experience is still ongoing, please consider to date.
10	**Deep worry for loved ones** **Have you ever been – for a period of your life – deeply worried for a loved one who had a serious problem that put them in grave danger without being able to help them?** This is an experience out of the norm (or that should be out of the norm) that may have happened to you more than once – for different periods, with different loved ones.
11	In this case: Who was this person to you (or who were these people)? For example, mother, father, partner, sibling, friend etc..
12	In this case: How long, overall, have you had this experience of deep worry? If such an experience is still ongoing, please consider to date.
13	**Alcohol, Psychiatric Drugs, and Other Drugs** **Have you ever used psychoactive substances – in particular, alcohol, psychiatric drugs, or other drugs – that have had (or have) a significant effect on your psychological experience or your general functioning as a person?** A substance is psychoactive when it affects mental processes.
14	In this case: Could you please indicate the substance you have used (or are using) that has had (or has) the most significant effect on you or your life? We indicate below a partial and simplified list of substances. If possible, please indicate the corresponding one or its category.
15	In this case: Do you feel that the effect of this substance is present in the current period?
16	In this case: Could you please indicate an additional substance you have used (or are using) – if any – that has had (or has) a significant effect on you or your life? We indicate below a partial and simplified list of substances. If possible, please indicate the corresponding one or its category. Otherwise, please select 'No Additional Substance'.
17	In this case: Do you feel that the effect of this second substance is present in the current period?
	[Section 2] Q_A – Attachment
1	I currently have a romantic relationship
2	I have had at least one romantic relationship in my life
3	I think I have had at least one romantic relationship that has changed my character (positively or negatively) By 'character', we mean above all your way of living a romantic or affective relationship in general.
	What I currently think and feel: [Below, we refer to 'my partner' to indicate 'a partner' – who is not necessarily your current partner if you have one]
1	In a romantic relationship, rationality must be the fundamental component
2	When one gets emotionally involved, they risk getting trapped in the relationship
3	In a relationship, I wonder whether my partner really cares about me
4	In dark times there is never anyone to share your pain with – no matter how much you want it
5	When it comes to emotions, one needs self-control

6	For me, it's important that I am always in a safe place or that I can reach one without obstacles in case of emergency
7	In a relationship, I suffer if I don't often feel the affectionate physical touch of my partner
8	I had a period in which I was overwhelmed by uncontrollable emotions – especially pain and anger – and I felt intolerable sensations
9	I feel the weight of others' expectations on me
10	Some people who are important to me have the power to influence my point of view
11	I had a period in which I felt so low that I wanted to take my own life
12	The slightest doubt that I have done something wrong can make me feel terrible anguish
13	Food and my weight play an important role in my life
14	When you leave home to live on your own, it is essential not to go too far – to be always able to get back in case you need help
15	In a relationship – being who I am – I like when my partner shares with me their intimate and profound feelings
16	In periods of great stress, I have felt the world around me as somehow unreal
17	Life requires a strong commitment to facing a destiny of loneliness
18	It is useless to hope for words of true comfort when you are down - because nobody will give them to you
19	How others see me is important to me
20	In a relationship, it often seems that my partner is with me only if they have nothing better to do
21	I had a period in which I couldn't feel anything, no emotions at all – as if I were completely empty, although not really sad Periods of possible 'emotional exhaustion' (burn out) due to the ongoing relationship with people in difficulty – a typical phenomenon of the helping professions, such as doctors, nurses, social workers, therapists, etc. – are to be excluded.
22	In a relationship, I have thoughts about my partner's loyalty
23	Refraining from taking food can give great satisfaction
24	I feel really disgusted by those who don't respect my rules
25	Sometimes, I feel strongly driven to check I have done everything right to avoid terrible things
26	Being acknowledged by people who count is important to me
27	In any situation, it is important to ensure that you can move freely
28	In some periods of my life, I have felt the anguish of being dirty or contaminated and having to clean up myself Exceptional periods that involve the entire life context – such as for the spread of a disease – are to be excluded. For example, a period of pandemic (such as that of the corona-virus) is to be excluded.
29	When I had a period in which I was overwhelmed by uncontrollable emotions – especially pain and anger – and I felt intolerable sensations, I would have done anything to get out of that state, even hurt myself or directly kill myself
30	Not checking multiple times that you did everything correctly can have terrible consequences
31	At some point, you have to prove to yourself that you can move away from home to explore the world
32	A strong person doesn't feel the need to be comforted
33	It is important to make sure that you don't get trapped in relationships with people
34	Sometimes, I feel strongly driven to do things following a precise criterion of mine that feels right to me – even though others don't see the reason of it
35	In a relationship, if my partner pressurizes me to think as they want, I feel ignored
36	In a relationship, the idea that I can be near my partner makes me feel much more protected
37	When I have found myself in trouble, I have realized that no one was there to support me with real affection
38	In a relationship – being who I am – I desire a partner who lets me hug or kiss them affectionately just because I love them
39	I trust logic much more than emotions
40	Sometimes, the idea of having caused harm to somebody – or even to myself – is like the end of the world to me – I would do anything to get that idea out of my head
41	In some places – even if absolutely normal – I feel uncomfortable, like I'm constricted or trapped
42	Failing makes me feel terribly lonely
43	To be sure of what I think about something, I always try to understand someone else's opinion
44	In a relationship, I think of what I'd do if my partner left me
45	Often, if I don't make sure multiple times that I did everything as I should, then the idea can torment me
46	In a relationship – being who I am – if something negative happens to me, I desire that my partner makes me feel their warm comfort

47	Being disapproved or criticized makes me uncomfortable
48	In a relationship, I get angry if I don't get the affection and support I need from my partner
49	In a relationship – being who I am – I need the affection and cuddles of my partner and want a partner who likes to give that
50	In a relationship, I know that sooner or later my partner will make me feel terribly bad
51	Moral issues – what is right or wrong – are at the heart of my thoughts
52	I have felt condemned to feel lonely forever
53	Being left makes me feel like I lost everything
54	When you haven't yet taken a position on an issue, you are always at risk of being judged
55	Sometimes, thinking of my relationship – irrationally – I felt that I could never leave my partner and, at the same time, I wished I would
56	I feel stuck and constricted when people cross the line I draw for them
57	For me, it's important to be liked
58	In periods of great stress, I have felt outside of my body
59	Sometimes, I have felt trapped by loved ones who were very close to me, and I have felt the need to feel freer to move
60	When I had a period in which I felt so low that I wanted to take my own life, I also had thoughts on how to do it concretely
61	For me, it's important to be able to go in and out freely from a situation
62	Sometimes, a seemingly small failure makes me feel inexplicably down
63	Generally speaking, I like to feel in my body the strong sensations or emotions given by an exciting substance
64	There is a higher law in the universe - which everyone should respect - and I am extremely careful to respect it
65	Loneliness is the normal condition of life
66	In some periods of my life, thoughts or images of grave things – happening to others or myself – continuously appeared in my mind without me wanting them to
67	In a relationship, I never trust to completely put myself in my partner's hands
68	Strong people keep their suffering to themselves and think about the real problems
69	In a relationship – being who I am – I desire to discuss my intimate concerns with my partner
70	I carefully monitor the internal activation of my body to keep it under control
71	Being in a romantic relationship always leaves me with a sense of fear
72	There is something wrong with the very essence of myself
73	Sometimes, the idea that what I did might have terrible consequences becomes an incessant torment that does not give me peace
74	In periods of great stress, I have felt my body did not really belong to me
75	In a relationship, I'm confident my partner would never leave me
76	In a romantic relationship, crying on the partner's shoulder is for the weak
77	In a relationship, sometimes, I need to get angry to make my partner hear me
78	Only if you fully commit yourself, someone will maybe really love you
79	When I don't have the situation under control, I feel constricted, trapped
80	In a relationship, it is important to keep one's partner's attention to oneself alive
81	Sometimes, if I don't do certain things the way I want to, I don't feel good with myself – even though others don't feel the need of it
82	Generally speaking, I like to feel in my body the strong sensations or emotions given by an exciting activity
83	In some periods of my life, I have felt continuously driven to do certain things or have certain thoughts – apparently irrelevant – to avoid terrible consequences
84	In important situations, I find it difficult to say no explicitly
85	For me, it's important that I can always be easily rescued by a loved one wherever I am
86	In a relationship, the idea of being left by my partner hardly enters my mind
87	The mere memory of those times when I didn't behave as requested makes me relive the embarrassment I felt
88	In a relationship, probably the most positive aspect is the sense of protection that your partner can give you
89	Who loves you the most is also the greatest danger to you
90	In a relationship, it is important to know what your partner does when you are not with them
91	Not respecting my rules would be unacceptable to me
92	In a relationship, sometimes, I feel trapped and restricted even if I love my partner
93	In a relationship, my partner hardly cares about me as much as I care about them
94	In a relationship – being who I am – I desire that my partner hugs or kisses me often for pure affection

95	Rationality is by far more important than emotions
96	In a relationship, sometimes, I think that – if they could – my partner would be with someone else
97	One needs to be strong and not cry
98	In a relationship, not receiving the attention I would like to from my partner makes me angry
99	In a relationship – being who I am – I desire to share my intimate and profound feelings with my partner
100	In my life, I always had to get by by myself
101	Finding real love is just a dream
102	In a romantic relationship, emotions are only a waste of time
103	In a relationship, my partner somehow makes me feel sure of who I am
104	Always doing the right thing is essential
105	Being disapproved or criticized makes me feel embarrassed or inadequate
106	I think that really reaching someone intimately is impossible
107	In periods of great stress, I have felt like I was another person, not myself
108	In some periods of my life, thoughts or images of disgusting things continuously appeared in my mind without me wanting them to
109	In a relationship – being who I am – I desire the emotional – intimate and profound – support of my partner
110	In a relationship, I often think that my partner will end up with someone else
111	In a relationship – being who I am – I need a partner who hugs and cuddles me
112	For me, it's important to feel that others approve of me
113	Sometimes, I think you need to fight to avoid a destiny of loneliness
114	In periods of great stress, I have felt the world around me as somehow separated from me
115	In a relationship, I think my partner prefers others' company to mine
116	Not meeting others' expectations makes me feel inadequate
117	When I had a period in which I couldn't feel anything, no emotions at all – as if I were completely empty, although not really sad – I wanted to die Periods of possible 'emotional exhaustion' (burn out) due to the ongoing relationship with people in difficulty – a typical phenomenon of the helping professions, such as doctors, nurses, social workers, therapists, etc. – are to be excluded.
118	When I get attached to someone, I immediately think I could lose them
119	In some periods of my life, I have had terrible thoughts that – even if I didn't want to – kept coming to mind and forced me to do something to get rid of them
120	For me, it's hard to get someone's attention and have some intimate emotional closeness
121	In a relationship, if my partner pressurizes me to be just like they want, I feel personally violated
122	In periods of great stress, I have felt a familiar place as somehow strange or unknown to me
123	It's very difficult to show people who are important to you that you disagree with them if they expect you to agree
124	There is an obvious order of things, and I feel extremely uncomfortable when it is not respected
125	When I had a period in which I was overwhelmed by uncontrollable emotions – especially pain and anger – and I felt intolerable sensations, I would have done anything to keep who I loved to myself
	[Section 3] Q_C – Caregiving
	Q_{CFy} – Caregiving Family
	Considering the 2 principal people who took care of you as a child as your maternal and paternal figures:
1	What percentage of time did my maternal figure take care – in their own way – of me? (0-100% compared to my paternal figure) If you answer "N", we assume that your paternal figure took care of you – in their own way – for a percentage of time "100-N". For example, if your maternal figure took care of you for 75% of time, we assume that your paternal figure took care of you for 25% of time.
	What percentage of time did my paternal figure take care – in their own way – of me? (0-100% compared to my maternal figure)
	When I was a child, how I remember – in images, thoughts, and feelings – my experience in my family:
1	I went outside the home to play with other kids or for other activities not supervised by my parents (none of them) By parents, we mean your maternal and paternal figure.
2	I felt lonely
3	I felt I needed help, and nobody helped me
4	In my family, sharing certain ideas kept us united
5	The family climate was relaxed

6	I had to learn how to get by by myself
7	Meeting family expectations made me feel I belonged to the family
8	I used to take care of at least one member of my family (mother, father, sibling, or other)
9	I felt sad
10	My parents got along well By parents, we mean your maternal and paternal figure. If you haven't had one of them, please give any answer – the question will not be considered.
11	Initially, leaving home and being left at school made me very nervous and tense: it took me time to stay calmer
12	I hated myself
13	I felt powerless
14	In my family, nobody was expected to have secrets
15	I had to spend much more time at home than most other children
16	My family was united
17	My parents could fight quite violently - verbally or physically By parents, we mean your maternal and paternal figure. If you haven't had one of them, please give any answer – the question will not be considered.
	Q_{CM} – Caregiving Mother
1	In my childhood, I had a maternal figure
2	My maternal figure – referred to as 'mother' below – has been:
3	My mother took care of me since I was: We can consider a person as a maternal figure only if they started taking care of you before you were 6 years old. In case of a noncontinuous period of time, please consider the earliest part of it. For example, if your mother took care of you when you were between 2 and 4 years old and then between 8 and 13, consider 2-4.
4	My mother took care of me until I was:
	When I was a child, how I remember – in images, thoughts, and feelings – my experience with my mother:
1	My mother could always accuse me of doing something bad – or not doing something – causing terrible damage for someone
2	All mothers are concerned about the health and safety of their children: mine was even more so
3	I feared that my mother would beat me up
4	I feel anger if I consider that my mother could have thought more about me and my needs
5	My mother always knew what was appropriate for the situation
6	Sometimes, I felt anguish for what my mother might do or say
7	When I didn't meet my mother's expectations, I felt at fault, but I didn't fear to lose her appreciation
8	Sometimes, my mother made my life difficult
9	My mother got mad at me when I did something wrong
10	I wished I could spend time with my mother but was rarely able to
11	Sometimes, my mother put me under a lot of pressure
12	Sometimes, I was worried about what could happen when my mother was with me
13	In some situations, the presence of my mother made me feel more self-confident
14	I was an independent child and refrained from asking comfort from my mother
15	At some point, I realized that I would never have my mother's love, but such a thing was unacceptable to me
16	When I needed some comfort, I wanted but couldn't go to my mother for it
17	Letting my mother down was a burden for me
18	I hugged or kissed my mother just to show her how much I loved her
19	I remember that sometimes – unfortunately – my mother wasn't there when I needed her
20	Sometimes, my mother made me suffer
21	I missed being with my mother and having a warm hug from her
22	Sometimes, my mother kept me waiting too long for her
23	My mother expressed disgust at whoever broke her rules
24	I could never really know whether my mother was about to blame me for something
25	When I went somewhere, I knew that my mother could always arrive in no time if I needed her
26	My mother had a constant and severe health problem – or so I thought
27	Sometimes, my mother made a fool of me, and I felt humiliated
28	Sometimes, my mother got ferociously angry at me
29	My relationship with my mother was affectionate
30	I loved my mother but – thinking of the circumstances with her – I also feel anger
31	My mother considered many activities that most children used to do as dangerous

32	Sometimes, I had to make an effort to get my mother to notice she should take care of me
33	My mother had strict rules and enforced them harshly
34	I have some vivid memories of my mother and I who – while playing games – look into each other's eyes and have fun together
35	Normally, my mother and I thought the same
36	Sometimes, I had to have a lot of patience with my mother
37	Sometimes, my mother threatened to kick me out of the house, and I was anguished at the thought
38	I loved it when my mother hugged and cuddled me – I really needed it
39	My mother punished me harshly when I did something wrong
40	When my mother saw me sad, she asked me affectionately about what happened and tried to console me
41	Even if I always tried not to make my mother think I had done something that I shouldn't have done, she always found something
42	My mother and I would both have been in favor if I had been invited to spend 1-2 weeks away from home for an adventurous activity, such as a summer camp, for example
43	My mother left home, and I spent the rest of my childhood without her
44	When I wasn't sure of something, I asked my mother
45	I was curious about my mother's tastes and opinions
46	When my mother was at home, I couldn't relax
47	I thought that something terrible might happen to my mother
48	Sometimes, how things went between me and my mother was quite irritating
49	My mother was in need, and I tried to stay close to her
50	For many things, I saw my mother as a point of reference - which I liked, or I would have liked, to follow
51	Sometimes, I got irritated because I didn't get the attention I needed from my mother
52	My mother caressed and hugged me with affection
53	I could get rather nervous when I had to part with my mother – I remember some of those moments well
54	My mother always had some advice to give me
55	I remember the warm sound of my mother's voice and her sweet words when she asked me how I was
56	My mother had strict rules that I was always afraid I could fail to respect
57	My mother used to follow my activities closely – much more than most other kids' mothers did
58	My mother was away or busy most of the time, and I wanted but couldn't stay near her
59	My mother paid attention to my behavior and blamed me for misbehaving
60	Sometimes, my mother's presence did not allow me to feel as free to move as I would have liked
61	Following my mother's rules put me under a lot of pressure
62	I used to look up to my mother (at least until a certain age)
63	Sometimes, my mother insisted on taking care of me, even though I didn't really feel the need for that – I remember some of those moments well
64	I thought of my mother and missed her
65	I longed for my mother's affection, but I was never able to have it
66	My mother had a serious problem that could make her leave home for good – or so I thought
67	Sometimes, I was preoccupied thinking that my mother wouldn't be there when I needed her
68	Sometimes, it seemed like my mother held a grudge against me
69	My mother used to take care of me but was also a kind of dictator
70	I was always worried I might have done something wrong and my mother would take it out on me
71	My mother was a rational person and rarely showed how much she loved me with tenderness and emotion
72	I needed the affection and cuddles of my mother, and my mother was aware of it
73	I hoped I could earn a warm hug from my mother
74	In some situations – which seemed normal to most other children – I wasn't comfortable without my mother's protection
75	Sometimes, my mother seemed to be mentally far away, like in another world
76	Sometimes, I got irritated because my mother interrupted me while I was doing something I liked – I remember some of those moments well
77	My mother talked about emotions and feelings such as happiness, sadness, and love
78	My mother always told or made me understand what was appropriate to do in a situation
79	Usually, when my mother was at home, I was on my own doing my own thing
80	Sometimes, I was scared by my mother
81	My mother seemed to suffer when I was sad
82	I used to be very close to my mother and maybe I didn't have all the experiences I could have

83	Sometimes, my mother wanted to know too much about me
	Q_{CF} – Caregiving Father
1	In my childhood, I had a paternal figure
2	My paternal figure - referred to as 'father' below - has been:
3	My father took care of me since I was: We can consider a person as a paternal figure only if they started taking care of you before you were 6 years old. In case of a noncontinuous period of time, please consider the earliest part of it. For example, if your father took care of you when you were between 2 and 4 years old and then between 8 and 13, consider 2-4.
4	My father took care of me until I was:
	When I was a child, how I remember – in images, thoughts, and feelings – my experience with my father:
1	When I didn't meet my father's expectations, I felt at fault, but I didn't fear to lose his appreciation
2	My father expressed disgust at whoever broke his rules
3	My father considered many activities that most children used to do as dangerous
4	I could get rather nervous when I had to part with my father – I remember some of those moments well
5	In some situations, the presence of my father made me feel more self-confident
6	My father got mad at me when I did something wrong
7	I used to look up to my father (at least until a certain age)
8	Sometimes, my father made me suffer
9	All fathers are concerned about the health and safety of their children: mine was even more so
10	Following my father's rules put me under a lot of pressure
11	My father always had some advice to give me
12	I loved my father but – thinking of the circumstances with him – I also feel anger
13	My father was away or busy most of the time, and I wanted but couldn't stay near him
14	I was an independent child and refrained from asking comfort from my father
15	Sometimes, I got irritated because I didn't get the attention I needed from my father
16	I was curious about my father's tastes and opinions
17	In some situations – which seemed normal to most other children – I wasn't comfortable without my father's protection
18	My father used to take care of me but was also a kind of dictator
19	I loved it when my father hugged and cuddled me – I really needed it
20	My father paid attention to my behavior and blamed me for misbehaving
21	Sometimes, I was scared by my father
22	Sometimes, my father kept me waiting too long for him
23	My father and I would both have been in favor if I had been invited to spend 1-2 weeks away from home for an adventurous activity, such as a summer camp, for example
24	Sometimes, I was preoccupied thinking that my father wouldn't be there when I needed him
25	Sometimes, my father got ferociously angry at me
26	My father was a rational person and rarely showed how much he loved me with tenderness and emotion
27	My father had a constant and severe health problem – or so I thought
28	I wished I could spend time with my father but was rarely able to
29	Sometimes, how things went between me and my father was quite irritating
30	When I wasn't sure of something, I asked my father
31	Sometimes, I had to make an effort to get my father to notice he should take care of me
32	I thought that something terrible might happen to my father
33	When my father saw me sad, he asked me affectionately about what happened and tried to console me
34	Sometimes, it seemed like my father held a grudge against me
35	My father had strict rules that I was always afraid I could fail to respect
36	Sometimes, my father's presence did not allow me to feel as free to move as I would have liked
37	I longed for my father's affection, but I was never able to have it
38	My father could always accuse me of doing something bad – or not doing something – causing terrible damage for someone
39	When my father was at home, I couldn't relax
40	Sometimes, my father seemed to be mentally far away, like in another world
41	My father always told or made me understand what was appropriate to do in a situation
42	Sometimes, I was worried about what could happen when my father was with me

43	Sometimes, my father insisted on taking care of me, even though I didn't really feel the need for that – I remember some of those moments well
44	My father left home, and I spent the rest of my childhood without him
45	Sometimes, I felt anguish for what my father might do or say
46	My father punished me harshly when I did something wrong
47	I missed being with my father and having a warm hug from him
48	Sometimes, my father threatened to kick me out of the house, and I was anguished at the thought
49	I hoped I could earn a warm hug from my father
50	Sometimes, my father made my life difficult
51	My father was in need, and I tried to stay close to him
52	I hugged or kissed my father just to show him how much I loved him
53	Letting my father down was a burden for me
54	For many things, I saw my father as a point of reference - which I liked, or I would have liked, to follow
55	My father had strict rules and enforced them harshly
56	Sometimes, my father put me under a lot of pressure
57	I remember that sometimes – unfortunately – my father wasn't there when I needed him
58	I needed the affection and cuddles of my father, and my father was aware of it
59	I feel anger if I consider that my father could have thought more about me and my needs
60	I thought of my father and missed him
61	My father used to follow my activities closely – much more than most other kids' fathers did
62	When I needed some comfort, I wanted but couldn't go to my father for it
63	I have some vivid memories of my father and I who – while playing games – look into each other's eyes and have fun together
64	My father had a serious problem that could make him leave home for good – or so I thought
65	Normally, my father and I thought the same
66	My father caressed and hugged me with affection
67	I was always worried I might have done something wrong and my father would take it out on me
68	Sometimes, my father made a fool of me, and I felt humiliated
69	Sometimes, I had to have a lot of patience with my father
70	My relationship with my father was affectionate
71	My father talked about emotions and feelings such as happiness, sadness, and love
72	I could never really know whether my father was about to blame me for something
73	My father always knew what was appropriate for the situation
74	Sometimes, I got irritated because my father interrupted me while I was doing something I liked – I remember some of those moments well
75	Usually, when my father was at home, I was on my own doing my own thing
76	I was worried that my father would beat me up
77	My father seemed to suffer when I was sad
78	When I went somewhere, I knew that my father could always arrive in no time if I needed him
79	I remember the warm sound of my father's voice and his sweet words when he asked me how I was
80	Even if I always tried not to make my father think I had done something that I shouldn't have done, he always found something
81	At some point, I realized that I would never have my father's love, but such a thing was unacceptable to me
82	Sometimes, my father wanted to know too much about me
83	I used to be very close to my father and maybe I didn't have all the experiences I could have
	In conclusion, we ask you if you suffered the loss of your mother or father.
1	My mother passed away
2	In that case: When my mother died, my age was
3	My father passed away
4	In that case: When my father died, my age was

Appendix B

The Attachment-Caregiving Questionnaire (ACQ) Scales

Below, the ACQ (base-)scales – corresponding to the ACQ in Appendix A – are reported. The Q_A scales are: (1) Disorganization (in blue); (2) Avoidance (in yellow); Ambivalence (in red); (4) Phobicity (in green); (5) Depressivity (in white); (6) Somaticity (in purple); Obsessivity (in brown). The Q_{CM} scales (expressed as a caregiver's feature) are: (1) Frightful (in blue); (2) Insensitive (in yellow); Unresponsive (in red); (4) Limiting (in green); (5) Unreachable (in white); (6) Defining (in purple); Judgmental (in brown). See Chapter 3 for a detailed description of the questionnaire.

	Q_A – Attachment
1	In a relationship, I know that sooner or later my partner will make me feel terribly bad
2	In a relationship, I never trust to completely put myself in my partner's hands
3	Being in a romantic relationship always leaves me with a sense of fear
4	Sometimes, thinking of my relationship – irrationally – I felt that I could never leave my partner and, at the same time, I wished I would
5	Who loves you the most is also the greatest danger to you
6	In periods of great stress, I have felt outside of my body
7	In periods of great stress, I have felt my body did not really belong to me
8	In periods of great stress, I have felt like I was another person, not myself
9	I had a period in which I couldn't feel anything, no emotions at all – as if I were completely empty, although not really sad Periods of possible 'emotional exhaustion' (burn out) due to the ongoing relationship with people in difficulty – a typical phenomenon of the helping professions, such as doctors, nurses, social workers, therapists, etc. – are to be excluded.
10	When I had a period in which I couldn't feel anything, no emotions at all – as if I were completely empty, although not really sad – I wanted to die Periods of possible 'emotional exhaustion' (burn out) due to the ongoing relationship with people in difficulty – a typical phenomenon of the helping professions, such as doctors, nurses, social workers, therapists, etc. – are to be excluded.
11	In periods of great stress, I have felt the world around me as somehow unreal
12	In periods of great stress, I have felt the world around me as somehow separated from me
13	In periods of great stress, I have felt a familiar place as somehow strange or unknown to me
14	I had a period in which I was overwhelmed by uncontrollable emotions – especially pain and anger – and I felt intolerable sensations

15	When I had a period in which I was overwhelmed by uncontrollable emotions – especially pain and anger – and I felt intolerable sensations, I would have done anything to get out of that state, even hurt myself or directly kill myself
16	When I had a period in which I was overwhelmed by uncontrollable emotions – especially pain and anger – and I felt intolerable sensations, I would have done anything to keep who I loved to myself
1	In a relationship – being who I am – I need the affection and cuddles of my partner and want a partner who likes to give that
2	In a relationship – being who I am – I need a partner who hugs and cuddles me
3	In a relationship – being who I am – if something negative happens to me, I desire that my partner makes me feel their warm comfort
4	In a relationship – being who I am – I desire the emotional – intimate and profound – support of my partner
5	In a relationship – being who I am – I desire to discuss my intimate concerns with my partner
6	In a relationship – being who I am – I desire a partner who lets me hug or kiss them affectionately just because I love them
7	In a relationship – being who I am – I desire to share my intimate and profound feelings with my partner
8	In a relationship – being who I am – I like when my partner shares with me their intimate and profound feelings
9	In a relationship – being who I am – I desire that my partner hugs or kisses me often for pure affection
10	In a relationship, I suffer if I don't often feel the affectionate physical touch of my partner
11	In a romantic relationship, crying on the partner's shoulder is for the weak
12	In a romantic relationship, rationality must be the fundamental component
13	In a romantic relationship, emotions are only a waste of time
14	Rationality is by far more important than emotions
15	I trust logic much more than emotions
16	One needs to be strong and not cry
17	A strong person doesn't feel the need to be comforted
18	Strong people keep their suffering to themselves and think about the real problems
1	In a relationship, the idea of being left by my partner hardly enters my mind
2	In a relationship, I'm confident my partner would never leave me
3	In a relationship, I often think that my partner will end up with someone else
4	In a relationship, sometimes, I think that – if they could – my partner would be with someone else
5	In a relationship, I think of what I'd do if my partner left me
6	In a relationship, I have thoughts about my partner's loyalty
7	In a relationship, it is important to know what your partner does when you are not with them
8	In a relationship, it often seems that my partner is with me only if they have nothing better to do
9	In a relationship, I think my partner prefers others' company to mine
10	In a relationship, I wonder whether my partner really cares about me
11	In a relationship, my partner hardly cares about me as much as I care about them
12	In a relationship, it is important to keep one's partner's attention to oneself alive
13	In a relationship, not receiving the attention I would like to from my partner makes me angry
14	In a relationship, I get angry if I don't get the affection and support I need from my partner
15	In a relationship, sometimes, I need to get angry to make my partner hear me
1	In a relationship, probably the most positive aspect is the sense of protection that your partner can give you
2	In a relationship, the idea that I can be near my partner makes me feel much more protected
3	For me, it's important that I can always be easily rescued by a loved one wherever I am
4	For me, it's important that I am always in a safe place or that I can reach one without obstacles in case of emergency
5	In a relationship, sometimes, I feel trapped and restricted even if I love my partner
6	When one gets emotionally involved, they risk getting trapped in the relationship
7	Sometimes, I have felt trapped by loved ones who were very close to me, and I have felt the need to feel freer to move
8	I feel stuck and constricted when people cross the line I draw for them
9	It is important to make sure that you don't get trapped in relationships with people
10	When I don't have the situation under control, I feel constricted, trapped
11	For me, it's important to be able to go in and out freely from a situation
12	In any situation, it is important to ensure that you can move freely
13	In some places – even if absolutely normal – I feel uncomfortable, like I'm constricted or trapped
14	When you leave home to live on your own, it is essential not to go too far – to be always able to get back in case you need help

15	At some point, you have to prove to yourself that you can move away from home to explore the world
16	I carefully monitor the internal activation of my body to keep it under control
17	When it comes to emotions, one needs self-control
18	Generally speaking, I like to feel in my body the strong sensations or emotions given by an exciting substance
19	Generally speaking, I like to feel in my body the strong sensations or emotions given by an exciting activity
1	I think that really reaching someone intimately is impossible
2	For me, it's hard to get someone's attention and have some intimate emotional closeness
3	Finding real love is just a dream
4	Being left makes me feel like I lost everything
5	When I get attached to someone, I immediately think I could lose them
6	Loneliness is the normal condition of life
7	I have felt condemned to feel lonely forever
8	Life requires a strong commitment to facing a destiny of loneliness
9	When I have found myself in trouble, I have realized that no one was there to support me with real affection
10	In dark times there is never anyone to share your pain with – no matter how much you want it
11	It is useless to hope for words of true comfort when you are down - because nobody will give them to you
12	In my life, I always had to get by by myself
13	Only if you fully commit yourself, someone will maybe really love you
14	Sometimes, I think you need to fight to avoid a destiny of loneliness
15	Failing makes me feel terribly lonely
16	Sometimes, a seemingly small failure makes me feel inexplicably down
17	I had a period in which I felt so low that I wanted to take my own life
18	When I had a period in which I felt so low that I wanted to take my own life, I also had thoughts on how to do it concretely
19	There is something wrong with the very essence of myself
1	In a relationship, my partner somehow makes me feel sure of who I am
2	In a relationship, if my partner pressurizes me to think as they want, I feel ignored
3	In a relationship, if my partner pressurizes me to be just like they want, I feel personally violated
4	Some people who are important to me have the power to influence my point of view
5	It's very difficult to show people who are important to you that you disagree with them if they expect you to agree
6	In important situations, I find it difficult to say no explicitly
7	Being acknowledged by people who count is important to me
8	For me, it's important to feel that others approve of me
9	Being disapproved or criticized makes me feel embarrassed or inadequate
10	Being disapproved or criticized makes me uncomfortable
11	I feel the weight of others' expectations on me
12	The mere memory of those times when I didn't behave as requested makes me relive the embarrassment I felt
13	Not meeting others' expectations makes me feel inadequate
14	How others see me is important to me
15	For me, it's important to be liked
16	When you haven't yet taken a position on an issue, you are always at risk of being judged
17	To be sure of what I think about something, I always try to understand someone else's opinion
18	Food and my weight play an important role in my life
19	Refraining from taking food can give great satisfaction
1	Not respecting my rules would be unacceptable to me
2	I feel really disgusted by those who don't respect my rules
3	Moral issues – what is right or wrong – are at the heart of my thoughts
4	There is an obvious order of things, and I feel extremely uncomfortable when it is not respected
5	There is a higher law in the universe - which everyone should respect - and I am extremely careful to respect it
6	Sometimes, if I don't do certain things the way I want to, I don't feel good with myself – even though others don't feel the need of it
7	Sometimes, I feel strongly driven to do things following a precise criterion of mine that feels right to me – even though others don't see the reason of it
8	Always doing the right thing is essential

9	The slightest doubt that I have done something wrong can make me feel terrible anguish
10	Often, if I don't make sure multiple times that I did everything as I should, then the idea can torment me
11	Not checking multiple times that you did everything correctly can have terrible consequences
12	Sometimes, the idea of having caused harm to somebody – or even to myself – is like the end of the world to me – I would do anything to get that idea out of my head
13	Sometimes, the idea that what I did might have terrible consequences becomes an incessant torment that does not give me peace
14	Sometimes, I feel strongly driven to check I have done everything right to avoid terrible things
15	In some periods of my life, thoughts or images of disgusting things continuously appeared in my mind without me wanting them to
16	In some periods of my life, thoughts or images of grave things – happening to others or myself – continuously appeared in my mind without me wanting them to
17	In some periods of my life, I have felt continuously driven to do certain things or have certain thoughts – apparently irrelevant – to avoid terrible consequences
18	In some periods of my life, I have felt the anguish of being dirty or contaminated and having to clean up myself Exceptional periods that involve the entire life context – such as for the spread of a disease – are to be excluded. For example, a period of pandemic (such as that of the corona-virus) is to be excluded.
19	In some periods of my life, I have had terrible thoughts that – even if I didn't want to – kept coming to mind and forced me to do something to get rid of them
	Q_{CM} – Caregiving Mother
1	Sometimes, my mother got ferociously angry at me
2	Sometimes, I felt anguish for what my mother might do or say
3	I feared that my mother would beat me up
4	Sometimes, my mother made a fool of me, and I felt humiliated
5	When my mother was at home, I couldn't relax
6	Sometimes, my mother made me suffer
7	Sometimes, I was scared by my mother
8	Sometimes, I was worried about what could happen when my mother was with me
9	Sometimes, my mother put me under a lot of pressure
10	Sometimes, my mother threatened to kick me out of the house, and I was anguished at the thought
11	Sometimes, my mother made my life difficult
12	Sometimes, my mother seemed to be mentally far away, like in another world
1	I needed the affection and cuddles of my mother, and my mother was aware of it
2	I loved it when my mother hugged and cuddled me – I really needed it
3	I was an independent child and refrained from asking comfort from my mother
4	I hugged or kissed my mother just to show her how much I loved her
5	I remember the warm sound of my mother's voice and her sweet words when she asked me how I was
6	My mother caressed and hugged me with affection
7	When my mother saw me sad, she asked me affectionately about what happened and tried to console me
8	My mother seemed to suffer when I was sad
9	My mother was a rational person and rarely showed how much she loved me with tenderness and emotion
10	My mother talked about emotions and feelings such as happiness, sadness, and love
11	My relationship with my mother was affectionate
12	I have some vivid memories of my mother and I who – while playing games – look into each other's eyes and have fun together
13	Usually, when my mother was at home, I was on my own doing my own thing
1	Sometimes, I had to have a lot of patience with my mother
2	Sometimes, my mother kept me waiting too long for her
3	I remember that sometimes – unfortunately – my mother wasn't there when I needed her
4	Sometimes, I was preoccupied thinking that my mother wouldn't be there when I needed her
5	Sometimes, I got irritated because I didn't get the attention I needed from my mother
6	Sometimes, I had to make an effort to get my mother to notice she should take care of me
7	Sometimes, I got irritated because my mother interrupted me while I was doing something I liked – I remember some of those moments well
8	Sometimes, my mother insisted on taking care of me, even though I didn't really feel the need for that – I remember some of those moments well

9	I feel anger if I consider that my mother could have thought more about me and my needs
10	I loved my mother but – thinking of the circumstances with her – I also feel anger
11	Sometimes, how things went between me and my mother was quite irritating
1	I could get rather nervous when I had to part with my mother – I remember some of those moments well
2	My mother and I would both have been in favor if I had been invited to spend 1-2 weeks away from home for an adventurous activity, such as a summer camp, for example
3	My mother considered many activities that most children used to do as dangerous
4	All mothers are concerned about the health and safety of their children: mine was even more so
5	When I went somewhere, I knew that my mother could always arrive in no time if I needed her
6	Sometimes, my mother's presence did not allow me to feel as free to move as I would have liked
7	My mother used to follow my activities closely – much more than most other kids' mothers did
8	In some situations – which seemed normal to most other children – I wasn't comfortable without my mother's protection
9	I used to be very close to my mother and maybe I didn't have all the experiences I could have
10	My mother was in need, and I tried to stay close to her
11	I thought that something terrible might happen to my mother
12	My mother had a serious problem that could make her leave home for good – or so I thought
1	At some point, I realized that I would never have my mother's love, but such a thing was unacceptable to me
2	I thought of my mother and missed her
3	I missed being with my mother and having a warm hug from her
4	I hoped I could earn a warm hug from my mother
5	I longed for my mother's affection, but I was never able to have it
6	I wished I could spend time with my mother but was rarely able to
7	My mother was away or busy most of the time, and I wanted but couldn't stay near her
8	When I needed some comfort, I wanted but couldn't go to my mother for it
9	My mother left home, and I spent the rest of my childhood without her
10	My mother had a constant and severe health problem – or so I thought
1	My mother always had some advice to give me
2	My mother always knew what was appropriate for the situation
3	My mother always told or made me understand what was appropriate to do in a situation
4	Normally, my mother and I thought the same
5	Letting my mother down was a burden for me
6	When I didn't meet my mother's expectations, I felt at fault, but I didn't fear to lose her appreciation
7	When I wasn't sure of something, I asked my mother
8	I was curious about my mother's tastes and opinions
9	I used to look up to my mother (at least until a certain age)
10	For many things, I saw my mother as a point of reference - which I liked, or I would have liked, to follow
11	In some situations, the presence of my mother made me feel more self-confident
12	Sometimes, my mother wanted to know too much about me
1	My mother expressed disgust at whoever broke her rules
2	My mother could always accuse me of doing something bad – or not doing something – causing terrible damage for someone
3	My mother paid attention to my behavior and blamed me for misbehaving
4	I could never really know whether my mother was about to blame me for something
5	My mother punished me harshly when I did something wrong
6	My mother had strict rules and enforced them harshly
7	Following my mother's rules put me under a lot of pressure
8	My mother had strict rules that I was always afraid I could fail to respect
9	Even if I always tried not to make my mother think I had done something that I shouldn't have done, she always found something
10	I was always worried I might have done something wrong and my mother would take it out on me
11	My mother used to take care of me but was also a kind of dictator
12	My mother got mad at me when I did something wrong
13	Sometimes, it seemed like my mother held a grudge against me

Appendix C

Sensitivity analysis for the avoidant-ambivalent ACM

The ACM's main equations for avoidance and ambivalence (eq.s 4.1-4.4) contain a coupling factor (C_f) that connects each agent's need to the other's. This appendix presents a sensitivity analysis of such a factor both in the avoidant (eq.s 4.1-4.2) and ambivalent (eq.s 4.3-4.4) cases. The influence of the factor ($C_f > 0$) was evaluated against the case of no coupling ($C_f = 0$) taking into account the trends of need and actions (approach and exploration rates) of the agents across the entire range of parameter levels ($A_v = \{0.1, 0.2, \dots, 0.9\},\ A_m = \{0.1, 0.2, \dots, 0.9\}$).

(1) Avoidant case. The need (Figure 1) and action (Figure 2) trends have been analyzed for C_f in the range $[0.0, 8.0]$. In this case, following the psychological literature, the system is considered to be compliant with the expected behavior when the need has a descending trend, which corresponds to decreasing approach and increasing exploration rates. According to this criterion, the system showed to work even when decoupled (Figures 1, 2 top), but improved its performance for increasing values of C_f, reaching its best around $C_f = 4.0$ (Figures 1, 2 center). At this point, the need showed a steeper trend, which corresponded to a more marked difference in terms of approaches and explorations between the extremes of the parameter range ($A_v = 0.1$ and $A_v = 0.9$). A further increase of C_f yielded a degradation of performance, which was completely lost for $C_f = 8.0$ (no monotonic trends of the curves with no approaches for $A_v \geq 0.5$) (Figures 1, 2 bottom). Therefore, the analysis showed a qualitative performance improvement of the coupled system compared to the decoupled one.

(2) Ambivalent case. The need (Figure 3) and action (Figure 4) trends have been analyzed for C_f in the range $[0.0, 6.0]$. In this case, following the psychological literature, the system is considered to be compliant with the expected behavior when: (1) For the child, the need has an ascending trend, which corresponds to increasing

approach and decreasing exploration rates; and (2) For the caregiver, the need has a descending trend, which corresponds to decreasing approach and increasing exploration rates. According to this criterion, the system showed not to work properly when decoupled (no monotonic trends of the curves with no child approaches for $A_m \leq 0.4$) (Figures 3, 4 top), but improved its performance for increasing values of C_f, reaching its best around $C_f = 2.0$ (Figures 3, 4 center). At this point, the need and action rates showed the expected trends. A further increase of C_f yielded a degradation of performance, which was completely lost for $C_f = 6.0$ (child need practically constant, saturated at its maximum, for $A_m \geq 0.4$) (Figure 3 bottom). Therefore, this analysis also showed a qualitative performance improvement of the coupled system compared to the decoupled one.

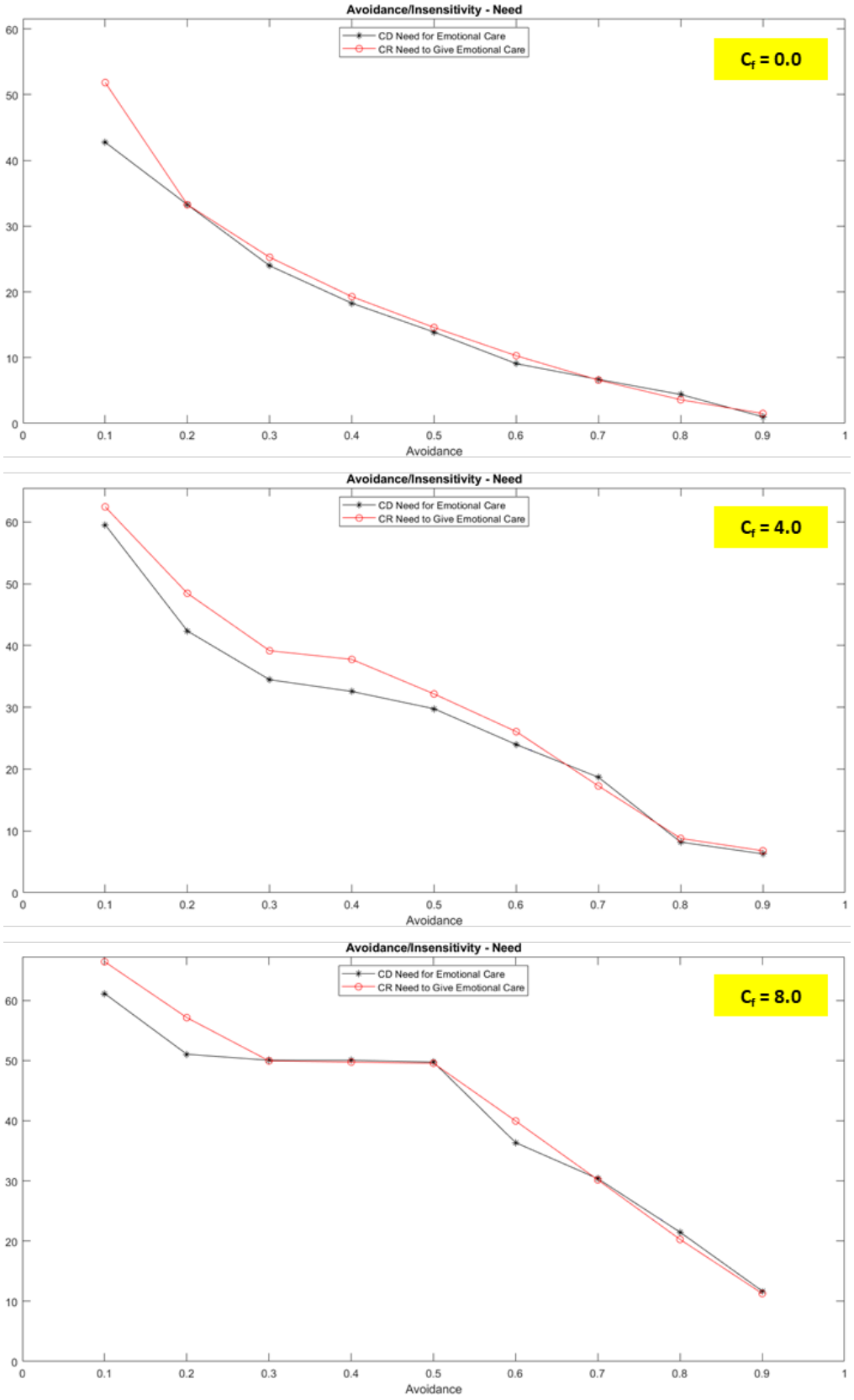


Figure 1. Avoidant case. Need function for the attacher (black) and caregiver (red) with 3 different coupling factors: $C_f = 0.0$ (top), $C_f = 4.0$ (center), $C_f = 8.0$ (bottom).

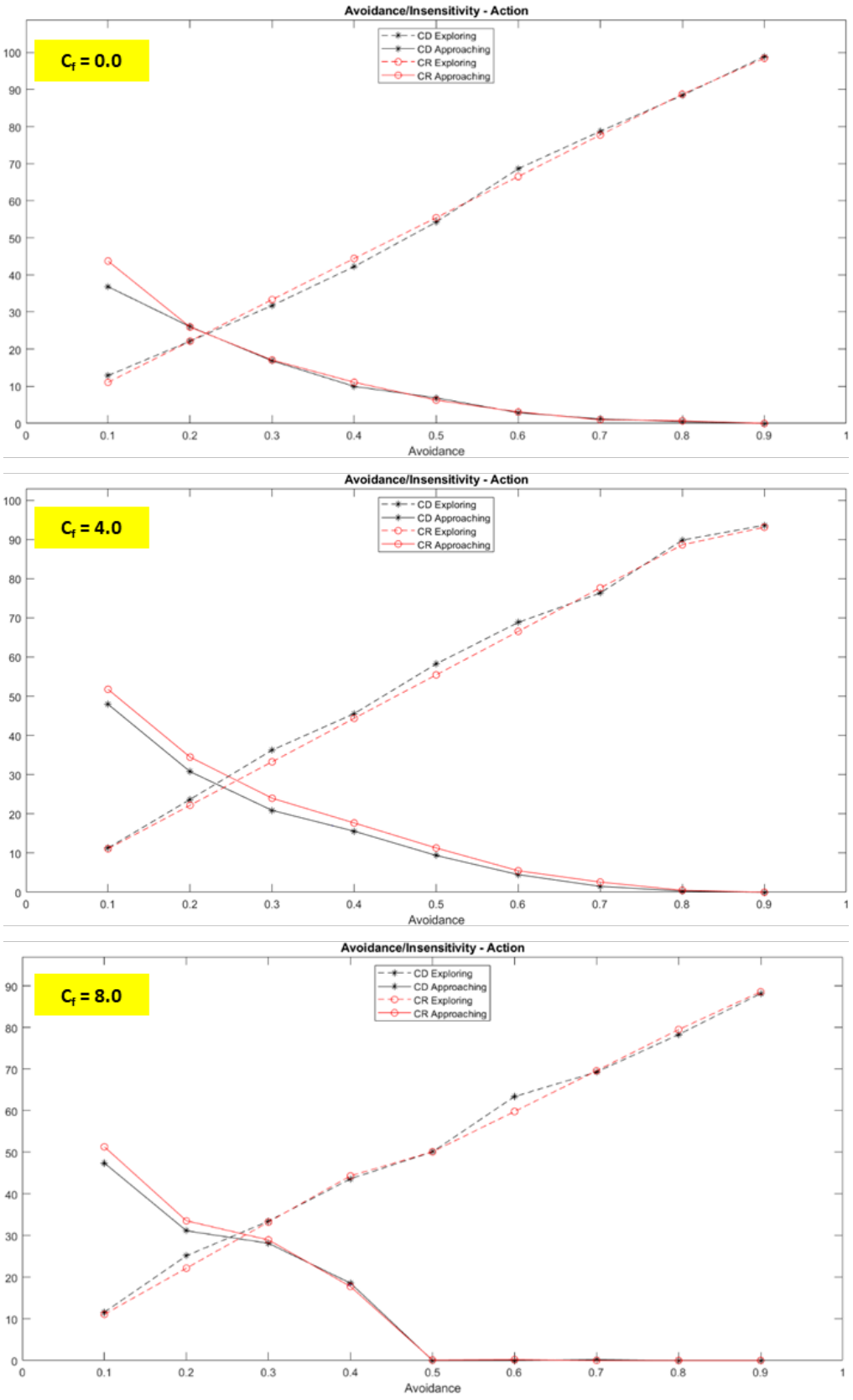


Figure 2. Avoidant case. Approach (solid) and exploration (dashed) for the attacher (black) and caregiver (red) with 3 different coupling factors: $C_f = 0.0$ (top), $C_f = 4.0$ (center), $C_f = 8.0$ (bottom).

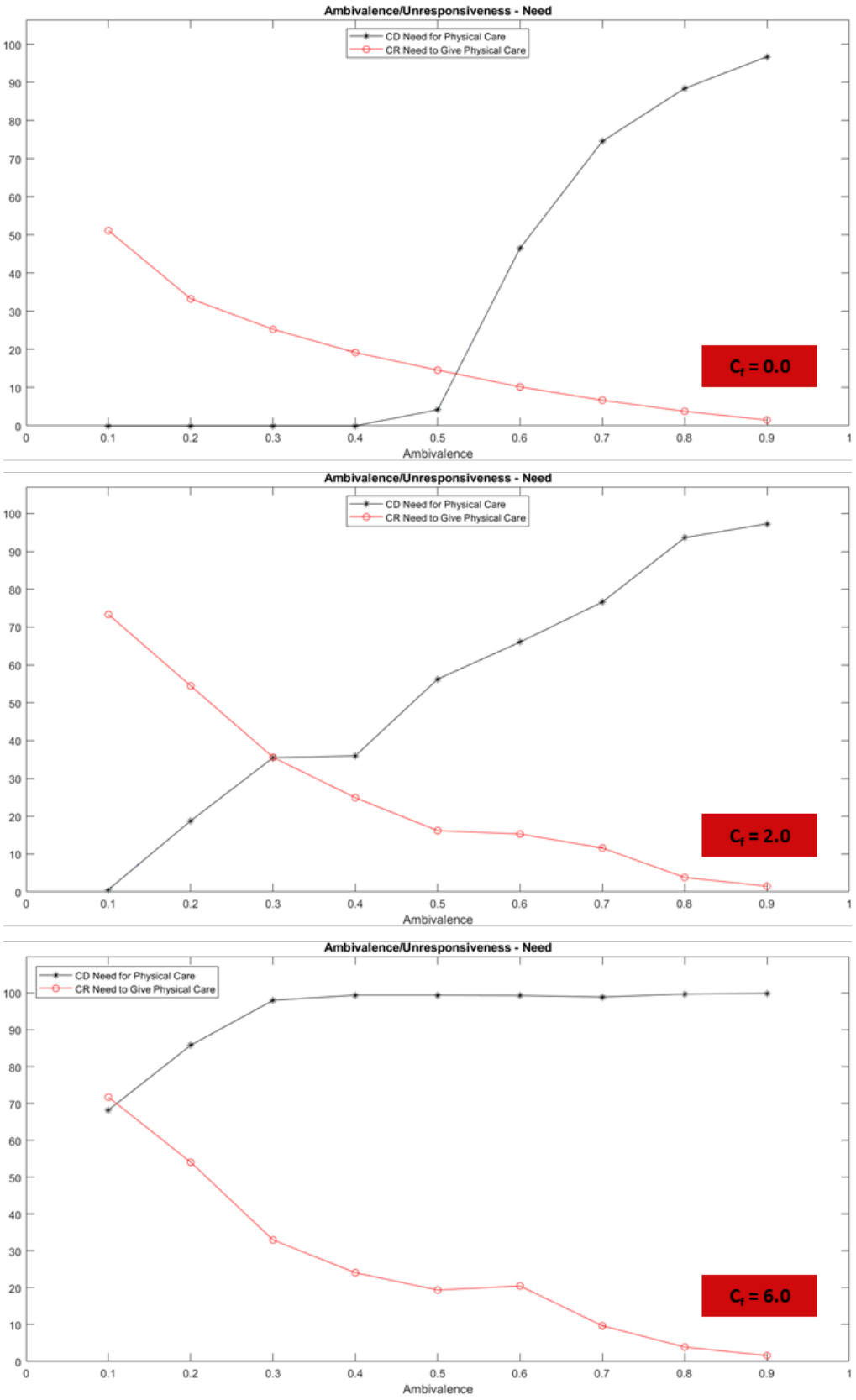


Figure 3. Ambivalent case. Need function for the attacher (black) and caregiver (red) with 3 different coupling factors: $C_f = 0.0$ (top), $C_f = 2.0$ (center), $C_f = 6.0$ (bottom).

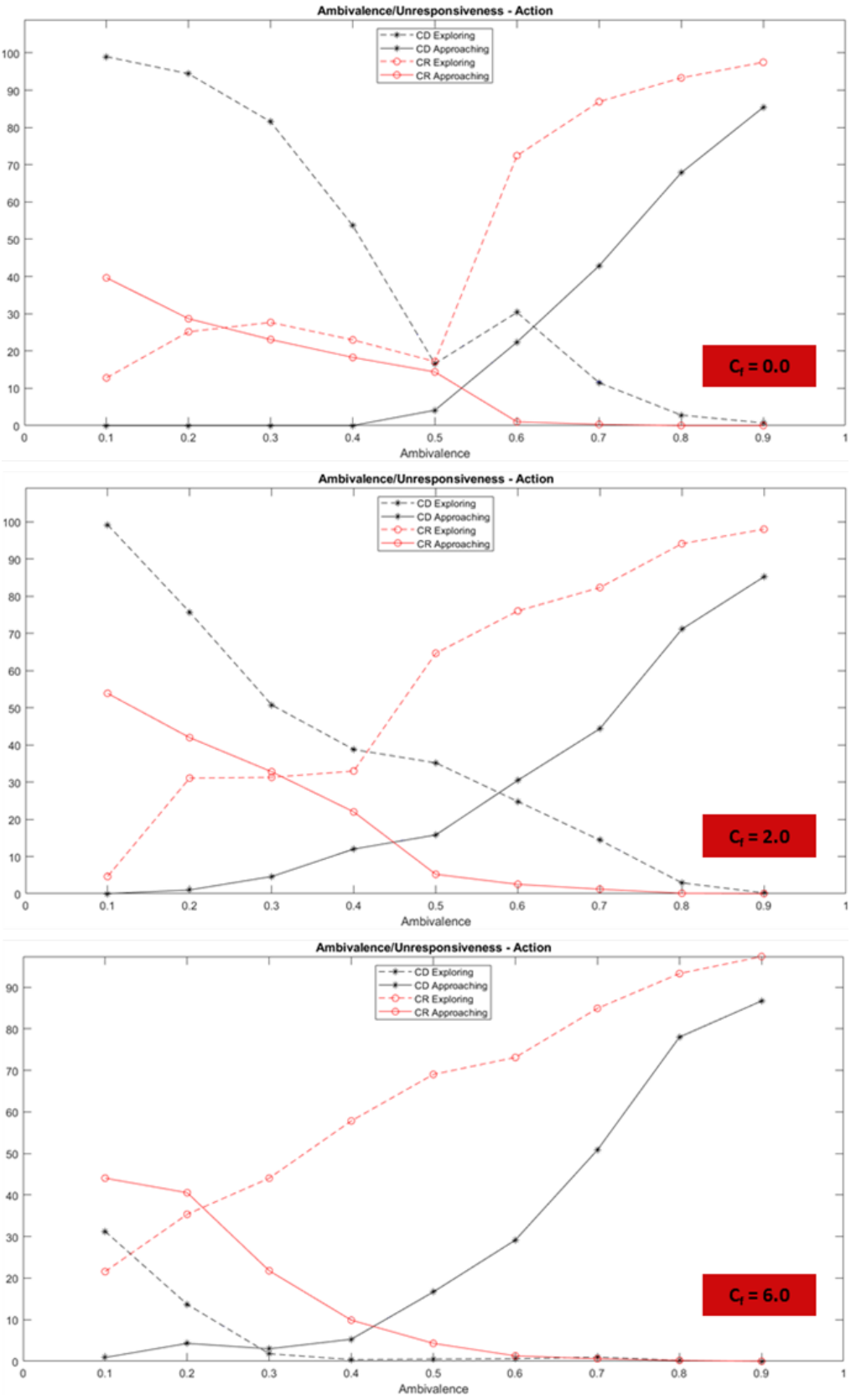


Figure 4. Ambivalent case. Approach (solid) and exploration (dashed) for the attacher (black) and caregiver (red) with 3 different coupling factors: $C_f = 0.0$ (top), $C_f = 2.0$ (center), $C_f = 6.0$ (bottom).

References

Ainsworth, M.D., and Bell, S.M. (1970). Attachment, exploration, and separation: illustrated by the behavior of one-year-olds in a strange situation. *Child Development* 41(1), 49-67.

Ainsworth, M.D.S., Blehar, M.C., Waters, E., and Wall, S. (1978). *Patterns of attachment: A psychological study of the strange situation.* Hillsdale, NJ: Earlbaum.

Aksan, N., and Kochanska, G. (2005). Conscience in childhood: old questions, new answers. *Developmental Psychology* 41(3), 506-516.

Alexander, F., and French, T.M. (1946). *Psychoanalytic Therapy: Principles and Application.* New York, NY Ronald Press.

Alexandrov, E.O., Cowan, P.A., and Cowan, C.P. (2005). Couple attachment and the quality of marital relationships: Method and concept in the validation of the new couple attachment interview and coding system. *Attachment & Human Development* 7(2), 123-152. doi: 10.1080/14616730500155170.

Allen, B. (2016). A RADical Idea: A Call to Eliminate "Attachment Disorder" and "Attachment Therapy" From the Clinical Lexicon. *Evidence-Based Practice in Child and Adolescent Mental Health* 1(1), 60-71. doi: 10.1080/23794925.2016.1172945.

Allen, J.P. (2008). "The Attachment System in Adolescence," in *Handbook of attachment: Theory, research, and clinical applications,* eds. J. Cassidy & P.R. Shaver. 2nd ed (New York, NY: The Guilford Press), 419-435.

Amengual, A. (2009). "A computational model of attachment secure responses in the strange situation". Technical Report TR-09-002, International Computer Science Institute).

Ammaniti, M., van Ijzendoorn, M.H., Speranza, A.M., and Tambelli, R. (2000). Internal working models of attachment during late childhood and early adolescence: an exploration of stability and change. *Attachment & Human Development* 2(3), 328-346. doi: 10.1080/14616730010001587.

Arciero, G., and Bondolfi, G. (2009). *Selfhood, identity and personality styles.* Hoboken, NJ: Wiley.

Ayuso, J.L., Alfonso, S., and Rivera, A. (1989). Childhood separation anxiety and panic disorder: a comparative study. *Progress in neuro-psychopharmacology & biological psychiatry* 13(5), 665-671.

Baddeley, A.D. (2000). The episodic buffer: a new component of working memory? *Trends in Cognitive Science* 4(11), 417-423.

Bakermans-Kranenburg, M.J., and van Ijzendoorn, M.H. (1993). A psychometric study of the Adult Attachment Interview: Reliability and discriminant validity. *Developmental psychology* 29(5), 870-879.

Bandalos, D.L., and Boehm-Kaufman, M.R. (2009). "Four common misconceptions in exploratory factor analysis," in *Statistical and methodological myths and urban legends: Doctrine, verity and fable in the organizational and social sciences,* eds. C.E. Lance & R.J. Vandenberg. (New York, NY: Routledge), 61-87.

Barone, L., and Del Corno, F. (eds.). (2006). *La valutazione dell'attaccamento adulto.* Milan, IT: Raffaello Cortina Editore.

Bartholomew, K. (1990). Avoidance of intimacy: An attachment perspective. *Journal of Social and Personal relationships* 7(2), 147-178.

Bartholomew, K., and Horowitz, L.M. (1991). Attachment styles among young adults: a test of a four-category model. *Journal of Personality and Social Psychology* 61(2), 226-244.

Basile, B., De Sanctis, B., Fadda, S., Luppino, O.I., Perdighe, C., Saliani, A.M., et al. (2018). Early life experiences in OCD and other disorders: A retrospective observational study using Imagery with Re-scripting. *Clinical Neuropsychiatry: Journal of Treatment Evaluation* 15(5), 299-305.

Basile, B., Mancini, F., Macaluso, E., Caltagirone, C., and Bozzali, M. (2013). Abnormal processing of deontological guilt in obsessive–compulsive disorder. *Brain structure and function* 219(4), 1321-1331.

Baumrind, D. (1971). Current patterns of parental authority. *Developmental Psychology Monographs* 4(1), 1-103.

Baumrind, D. (2013). "Authoritative parenting revisited: History and current status," in *Authoritative parenting: Synthesizing nurturance and discipline for optimal child development.,* eds. R.E. Larzelere, A.S. Morris & A.W. Harrist. (Washington, DC, US: American Psychological Association), 11-34.

Baumrind, D., Larzelere, R.E., and Owens, E.B. (2010). Effects of Preschool Parents' Power Assertive Patterns and Practices on Adolescent Development. *Parenting* 10(3), 157-201. doi: 10.1080/15295190903290790.

Bechtel, W. (1998). Representations and Cognitive Explanations: Assessing the Dynamicist's Challenge in Cognitive Science. 22(3), 295-318. doi: https://doi.org/10.1207/s15516709cog2203_2.

Beck, A.T. (1967). *Depression: Clinical, experimental and theoretical aspects.* New York, NY: Harper and Row.

Beck, A.T. (1976). *Cognitive therapy and the emotional disorders.* New York, NY: International Universities Press.

Beck, A.T., Davis, D.D., and Freeman, A. (eds.). (2015). *Cognitive Therapy of Personality Disorders.* New York, NY: The Guilford Press.

Beck, A.T., and Haigh, E.A. (2014). Advances in cognitive theory and therapy: the generic cognitive model. *Annual Review of Clinical Psychology* 10, 1-24. doi: 10.1146/annurev-clinpsy-032813-153734.

Beck, J.S. (2011). *Cognitive Behavior Therapy. Basics and Beyond.* New York, NY: The Guilford Press.

Behar A, R., Manzo G, R., and Casanova Z, D. (2006). [Lack of assertiveness in patients with eating disorders]. *Revista medica de Chile* 134(3), 312-319. doi: /s0034-98872006000300007.

Behne, T., Carpenter, M., Call, J., and Tomasello, M. (2005). Unwilling versus unable: infants' understanding of intentional action. *Developmental psychology* 41(2), 328-337.

Behrens, K.Y., Haltigan, J.D., and Bahm, N.I.G. (2016). Infant attachment, adult attachment, and maternal sensitivity: revisiting the intergenerational transmission gap. *Attachment & Human Development* 18(4), 337-353. doi: 10.1080/14616734.2016.1167095.

Belden, A.C., Sullivan, J.P., and Luby, J.L. (2007). Depressed and healthy preschoolers' internal representations of their mothers' caregiving: Associations with observed caregiving behaviors one year later. *Attachment & Human Development* 9(3), 239-254. doi: 10.1080/14616730701455395.

Berghaus, B.J. (2011). A new look at attachment theory and adult attachment behavior. *Behaviorology Today* 14(2), 3-10.

Berne, E. (1972). *What do you say after you say hello? The Psychology of Human Destiny.* New York, NY: Bantam Books.

Berne, E. (1973). *Sex In Human Loving.* London, UK: Penguin Books.

Bernier, A., Matte-Gagné, C., Bélanger, M.E., and Whipple, N. (2014). Taking stock of two decades of attachment transmission gap: Broadening the assessment of maternal behavior. *Child development* 85(5), 1852-1865.

Berry, K., and Danquah, A. (2016). Attachment-informed therapy for adults: Towards a unifying perspective on practice. *Psychology and Psychotherapy: Theory, Research and Practice* 89(1), 15-32. doi: 10.1111/papt.12063.

Bishop, C. (2006). *Pattern Recognition and Machine Learning.* New York, NY: Springer.

Blatt, S.J., and Levy, K.N. (2003). Attachment Theory, Psychoanalysis, Personality Development, and Psychopathology. *Psychoanalytic Inquiry* 23(1), 102-150. doi: 10.1080/07351692309349028.

Bo, S., Abu-Akel, A., Kongerslev, M., Haahr, U.H., and Bateman, A. (2014). Mentalizing Mediates the Relationship Between Psychopathy and Type of Aggression in Schizophrenia. *The Journal of Nervous and Mental Disease* 202(1), 55-63.

Bolen, R.M. (2000). Validity of Attachment Theory. *Trauma, Violence, & Abuse* 1(2), 128-153. doi: 10.1177/1524838000001002002.

Bonabeau, E. (2002). Agent-based modeling: Methods and techniques for simulating human systems. *Proceedings of the National Academy of Sciences* 99(suppl. 3), 7280-7287. doi: 10.1073/pnas.082080899.

Borghi, A.M., and Fini, C. (2019). Theories and Explanations in Psychology. *Frontiers in Psychology* 10, 958.

Botto, S.V., and Rochat, P. (2018). Sensitivity to the evaluation of others emerges by 24 months. *Developmental Psychology* 54(9), 1723–1734.

Bouchard, T.J. (2004). Genetic Influence on Human Psychological Traits: A Survey. *Current Directions in Psychological Science* 13(4), 148-151. doi: 10.1111/j.0963-7214.2004.00295.x.

Bowlby, J. (1969/1982). *Attachment and Loss. Volume 1, Attachment.* New York, NY: Basic Books.

Bowlby, J. (1973). *Attachment and Loss, volume 2. Separation: Anxiety and Anger.* New York, NY: Basic Books.

Bowlby, J. (1979). *The Making and Breaking of Affectional Bonds.* London, UK: Tavistock Publications.

Bowlby, J. (1980). *Attachment and Loss, volume 3. Loss: Sadness and Depression.* New York, NY: Basic Books.

Bowlby, J. (1988). *A Secure Base. Parent-Child Attachment and Healthy Human Development.* New York, NY: Basic Books.

Boysan, M., and Çam, Z. (2016). An investigation into the role of attachment insecurities in obsessive-compulsive symptoms. *British Journal of Guidance & Counselling* 46(5), 566-581.

Braitenberg, V. (1984). *Vehicles: experiments in synthetic psychology.* Cambridge, MA: MIT Press.

Brennan, K.A., Clark, C.L., and Shaver, P.R. (1998). "Self-report measurement of adult attachment: An integrative overview," in *Attachment Theory and Close Relationships,* eds. J.A. Simpson & W.S. Rholes. (New York, NY: The Guilford Press), 46-76.

Brennan, K.A., Shaver, P.R., and Tobey, A.E. (1991). Attachment styles, gender and parental problem drinking. *Journal of Social and Personal Relationships* 8(4), 451-466.

Bresler, J., and Starr, K.E. (2015). *Relational psychoanalysis and psychotherapy integration: An evolving synergy.* New York, NY: Routledge.

Bretherton, I. (1993). "The roots and growing points of attachment theory," in *Attachment across the life cycle,* eds. C.M. Parkes, J. Stevenson-Hinde & P. Marris. (New York, NY: Routledge), 17-40.

Bretherton, I., and Munholland, K.A. (2008). "Internal working models in attachment relationships: Elaborating a central construct in attachment theory," in *Handbook of attachment: Theory, research, and clinical applications,* eds. J. Cassidy & P.R. Shaver. 2nd ed (New York, NY: The Guilford Press), 102-127.

Brown, G.W., and Harris, T. (1978). *Social Origins of Depression. A Study of Psychiatric Disorder in Women.* London, UK: Tavistock Publications.

Brumariu, L.E. (2015). Parent–Child Attachment and Emotion Regulation. *New Directions for Child and Adolescent Development* 2015(148), 31-45. doi: 10.1002/cad.20098.

Buono, L., Chau, R., Lewis, G., Madras, N., Pugh, M., Rossi, L., et al. (2006). "Mathematical models of mother/child attachment". Fields–MITACS Industrial Problems Workshop).

Buss, D.M. (ed.). (2005). *The handbook of evolutionary psychology.* Hoboken, NJ: Wiley.

Butcher, J.N., Graham, J.R., Ben-Porath, Y.S., Tellegen, A., Dahlstrom, W.G., and Kaemmer, B. (2001). *MMPI-2: Manual for administration and scoring.* Minneapolis, MN: University of Minnesota Press.

Butcher, J.N., and Williams, C.L. (2009). Personality Assessment with the MMPI-2: Historical Roots, International Adaptations, and Current Challenges. *Applied Psychology: Health and Well-Being* 1(1), 105-135. doi: 10.1111/j.1758-0854.2008.01007.x.

Cameron, J.J., Finnegan, H., and Morry, M.M. (2012). Orthogonal dreams in an oblique world: A meta-analysis of the association between attachment anxiety and avoidance. *Journal of Research in Personality* 46(5), 472-476. doi: https://doi.org/10.1016/j.jrp.2012.05.001.

Carcione, A., Nicolò, G., Pedone, R., Popolo, R., Conti, L., Fiore, D., et al. (2011). Metacognitive mastery dysfunctions in personality disorder psychotherapy. *Psychiatry Research* 190(1), 60-71. doi: https://doi.org/10.1016/j.psychres.2010.12.032.

Carcione, A., Nicolò, G., and Semerari, A. (eds.). (2016). *Curare i casi complessi. La terapia metacognitiva interpersonale dei disturbi di personalità.* Bari, IT: Laterza.

Carcione, A., Riccardi, I., Bilotta, E., Leone, L., Pedone, R., Conti, L., et al. (2019). Metacognition as a Predictor of Improvements in Personality Disorders. *Frontiers in Psychology* 10, 1-10.

Carlin, J.D., and Calder, A.J. (2013). The neural basis of eye gaze processing. *Current opinion in neurobiology* 23(3), 450-455.

Carruthers, P. (2006). *The Architecture of the Mind.* Oxford, UK: University Press.

Cassidy, J., and Shaver, P.R. (eds.). (1999). *Handbook of Attachment: Theory, Research, and Clinical Applications.* New York, NY: The Guilford Press.

Cassidy, J., and Shaver, P.R. (eds.). (2008). *Handbook of Attachment: Theory, Research, and Clinical Applications.* New York, NY: The Guilford Press.

Cassidy, J., and Shaver, P.R. (eds.). (2016). *Handbook of Attachment: Theory, Research, and Clinical Applications.* New York, NY: The Guilford Press.

Castelfranchi, C., Mancini, F., and Miceli, M. (2002). *Fondamenti di Cognitivismo Clinico.* Turin, IT: Bollati Boringhieri.

Chisholm, J.S. (1996). The evolutionary ecology of attachment organization. *Human Nature* 7(1), 1-37.

Chisholm, J.S., and Sieff, D.F. (2014). "Live Fast, Die Young: An evolved response to hostile environments," in *Understanding and Healing Emotional Trauma: Conversations with Pioneering Clinicians and Researchers,* ed. D.F. Sieff. (New York, NY: Routledge), 163-181.

Chopik, W.J., Edelstein, R.S., and Fraley, R.C. (2013). From the Cradle to the Grave: Age Differences in Attachment From Early Adulthood to Old Age. *Journal of Personality* 81(2), 171-183. doi: 10.1111/j.1467-6494.2012.00793.x.

Chow, S.M., Ou, L., Ciptadi, A., Prince, E.B., You, D., Hunter, M.D., et al. (2018). Representing Sudden Shifts in Intensive Dyadic Interaction Data Using Differential Equation Models with Regime Switching. *Psychometrika* 83(2), 476-510. doi: 10.1007/s11336-018-9605-1.

Cittern, D. (2016). *A Behavioral Systems Approach Toward a Unified Theory of Human Motivation: A computational model of attachment theory dynamics.* Imperial College London

Clark, A. (1997). *Being There: Putting Brain, Body, and World Together Again.* Cambridge, Ma: MIT Press.

Cofer, C.N., and Appley, M.H. (1964). *Motivation: Theory and research.* Hoboken, NJ: Wiley.

Coleman, P., and Watson, A. (2000). Infant Attachment as a Dynamic System. *Human Development* 43(6), 295-313.

Collins, N.L. (1996). Working models of attachment: Implications for explanation, emotion, and behavior. *Journal of personality and social psychology* 71(4), 810-832.

Collins, N.L., Ford, M.B., Guichard, A.C., and Allard, L.M. (2006). Working models of attachment and attribution processes in intimate relationships. *Personality and Social Psychology Bulletin* 32(2), 201-219.

Collins, N.L., and Read, S.J. (1990). Adult attachment, working models, and relationship quality in dating couples. *Journal of personality and social psychology* 58(4), 644-663.

Coplan, R.J., and Arbeau, K.A. (2009). "Peer interactions and play in early childhood," in *Handbook of peer interactions, relationships, and groups,* eds. K.H. Rubin, W.M. Bukowski & B. Laursen. (New York, NY: The Guilford Press.), 143-161.

Corr, P.J., and Matthews, G. (eds.). (2009). *The Cambridge Handbook of Personality Psychology.* New York, NY: Cambridge University Press.

Cowan, P.A., and Cowan, C.P. (2007). Attachment theory: Seven unresolved issues and questions for future research. *Research in Human Development* 4(3-4), 181-201. doi: 10.1080/15427600701663007.

Crittenden, P.M. (1995). "Attachment and psychopathology," in *Attachment theory: Social, developmental, and clinical perspectives,* eds. S. Goldberg, R. Muir & J. Kerr. (Hillsdale, NJ: Analytic Press), 367-406.

Crittenden, P.M. (2008). *Raising parents: Attachment, parenting and child safety.* Cullompton, UK: Willan.

Crowell, J.A., Fraley, R.C., and Roisman, G.I. (2016). "Measurement of Individual Differences in Adult Attachment," in *Handbook of Attachment: Theory, Research, and Clinical Applications,* eds. J. Cassidy & P.R. Shaver. (New York, NY: The Guilford Press), 598-635.

Crowell, J.A., Fraley, R.C., and Shaver, P.R. (1999). "Measurement of individual differences in adolescent and adult attachment," in *Handbook of attachment: Theory, research, and clinical applications.* (New York, NY, US: The Guilford Press), 434-465.

Dancey, C.P., and Reidy, J. (2011). *Statistics without maths for psychology.* London, UK: Pearson education.

Dawson, M.R.W. (2004). *Minds And Machines: Connectionism And Psychological Modeling.* Hoboken, NJ: Blackwell.

De Wolff, M.S., and van Ijzendoorn, M.H. (1997). Sensitivity and Attachment: A Meta-Analysis on Parental Antecedents of Infant Attachment. *Child Development* 68(4), 571-591. doi: 10.1111/j.1467-8624.1997.tb04218.x.

DeKlyen, M., and Greenberg, M.T. (2016). "Attachment and psychopathology in childhood," in *Handbook of attachment. Theory, research, and clinical applications,* eds. J. Cassidy & P.R. Shaver. 3rd ed (New York, NY: The Guilford Press), 639-666.

Denis, D.J. (2018). *SPSS data analysis for univariate, bivariate, and multivariate statistics.* Hoboken, NJ: Wiley.

Dimaggio, G. (2015). Awareness of maladaptive interpersonal schemas as a core element of change in psychotherapy for personality disorders. *Journal of Psychotherapy Integration* 25(1), 39-44.

Dimaggio, G., and Lysaker, P.H. (eds.). (2010). *Metacognition and Severe Adult Mental Disorders: From Research to Treatment.* London, UK: Routledge.

Dimaggio, G., and Lysaker, P.H. (2015). Metacognition and Mentalizing in the Psychotherapy of Patients With Psychosis and Personality Disorders. *Journal of Clinical Psychology* 71(2), 117-124. doi: 10.1002/jclp.22147.

Dimaggio, G., and Lysaker, P.H. (2018). A Pragmatic View of Disturbed Self-Reflection in Personality Disorders: Implications for Psychotherapy. *Journal of Personality Disorders* 32(3), 311-328. doi: 10.1521/pedi.2018.32.3.311.

Dimaggio, G., Montano, A., Popolo, R., and Salvatore, G. (2015). *Metacognitive interpersonal therapy for personality disorders: A treatment manual.* London: Routledge.

Dimaggio, G., Popolo, R., and Salvatore, G. (2019). "Chapter 8 - Formulation of Functioning for Avoidant Personality Disorder in Metacognitive Interpersonal Therapy," in *Case Formulation for Personality Disorders,* ed. U. Kramer. (Cambridge, MA: Academic Press), 137-160.

Dimaggio, G., Salvatore, G., MacBeth, A., Ottavi, P., Buonocore, L., and Popolo, R. (2017). Metacognitive Interpersonal Therapy for Personality Disorders: A Case Study Series. *Journal of Contemporary Psychotherapy* 47(1), 11-21. doi: 10.1007/s10879-016-9342-7.

Doron, G., Moulding, R., Kyrios, M., Nedeljkovic, M., and Mikulincer, M. (2009). Adult attachment insecurities are related to obsessive compulsive phenomena. *Journal of Social and Clinical Psychology* 28(8), 1022-1049.

Duda, R.O., Hart, P.E., and Stork, D.G. (2000). *Pattern classification.* Hoboken, NJ: Wiley.

Dweck, C.S. (2008). Can Personality Be Changed? The Role of Beliefs in Personality and Change. *Current Directions in Psychological Science* 17(6), 391-394. doi: 10.1111/j.1467-8721.2008.00612.x.

Ellis, A. (1962). *Reason and emotion in psychotherapy.* Oxford, UK: Lyle Stuart.

Ellis, B.J., Figueredo, A.J., Brumbach, B.H., and Schlomer, G.L. (2009). Fundamental dimensions of environmental risk: The impact of harsh versus unpredictable environments on the evolution and development of life history strategies. *Human Nature* 20(2), 204-268.

Engler, B. (2013). *Personality Theories.* Boston, MA: Cengage Learning.

Faber, A., Dubé, L., and Knäuper, B. (2018). Attachment and eating: A meta-analytic review of the relevance of attachment for unhealthy and healthy eating behaviors in the general population. *Appetite* 123, 410-438. doi: https://doi.org/10.1016/j.appet.2017.10.043.

Faravelli, C., Di Paola, F., Scarpato, M.A., and Fioravanti, G. (2010). Parental attitudes of mothers of patients with panic disorder. *Journal of Psychopathology* 16, 144-149.

Faravelli, C., Panichi, C., Pallanti, S., Paterniti, S., Grecu, L.M., and Rivelli, S. (1991). Perception of early parenting in panic and agoraphobia. *Acta Psychiatrica Scandinavica* 84(1), 6-8.

Farnfield, S., Hautamäki, A., Nørbech, P., and Sahhar, N. (2010). DMM assessments of attachment and adaptation: Procedures, validity and utility. *Clinical Child Psychology and Psychiatry* 15(3), 313-328.

Feeney, J.A. (2016). "Adult Romantic Attachment. Developments in the Study of Couple Relationships," in *Handbook of attachment: Theory, research, and clinical applications,* eds. J. Cassidy & P.R. Shaver. 3rd ed (New York, NY: The Guilford Press), 435-463.

Feldman, R. (2017). The neurobiology of human attachments. *Trends in Cognitive Sciences* 21(2), 80-99.

Field, A. (2018). *Discovering statistics using IBM SPSS statistics.* Thousand Oaks, CA: SAGE Publications.

Fitton, V.A. (2012). Attachment Theory: History, Research, and Practice. *Psychoanalytic Social Work* 19(1-2), 121-143. doi: 10.1080/15228878.2012.666491.

Fitzgerald, M. (2019). "The Future of Psychiatry and Neurodevelopmental Disorders: A Paradigm Shift," in *Neurodevelopment and Neurodevelopmental Disorder,* ed. M. Fitzgerald. (London: IntechOpen).

Fonagy, P., and Bateman, A.W. (2016). Adversity, attachment, and mentalizing. *Comprehensive Psychiatry* 64, 59-66. doi: https://doi.org/10.1016/j.comppsych.2015.11.006.

Fonagy, P., Gergely, G., Jurist, E.L., and Target, M. (2002). *Affect Regulation, Mentalization, and the Development of the Self.* New York, NY: Other Press.

Fox, N.A. (2014). What Do We Know about Sensitive Periods in Human Development and How Do We Know It? *Human Development* 57(4), 173-175.

Fox, N.A., Kimmerly, N.L., and Schafer, W.D. (1991). Attachment to Mother/Attachment to Father: A Meta-Analysis. *Child Development* 62(1), 210-225. doi: https://doi.org/10.1111/j.1467-8624.1991.tb01526.x.

Fraley, R.C. (2002). Attachment stability from infancy to adulthood: Meta-analysis and dynamic modeling of developmental mechanisms. *Personality and social psychology review* 6(2), 123-151.

Fraley, R.C., and Brumbaugh, C.C. (2004). "A Dynamical Systems Approach to Conceptualizing and Studying Stability and Change in Attachment Security," in *Adult attachment: Theory, research, and clinical implications.,* eds. W.S. Rholes & J.A. Simpson. (New York, NY: Guilford), 86-132.

Fraley, R.C., Heffernan, M.E., Vicary, A.M., and Brumbaugh, C.C. (2011). The experiences in close relationships—Relationship Structures Questionnaire: A method for assessing attachment orientations across relationships. *Psychological Assessment* 23(3), 615-625. doi: 10.1037/a0022898.

Fraley, R.C., Hudson, N.W., Heffernan, M.E., and Segal, N. (2015). Are adult attachment styles categorical or dimensional? A taxometric analysis of general and relationship-specific attachment orientations. *Journal of Personality and Social Psychology* 109(2), 354.

Fraley, R.C., and Roisman, G.I. (2019). The development of adult attachment styles: four lessons. *Current Opinion in Psychology* 25, 26-30. doi: https://doi.org/10.1016/j.copsyc.2018.02.008.

Fraley, R.C., and Shaver, P.R. (2000). Adult romantic attachment: Theoretical developments, emerging controversies, and unanswered questions. *Review of general psychology* 4(2), 132-154.

Fraley, R.C., and Shaver, P.R. (2008). "Attachment theory and its place in contemporary personality research," in *Handbook of Personality: Theory and Research,* eds. O. John & R.W. Robins. 3rd ed (New York, NY: The Guilford Press), 518-541.

Fraley, R.C., and Spieker, S.J. (2003). Are infant attachment patterns continuously or categorically distributed? A taxometric analysis of strange situation behavior. *Developmental Psychology* 39(3), 387-404.

Fraley, R.C., and Waller, N.G. (1998). "Adult attachment patterns: A test of the typological model," in *Attachment theory and close relationships,* eds. J.A. Simpson & W.S. Rholes. (New York, NY: The Guilford Press), 77-114.

Fraley, R.C., Waller, N.G., and Brennan, K.A. (2000). An item response theory analysis of self-report measures of adult attachment. *Journal of personality and social psychology* 78(2), 350-365.

Friedenberg, J., and Silverman, G. (2016). *Cognitive science: an introduction to the study of mind.* Thousand Oaks, CA: SAGE Publications.

Friedman, H.S., and Schustack, M.W. (2015). *Personality: Classic Theories and Modern Research.* New York, NY: Pearson.

Friston, K. (2010). The free-energy principle: a unified brain theory? *Nature reviews neuroscience* 11(2), 127-138.

Furman, W., and Simon, V.A. (2006). Actor and Partner Effects of Adolescents' Romantic Working Models and Styles on Interactions with Romantic Partners. *Child Development* 77(3), 588-604. doi: https://doi.org/10.1111/j.1467-8624.2006.00892.x.

Gagliardi, M. (2021). How Our Caregivers Shape Who We Are: The Seven Dimensions of Attachment at the Core of Personality. *Frontiers in Psychology* 12(2656). doi: 10.3389/fpsyg.2021.657628.

George, C., Kaplan, N., and Main, M. (1985). *The Adult Attachment Interview.* Berkeley, CA: Unpublished manuscript, University of California.

George, D., and Mallery, P. (2019). *IBM SPSS statistics 26 step by step: A simple guide and reference.* New York, NY: Routledge.

Glancy, J., Groß, R., Stone, J.V., and Wilson, S.P. (2015). A Self-Organising Model of Thermoregulatory Huddling. *PLOS Computational Biology* 11(9), e1004283. doi: 10.1371/journal.pcbi.1004283.

Gordon-King, K., Schweitzer, R.D., and Dimaggio, G. (2019). Metacognitive Interpersonal Therapy for Personality Disorders: The Case of a Man with Obsessive–Compulsive Personality Disorder and Avoidant Personality Disorder. *Journal of Contemporary Psychotherapy* 49(1), 39-47. doi: 10.1007/s10879-018-9404-0.

Gothard, K.M. (2014). The amygdalo-motor pathways and the control of facial expressions. *Frontiers in neuroscience* 8(43), 1-7.

Gray, P.O. (2006). *Psychology.* New York, NY: Worth Publishers.

Green, J., Stanley, C., Smith, V., and Goldwyn, R. (2000). A new method of evaluating attachment representations in young school-age children: The Manchester Child Attachment Story Task. *Attachment & Human Development* 2(1), 48-70.

Grice, H.P. (1975). "Logic and conversation," in *Syntax and semantics: Vol. 3. Speech acts,* eds. P. Cole & J.L. Moran. (New York, NY: Academic Press), 41-58.

Guidano, V.F. (1987). *Complexity of the self: A developmental approach to psychopathology and therapy.* New York, NY: The Guilford Press.

Guidano, V.F. (1991). *The self in process: Toward a post-rationalist cognitive therapy.* New York, NY: The Guilford Press.

Guidano, V.F. (2007). *Psicoterapia cognitiva post-razionalista. Una ricognizione dalla teoria alla clinica.* Milan, IT: FrancoAngeli.

Guidano, V.F., and Liotti, G. (1983). *Cognitive processes and emotional disorders.* New York, NY: The Guilford Press.

Gunning, D., Stefik, M., Choi, J., Miller, T., Stumpf, S., and Yang, G.-Z. (2019). XAI—Explainable artificial intelligence. *Science Robotics* 4(37), 1-3. doi: 10.1126/scirobotics.aay7120.

Hair, J.F., Black, W.C., Babin, B.J., and Anderson, R.E. (2013). *Multivariate Data Analysis.* London, UK: Pearson.

Hall, J., and Llewelyn, S. (2006). *What is Clinical Psychology?* Oxford, UK: Oxford University Press.

Hamilton, W.D. (1964). The genetical evolution of social behaviour. *Journal of Theoretical Biology* 7(1), 1-52.

Harlow, H.F. (1959). Love in Infant Monkeys. *Scientific American* 200(6), 68-75.

Harlow, H.F., and Harlow, M.K. (1962). Social deprivation in monkeys. *Scientific american* 207(5), 136-150.

Harlow, H.F., and Suomi, S.J. (1970). Nature of love - simplified. *American Psychologist* 25(2), 161-168. doi: 10.1037/h0029383.

Harlow, H.F., and Zimmermann, R.R. (1959). Affectional responses in the infant monkey. *Science* 130(3373), 421-432.

Harrist, A.W., and Waugh, R.M. (2002). Dyadic synchrony: Its structure and function in children's development. *Developmental Review* 22(4), 555-592. doi: https://doi.org/10.1016/S0273-2297(02)00500-2.

Hartmann, A., Zeeck, A., and Barrett, M.S. (2010). Interpersonal problems in eating disorders. *International Journal of Eating Disorders* 43(7), 619-627. doi: 10.1002/eat.20747.

Hazan, C., and Shaver, P.R. (1987). Romantic love conceptualized as an attachment process. *Journal of personality and social psychology* 52(3), 511-524.

Hazan, C., and Shaver, P.R. (1994). Attachment as an organizational framework for research on close relationships. *Psychological inquiry* 5(1), 1-22.

Hennighausen, K.H., and Lyons Ruth, K. (2005). "Disorganization of behavioral and attentional strategies toward primary attachment figures: from biologic to dialogic processes," in *Attachment and bonding: a new synthesis,* eds. S. Carter, L. Ahnert, K.E. Grassmann, S. Hrdy, M. Lamb, S. Porges & N. Sachser. (Cambridge, MA: MIT Press), 269–301.

Heppner, P.P., Heppner, M.J., Lee, D.-g., Wang, Y.-W., Park, H.-j., and Wang, L.-f. (2006). Development and validation of a collectivist coping styles inventory. *Journal of Counseling Psychology* 53(1), 107–125.

Hertler, S.C. (2015a). The evolutionary logic of the obsessive trait complex: obsessive compulsive personality disorder as a complementary behavioral syndrome. *Psychological Thought* 8(1), 17–34.

Hertler, S.C. (2015b). Obsessive Compulsive Personality Disorder as an Adaptive Anachronism: The Operation of Phylogenetic Inertia Upon Obsessive Populations in Western Modernity. *Psychological Topics* 24(2), 207-232.

Hess, E.H. (1959). Imprinting. *Science* 130(3368), 133-141. doi: 10.1126/science.130.3368.133.

Hesse, E. (2008). "The Adult Attachment Interview. Protocol, Method of Analysis, and Empirical Studies," in *Handbook of Attachment: Theory, Research, and Clinical Applications,* eds. J. Cassidy & P.R. Shaver. 2nd ed (New York, NY: The Guilford Press), 552-598.

Hesse, E. (2016). "The Adult Attachment Interview: Protocol, Method of Analysis, and Empirical Studies: 1985–2015," in *Handbook of Attachment: Theory, Research, and Clinical Applications,* eds. J. Cassidy & P.R. Shaver. 3rd ed (New York, NY: The Guilford Press), 553-597.

Hoehl, S., Reid, V.M., Parise, E., Handl, A., Palumbo, L., and Striano, T. (2009). Looking at eye gaze processing and its neural correlates in infancy—Implications for social development and autism spectrum disorder. *Child Development* 80(4), 968-985.

Hollenstein, T., Tighe, A.B., and Lougheed, J.P. (2017). Emotional development in the context of mother–child relationships. *Current Opinion in Psychology* 17, 140-144. doi: https://doi.org/10.1016/j.copsyc.2017.07.010.

Hopkins, J., Lavigne, J.V., Gouze, K.R., LeBailly, S.A., and Bryant, F.B. (2013). Multi-domain Models of Risk Factors for Depression and Anxiety Symptoms in Preschoolers: Evidence for Common and Specific Factors. *Journal of Abnormal Child Psychology* 41(5), 705-722. doi: 10.1007/s10802-013-9723-2.

Howitt, D., and Cramer, D. (2017). *Understanding statistics in psychology with SPSS.* London, UK: Pearson.

Itier, R.J., and Batty, M. (2009). Neural bases of eye and gaze processing: the core of social cognition. *Neuroscience & Biobehavioral Reviews* 33(6), 843-863.

Ivarsson, T., Granqvist, P., Gillberg, C., and Broberg, A.G. (2010). Attachment states of mind in adolescents with Obsessive–Compulsive Disorder and/or depressive disorders: a controlled study. *European child & adolescent psychiatry* 19(11), 845-853.

Jennings, N.R. (1999). "Agent-based computing: Promise and perils", in: *16th Int. Joint Conf. on Artificial Intelligence (IJCAI-99).* (Sweden).

Kaiser, H.F. (1974). An index of factorial simplicity. *Psychometrika* 39(1), 31-36.

Karterud, S.W., and Kongerslev, M.T. (2019). A Temperament-Attachment-Mentalization-Based (TAM) Theory of Personality and Its Disorders. *Frontiers in Psychology* 10(518), 1-17. doi: 10.3389/fpsyg.2019.00518.

Kendler, K.S., Myers, J., and Prescott, C.A. (2000). Parenting and adult mood, anxiety and substance use disorders in female twins: an epidemiological, multi-informant, retrospective study. *Psychological Medicine* 30(2), 281-294. doi: undefined.

Kerns, K.A., and Brumariu, L.E. (2016). "Attachment in Middle Childhood," in *Handbook of attachment: Theory, research, and clinical applications,* eds. J. Cassidy & P.R. Shaver. 3rd ed (New York, NY: The Guilford Press), 349-365.

Knudsen, E.I. (2004). Sensitive Periods in the Development of the Brain and Behavior. *Journal of Cognitive Neuroscience* 16(8), 1412-1425. doi: 10.1162/0898929042304796.

Knudsen, E.I. (2013). "Early Experience and Sensitive Periods," in *Fundamental Neuroscience (Fourth Edition),* eds. L.R. Squire, D. Berg, F.E. Bloom, S. du Lac, A. Ghosh & N.C. Spitzer. 4th ed (San Diego: Academic Press), 479-495.

Kobak, R., Zajac, K., and Madsen, S. (2016). "Attachment disruptions, reparative processes, and psychopathology: Theoretical and clinical implications," in *Handbook of attachment: Theory, research, and clinical applications,* eds. J. Cassidy & P.R. Shaver. 3rd ed), 25-39.

Kochanska, G., Koenig, J.L., Barry, R.A., Kim, S., and Yoon, J.E. (2010). Children's conscience during toddler and preschool years, moral self, and a competent, adaptive developmental trajectory. *Developmental psychology* 46(5), 1320-1332. doi: 10.1037/a0020381.

Kossowsky, J., Pfaltz, M.C., Schneider, S., Taeymans, J., Locher, C., and Gaab, J. (2013). The separation anxiety hypothesis of panic disorder revisited: a meta-analysis. *American Journal of Psychiatry* 170(7), 768-781.

Landers, M.S., and Sullivan, R.M. (2012). The development and neurobiology of infant attachment and fear. *Developmental neuroscience* 34(2-3), 101-114.

Leahy, R.L. (2004). *Contemporary cognitive therapy: Theory, research, and practice.* New York, NY: The Guilford Press.

Leerkes, E.M., and Wong, M.S. (2012). Infant distress and regulatory behaviors vary as a function of attachment security regardless of emotion context and maternal involvement. *Infancy* 17(5), 455-478.

Lennertz, L., Grabe, H.J., Ruhrmann, S., Rampacher, F., Vogeley, A., Schulze-Rauschenbach, S., et al. (2010). Perceived parental rearing in subjects with obsessive–compulsive disorder and their siblings. *Acta Psychiatrica Scandinavica* 121(4), 280-288. doi: 10.1111/j.1600-0447.2009.01469.x.

Levy, K.N., Johnson, B.N., Clouthier, T.L., Scala, J., and Temes, C.M. (2015). An attachment theoretical framework for personality disorders. *Canadian Psychology/Psychologie Canadienne* 56(2), 197-207.

Lewis, M. (2011). "The self-conscious emotions," in *Encyclopedia on Early Development: Emotions,* eds. R.E. Tremblay, M. Boivin, R.D. Peters & M. Lewis. (Montreal, Ca: The Centre of Excellence for Early Childhood Development), 6-9.

Lichtenberg, J.D., Lachmann, F.M., and Fosshage, J.L. (2010). *Psychoanalysis and Motivational Systems: A New Look.* London, UK: Routledge.

Likhachev, M., and Arkin, R.C. (2000). Robotic Comfort Zones. *Proceedings of SPIE: Sensor Fusion and Decentralized Control in Robotic Systems III Conference* 4196, 27-41.

Liotti, G. (1992). Disorganized/disoriented attachment in the etiology of the dissociative disorders. *Dissociation: Progress in the Dissociative Disorders* 5(4), 196-204.

Liotti, G. (2004). Trauma, dissociation, and disorganized attachment: Three strands of a single braid *Psychotherapy: Theory, research, practice, training* 41(4), 472-486.

Liotti, G. (2009). "Attachment and dissociation," in *Dissociation and the dissociative disorders: DSM-V and beyond,* eds. P.F. Dell & J.A. O'Neil. (New York, NY: Routledge), 53–65.

Liotti, G. (2011). Attachment disorganization and the controlling strategies: An illustration of the contributions of attachment theory to developmental psychopathology and to psychotherapy integration. *Journal of Psychotherapy Integration* 21(3), 232-252.

Liotti, G. (2016). "Attachment, implicit memory, and the unrepressed unconscious," in *Unrepressed Unconscious, Implicit Memory, and Clinical Work,* eds. G. Craparo & C. Mucci. (New York, NY: Routledge).

Liotti, G., and Ardovini, C. (2008). "Motivi e.significati dell'agire interpersonale: Rapporti fra motivazione, emozione e pensiero nella prospettiva evoluzionista," eds. G. Liotti & F. Monticelli. (Milan, IT: Raffaello Cortina Editore), 3-23.

Liotti, G., and Farina, B. (2011). *Sviluppi traumatici. Eziopatogenesi, clinica e terapia della dimensione dissociativa.* Milan, IT: Raffaello Cortina Editore.

Liotti, G., Fassone, G., and Monticelli, F. (eds.). (2017). *L'evoluzione delle emozioni e dei sistemi motivazionali.* Milan, IT: Raffaello Cortina Editore.

Liotti, G., and Monticelli, F. (eds.). (2008). *I sistemi motivazionali nel dialogo clinico.* Milan, IT: Raffaello Cortina Editore.

Liotti, G., and Monticelli, F. (2014). *Teoria e clinica dell'Alleanza Terapeutica. Una prospettiva cognitivo-evoluzionista.* Milan, IT: Raffaello Cortina Editore.

Lorenz, K.Z. (1937). The companion in the bird's world. *The Auk* 54(3), 245-273.

Lorenz, K.Z. (1981). *The foundations of ethology.* New York, NY: Springer.

Loughead, J., Gur, R.C., Elliott, M., and Gur, R.E. (2008). Neural circuitry for accurate identification of facial emotions. *Brain Research* 1194, 37-44.

Luby, J.L., Belden, A., Harms, M.P., Tillman, R., and Barch, D.M. (2016). Preschool is a sensitive period for the influence of maternal support on the trajectory of hippocampal development. *Proceedings of the national Academy of Sciences* 113(20), 5742-5747.

Lyons-Ruth, K., and Jacobvitz, D. (2008). "Attachment disorganization: Genetic factors, parenting contexts, and developmental transformation from infancy to adulthood," in *Handbook of attachment: Theory, research, and clinical applications,* eds. J. Cassidy & P. Shaver. 2nd ed (New York, NY: The Guilford Press), 666-697.

Lyons-Ruth, K., and Jacobvitz, D. (2016). "Attachment Disorganization from Infancy to Adulthood. Neurobiological Correlates, Parenting Contexts, and Pathways to Disorder," in *Handbook of attachment. Theory, research, and clinical applications,* eds. J. Cassidy & P.R. Shaver. 3rd ed (New York, NY: The Guilford Press).

Maier, M.A., Bernier, A., Pekrun, R., Zimmermann, P., Strasser, K., and Grossmann, K.E. (2005). Attachment state of mind and perceptual processing of emotional stimuli. *Attachment & Human Development* 7(1), 67-81. doi: 10.1080/14616730500039606.

Main, M., and Hesse, E. (1990). "Parents' unresolved traumatic experiences are related to infant disorganized attachment status: Is frightened and/or frightening parental behavior the linking mechanism?," in *Attachment during the preschool years: Theory, research and intervention,* eds. G. M.T, C. D & C. E.M. (Chicago, IL: University of Chicago Press), 161-182.

Main, M., and Hesse, E. (1992). "Frightening, frightened, dissociated, or disorganized behavior on the part of the parent: A coding system for parent{infant interactions".).

Main, M., Kaplan, N., and Cassidy, J. (1985). Security in infancy, childhood, and adulthood: A move to the level of representation. *Growing points of attachment theory and research. Monographs of the Society for Research in Child Development* 50(1-2), 66–104.

Main, M., and Solomon, J. (1990). "Procedures for identifying infants as disorganized/ disoriented during the Ainsworth strange situation," in *Attachment in the Preschool Years: Theory, Research, and Intervention,* eds. M.T. Greenberg, D. Cichetti & E.M. Cummings. (Chicago, IL: University of Chicago Press), 121-160.

Mallinckrodt, B. (2010). The psychotherapy relationship as attachment: Evidence and implications. *Journal of Social and Personal Relationships* 27(2), 262–270.

Mancini, F., and Gangemi, A. (2015). Deontological guilt and obsessive compulsive disorder. *Journal of Behavior Therapy and Experimental Psychiatry* 49, 157-163. doi: https://doi.org/10.1016/j.jbtep.2015.05.003.

Margolis, E., and Laurence, S. (2013). In defense of nativism. *Philosophical Studies* 165(2), 693-718. doi: 10.1007/s11098-012-9972-x.

Marvin, R.S., Britner, P.A., and Russell, B.S. (2016). "Normative Development. The Ontogeny of Attachment in Childhood," in *Handbook of attachment: Theory, research, and clinical applications,* eds. J. Cassidy & P.R. Shaver. 3rd ed (New York, NY: The Guilford Press), 273-290.

Matte-Gagné, C., Harvey, B., Stack, D.M., and Serbin, L.A. (2015). Contextual Specificity in the Relationship between Maternal Autonomy Support and Children's Socio-emotional Development: A Longitudinal Study from Preschool to Preadolescence. *Journal of Youth and Adolescence* 44(8), 1528-1541. doi: 10.1007/s10964-014-0247-z.

McConnell, M., and Moss, E. (2011). Attachment across the Life Span: Factors that Contribute to Stability and Change. *Australian Journal of Educational & Developmental Psychology* 11, 60-77.

McCrae, R.R., and Costa, P.T. (2003). *Personality in adulthood: A five-factor theory perspective.* New York, NY: The Guilford Press.

Mercer, J. (2011). Attachment theory and its vicissitudes: Toward an updated theory. *Theory & Psychology* 21(1), 25-45. doi: 10.1177/0959354309356136.

Mikulincer, M., and Shaver, P.R. (2016). *Attachment in Adulthood: Structure, Dynamics, and Change.* New York, NY The Guilford Press.

Mikulincer, M., Shaver, P.R., and Pereg, D. (2003). Attachment Theory and Affect Regulation: The Dynamics, Development, and Cognitive Consequences of Attachment-Related Strategies. *Motivation and Emotion* 27(2), 77–102.

Minuchin, S., Rosman, B.L., and Baker, L. (1978). *Psychosomatic Families: Anorexia Nervosa in Context.* Cambridge, MA Harvard University Press.

Montague, P.R., Dolan, R.J., Friston, K.J., and Dayan, P. (2012). Computational psychiatry. *Trends in Cognitive Sciences* 16(1), 72-80. doi: https://doi.org/10.1016/j.tics.2011.11.018.

Myhr, G., Sookman, D., and Pinard, G. (2004). Attachment security and parental bonding in adults with obsessive-compulsive disorder: a comparison with depressed out-patients and healthy controls. *Acta Psychiatrica Scandinavica* 109(6), 447-456.

Nakamori, T., Maekawa, F., Sato, K., Tanaka, K., and Ohki-Hamazaki, H. (2013). Neural basis of imprinting behavior in chicks. *Development, Growth & Differentiation* 55(1), 198-206. doi: 10.1111/dgd.12028.

Nardi, B., Arimatea, E., Giovagnoli, S., Blasi, S., Bellantuono, C., and Rezzonico, G. (2012). The mini questionnaire of personal organization (MQPO): Preliminary validation of a new post-rationalist personality questionnaire. *Clinical psychology & psychotherapy* 19(1), 78-90.

Nardi, B., and Bellantuono, C. (2008). A new adaptive and evolutionary conceptualization of the Personal Meaning Organization (PMO) framework. *European Psychotherapy* 8(1), 5-16.

Nardi, B., Rezzonico, G., and Bellantuono, C. (2010). Toward a scientific framework for the Personal Meaning Organization (PMO) paradigm: neuroimaging and genetic studies. *Quaderni Italiani di Psichiatria* 29(3), 81-88. doi: https://doi.org/10.1016/j.quip.2010.07.003.

Neal, Z.P., and Lawlor, J.A. (2016). "Agent-based models," in *Handbook of methodological approaches to community-based research: Qualitative, quantitative, and mixed methods,* eds. L. Jason, A. & D. Glenwick, S.), 197-206.

Nelson, C.A., Zeanah, C.H., Fox, N.A., Marshall, P.J., Smyke, A.T., and Guthrie, D. (2007). Cognitive recovery in socially deprived young children: The Bucharest Early Intervention Project. *Science* 318(5858), 1937-1940.

Nelson, K. (2007). *Young Minds in Social Worlds: Experience, Meaning, and Memory.* Cambridge, MA: Harvard University Press.

Nicolais, G., Fazeli-Fariz Hendi, S., Modesti, C., and Presaghi, F. (2017). EARLY MORAL CONSCIENCE: THE DEVELOPMENT OF A MORAL SHORT PLAYED STORIES PROCEDURE. *Infant Mental Health Journal* 38(3), 391-405. doi: 10.1002/imhj.21640.

Noftle, E.E., and Shaver, P.R. (2006). Attachment dimensions and the big five personality traits: Associations and comparative ability to predict relationship quality. *Journal of Research in Personality* 40(2), 179-208. doi: https://doi.org/10.1016/j.jrp.2004.11.003.

O'Reilly, R.C. (1996). The Leabra model of neural interactions and learning in the neocortex. *Unpublished doctoral dissertation, Carnegie Mellon University*.

Obegi, J.H., and Berant, E. (2010). *Attachment theory and research in clinical work with adults.* New York, NY: The Guilford Press.

Ogden, P., Minton, K., and Pain, C. (2006). *Trauma and the Body: A Sensorimotor Approach to Psychotherapy.* New York, NY: W. W. Norton & Company.

Oltmanns, T.F., Martin, M.T., Davison, G.C., and Neale, J.M. (2012). *Case studies in abnormal psychology.* Hoboken, NJ: Wiley.

Opendak, M., Gould, E., and Sullivan, R. (2017). Early life adversity during the infant sensitive period for attachment: Programming of behavioral neurobiology of threat processing and social behavior. *Developmental cognitive neuroscience* 25, 145-159. doi: 10.1016/j.dcn.2017.02.002.

Opendak, M., and Sullivan, R.M. (2016). Unique neurobiology during the sensitive period for attachment produces distinctive infant trauma processing. *European Journal of Psychotraumatology* 7(1), 1-17. doi: 10.3402/ejpt.v7.31276.

Opendak, M., and Sullivan, R.M. (2019). Unique infant neurobiology produces distinctive trauma processing. *Developmental Cognitive Neuroscience* 36, 1-9. doi: https://doi.org/10.1016/j.dcn.2019.100637.

Orfanos, S.D. (2018). "Relational Psychoanalysis and Psychotherapy," in *Reference Module in Neuroscience and Biobehavioral Psychology*. Elsevier).

Osmo, F., Duran, V., Wenzel, A., de Oliveira, I.R., Nepomuceno, S., Madeira, M., et al. (2018). The Negative Core Beliefs Inventory: Development and psychometric properties. *Journal of Cognitive Psychotherapy* 32(1), 67-84. doi: 10.1891/0889-8391.32.1.67.

Otowa, T., Gardner, C.O., Kendler, K.S., and Hettema, J.M. (2013). Parenting and risk for mood, anxiety and substance use disorders: a study in population-based male twins. *Social psychiatry and psychiatric epidemiology* 48(11), 1841-1849.

Otowa, T., York, T.P., Gardner, C.O., Kendler, K.S., and Hettema, J.M. (2014). The impact of childhood parental loss on risk for mood, anxiety and substance use disorders in a population-based sample of male twins. *Psychiatry Research* 220(1), 404-409. doi: https://doi.org/10.1016/j.psychres.2014.07.053.

Paetzold, R.L., Rholes, W.S., and Kohn, J.L. (2015). Disorganized Attachment in Adulthood: Theory, Measurement, and Implications for Romantic Relationships. *Review of General Psychology* 19(2), 146-156. doi: 10.1037/gpr0000042.

Panksepp, J. (1998). *Affective Neuroscience: The Foundation of Human and Animal Emotion.* Oxford, UK: Oxford University Press.

Panksepp, J., and Biven, L. (2012). *The Archaeology of Mind: Neuroevolutionary Origins of Human Emotions.* New York, NY: W. W. Norton & Company.

Parker, G. (1983). Parental 'affectionless control' as an antecedent to adult depression: a risk factor delineated. *Archives of General Psychiatry* 40(9), 956-960.

Parkes, C.M., Stevenson-Hinde, J., and Marris, P. (1993). *Attachment across the life cycle.* New York, NY: Routledge.

Parsian, N., and Dunning, T. (2009). Developing and validating a questionnaire to measure spirituality: A psychometric process. *Global journal of health science* 1(1), 2-11.

Peer, M., Salomon, R., Goldberg, I., Blanke, O., and Arzy, S. (2015). Brain system for mental orientation in space, time, and person. *Proceedings of the National Academy of Sciences of the United States of America* 112(35), 11072-11077. doi: 10.1073/pnas.1504242112.

Pelphrey, K.A., Morris, J.P., and McCarthy, G. (2005). Neural basis of eye gaze processing deficits in autism. *Brain* 128, 1038-1048. doi: 10.1093/brain/awh404.

Perdighe, C., and Mancini, F. (eds.). (2010). *Elementi di psicoterapia cognitiva.* Rome, IT: Giovanni Fioriti Editore.

Petters, D. (Year). "Implementing a theory of attachment: A simulation of the strange situation with autonomous agents", in: *Seventh international conference on cognitive modelling*), 226-231.

Petters, D. (2019). The attachment control system and computational modeling: Origins and prospects. *Developmental Psychology* 55(2), 227-239. doi: 10.1037/dev0000647.

Petters, D., and Beaudoin, L. (2017). "Attachment Modelling: From Observations to scenarios to designs," in *Computational neurology and psychiatry*. (New York, NY: Springer), 227-271.

Petters, D., and Waters, E. (Year). "Modelling emotional attachment: An integrative framework for architectures and scenarios", in: *International Joint Conference on Neural Networks*: IEEE), 1006–1013.

Picardi, A., Gaetano, P., Toni, A., Caroppo, E., and Arciero, G. (2004). Sostegno alla teoria delle "organizzazioni di significato personale" da altre elaborazioni teoriche nell'area della personalità: uno studio di validità convergente del QSP. *Rivista di Psichiatria* 39(2), 112-124.

Picardi, A., and Mannino, G. (2001). Personal meaning organisations: toward an empirical validation. *Rivista di psichiatria* 36(4), 224-233.

Picardi, A., Mannino, G., Arciero, G., Gaetano, P., Pilleri, M.F., Arduini, L., et al. (2003). Costruzione e validazione del QSP, uno strumento per la valutazione dello stile di personalità secondo la teoria delle "organizzazioni di significato personale". *Rivista di Psichiatria* 38(1), 13-34.

Pinquart, M., Feußner, C., and Ahnert, L. (2013). Meta-analytic evidence for stability in attachments from infancy to early adulthood. *Attachment & Human Development* 15(2), 189-218.

Pitt, D. (2020). "Mental Representation", in: *The Stanford Encyclopedia of Philosophy.* (ed.) E.N. Zalta. Spring 2020 ed.: Metaphysics Research Lab, Stanford University).

Plante, T.G. (2010). *Contemporary Clinical Psychology.* Hoboken, NJ: Wiley.

Platts, H., Tyson, M., and Mason, O. (2002). Adult attachment style and core beliefs: Are they linked? *Clinical Psychology & Psychotherapy* 9(5), 332-348.

Plomin, R. (2018). *Blueprint: How DNA Makes Us Who We Are.* Cambridge, MA: MIT Press.

Prescott, T.J. (2015). Me in the machine. *New Scientist* 225(3013), 36-39. doi: https://doi.org/10.1016/S0262-4079(15)60554-1.

Prescott, T.J., and Camilleri, D. (2018). "The Synthetic Psychology of the Self," in *Cognitive Architectures,* eds. M.I. Aldinhas Ferreira, J. Silva Sequeira & R. Ventura. (New York, NY: Springer), 85-104.

Prince, E.B., Ciptadi, A., Tao, Y., Rozga, A., Martin, K.B., Rehg, J., et al. (2021). Continuous measurement of attachment behavior: A multimodal view of the strange situation procedure. *Infant Behavior and Development* 63, 101565. doi: https://doi.org/10.1016/j.infbeh.2021.101565.

Rao, H., Betancourt, L., Giannetta, J.M., Brodsky, N.L., Korczykowski, M., Avants, B.B., et al. (2010). Early parental care is important for hippocampal maturation: Evidence from brain morphology in humans. *NeuroImage* 49(1), 1144-1150. doi: https://doi.org/10.1016/j.neuroimage.2009.07.003.

Ravitz, P., Maunder, R., Hunter, J., Sthankiya, B., and Lancee, W. (2010). Adult attachment measures: A 25-year review. *Journal of Psychosomatic Research* 69(4), 419-432. doi: https://doi.org/10.1016/j.jpsychores.2009.08.006.

Reindl, V., Gerloff, C., Scharke, W., and Konrad, K. (2018). Brain-to-brain synchrony in parent-child dyads and the relationship with emotion regulation revealed by fNIRS-based hyperscanning. *NeuroImage* 178, 493-502. doi: https://doi.org/10.1016/j.neuroimage.2018.05.060.

Rezvan, S., Bahrami, F., Abedi, M., MacLeod, C., Doost, H.T.N., and Ghasemi, V. (2012). Attachment insecurity as a predictor of obsessive–compulsive symptoms in female children. *Counselling Psychology Quarterly* 25(4), 403-415.

Robinson, C.C., Mandleco, B., Olsen, S.F., and Hart, C.H. (1995). Authoritative, authoritarian, and permissive parenting practices: Development of a new measure. *Psychological reports* 77(3), 819-830.

Roisman, G.I., and Fraley, R.C. (2006). The Limits of Genetic Influence: A Behavior-Genetic Analysis of Infant-Caregiver Relationship Quality and Temperament. *Child Development* 77(6), 1656-1667. doi: 10.1111/j.1467-8624.2006.00965.x.

Roisman, G.I., Fraley, R.C., and Belsky, J. (2007a). A taxometric study of the Adult Attachment Interview. *Developmental psychology* 43(3), 675-686.

Roisman, G.I., Holland, A., Fortuna, K., Fraley, R.C., Clausell, E., and Clarke, A. (2007b). The Adult Attachment Interview and self-reports of attachment style: an empirical rapprochement. *Journal of personality and social psychology* 92(4), 678–697.

Rosa-Mendes, M., Pires, R., and Ferreira, A.S. (2019). Personality traits of the alternative DSM-5 model and the attachment dimensions in Portuguese adults. *Personality and Individual Differences* 143, 21-29.

Roth, T.L., Barr, G.A., Lewis, M.J., and R.M., S. (2016). "Neurobiology and programming capacity of attachment learning to nurturing and abusive caregivers," in *Environmental Experience and Plasticity of the Developing Brain,* ed. A. Sale. (Hoboken, NJ: Wiley).

Rouquette, A., and Falissard, B. (2011). Sample size requirements for the internal validation of psychiatric scales. *International journal of methods in psychiatric research* 20(4), 235-249.

Rovee-Collier, C.K., Hayne, H., and Colombo, M. (2001). *The development of implicit and explicit memory.* Amsterdam, NL: John Benjamins Publishing Company.

Rutter, M., Kreppner, J., and Sonuga-Barke, E. (2009). Emanuel Miller Lecture: Attachment insecurity, disinhibited attachment, and attachment disorders: where do research findings leave the concepts? *Journal of Child Psychology and Psychiatry* 50(5), 529-543.

Safran, J.D., and Segal, Z.V. (1996). *Interpersonal Process in Cognitive Therapy.* Lanham, MD: Rowman & Littlefield.

Sagi, A., van Ijzendoorn, M.H., Scharf, M., Koren-Karie, N., Joels, T., and Mayseless, O. (1994). Stability and discriminant validity of the adult attachment interview: a psychometric study in young Israeli adults. *Developmental psychology* 30(5), 771-777.

Salzen, E.A. (1967). Imprinting in birds and primates. *Behaviour* 28(3-4), 232-254.

Schaller, M., Kenrick, D.T., Neel, R., and Neuberg, S.L. (2017). Evolution and human motivation: A fundamental motives framework. *Social and Personality Psychology Compass* 11(6). doi: 10.1111/spc3.12319.

Schmidt, U., Jiwany, A., and Treasure, J. (1993). A controlled study of alexithymia in eating disorders. *Comprehensive Psychiatry* 34(1), 54-58. doi: https://doi.org/10.1016/0010-440X(93)90036-4.

Schore, A.N. (1994). *Affect Regulation and the Origin of the Self: The Neurobiology of Emotional Development.* New York, NY: Routledge.

Schore, A.N. (2000). Attachment and the regulation of the right brain. *Attachment & human development* 2(1), 23-47.

Schore, A.N. (2003). *Affect Dysregulation and Disorders of the Self.* New York, NY: W. W. Norton & Company.

Schore, A.N. (2005). Attachment, affect regulation, and the developing right brain: Linking developmental neuroscience to pediatrics. *Pediatrics in review* 26(6), 204-217.

Schore, A.N. (2009). "Attachment trauma and the developing right brain: Origins of pathological dissociation," in *Dissociation and the dissociative disorders: DSM-V and beyond*. (New York, NY: Routledge), 107-141.

Seligman, M.E.P. (1975). *Helplessness. On depression, development, and death.* San Francisco, CA: W. H. Freeman.

Semerari, A., Carcione, A., Dimaggio, G., Falcone, M., Nicolò, G., Procacci, M., et al. (2003). How to evaluate metacognitive functioning in psychotherapy? The metacognition assessment scale and its applications. *Clinical Psychology & Psychotherapy* 10(4), 238-261. doi: 10.1002/cpp.362.

Semerari, A., Carcione, A., Dimaggio, G., Nicolò, G., and Procacci, M. (2007). Understanding minds: Different functions and different disorders? The contribution of psychotherapy research. *Psychotherapy Research* 17(1), 106-119. doi: 10.1080/10503300500536953.

Semerari, A., Colle, L., Pellecchia, G., Buccione, I., Carcione, A., Dimaggio, G., et al. (2014). Metacognitive Dysfunctions in Personality Disorders: Correlations With Disorder Severity and Personality Styles. *Journal of Personality Disorders* 28(6), 751-766. doi: 10.1521/pedi_2014_28_137.

Sette, G., Coppola, G., and Cassibba, R. (2015). The transmission of attachment across generations: The state of art and new theoretical perspectives. *Scandinavian journal of psychology* 56(3), 315-326.

Shafran, R., Watkins, E., and Charman, T. (1996). Guilt in obsessive-compulsive disorder. *Journal of Anxiety Disorders* 10(6), 509-516. doi: https://doi.org/10.1016/S0887-6185(96)00026-6.

Shaver, P.R., and Mikulincer, M. (2002). Attachment-related psychodynamics. *Attachment & Human Development* 4(2).

Sherman, L.J., Rice, K., and Cassidy, J. (2015). Infant capacities related to building internal working models of attachment figures: A theoretical and empirical review. *Developmental Review* 37, 109-141. doi: https://doi.org/10.1016/j.dr.2015.06.001.

Shipley, W.U. (1963). The demonstration in the domestic guinea pig of a process resembling classical imprinting. *Animal Behaviour* 11(4), 470-474.

Sibley, C.G., Fischer, R., and Liu, J.H. (2005). Reliability and validity of the revised experiences in close relationships (ECR-R) self-report measure of adult romantic attachment. *Personality and social psychology bulletin* 31(11), 1524-1536.

Silove, D., Harris, M., Morgan, A., Boyce, P., Manicavasagar, V., Hadzi-Pavlovic, D., et al. (1995). Is early separation anxiety a specific precursor of panic disorder–agoraphobia? A community study. *Psychological Medicine* 25(2), 405-411.

Simpson, J.A., and Belsky, J. (2016). "Attachment Theory within a Modern Evolutionary Framework," in *Handbook of attachment: Theory, research, and clinical applications,* eds. J. Cassidy & P.R. Shaver. 3rd ed (New York, NY: The Guilford Press), 91-116.

Simpson, J.A., Rholes, W.S., and Nelligan, J.S. (1992). Support seeking and support giving within couples in an anxiety-provoking situation: The role of attachment styles. *Journal of personality and social psychology* 62(3), 434-446.

Simpson, J.A., Rholes, W.S., and Phillips, D. (1996). Conflict in close relationships: An attachment perspective. *Journal of personality and social psychology* 71(5), 899-914.

Skinner, E., Johnson, S., and Snyder, T. (2005). Six Dimensions of Parenting: A Motivational Model. *Parenting: Science and Practice* 5(2), 175-235. doi: 10.1207/s15327922par0502_3.

Slavich, G.M., Monroe, S.M., and Gotlib, I.H. (2011). Early parental loss and depression history: Associations with recent life stress in major depressive disorder. *Journal of Psychiatric Research* 45(9), 1146-1152. doi: https://doi.org/10.1016/j.jpsychires.2011.03.004.

Sloman, A. (2008). "The cognition and affect project: Architectures, architecture-schemas, and the new science of mind.". (Tech. rep., University of Birmingham (Available at http://www.cs.bham.ac.uk/research/cogaff/)).

Sloman, A., and Logan, B. (1999). Building cognitively rich agents using the SIM_AGENT toolkit. *Communications of the Association for Computing Machinery* 42(3), 71-77.

Sloman, A., and Poli, R. (Year). "SIM_AGENT: A toolkit for exploring agent designs", in: *Intelligent Agents*, eds. M. Wooldridge, J. Mueller & M. Tambe (New York, NY: Springer), 392–407.

Solomon, J., and George, C. (2016). "The Measurement of Attachment Security and Related Constructs in Infancy and Early Childhood," in *Handbook of Attachment: Theory, Research, and Clinical Applications,* eds. J. Cassidy & P.R. Shaver. (New York, NY: The Guilford Press), 366-396.

Somvanshi, P.R., and Venkatesh, K.V. (2013). "Hill Equation," in *Encyclopedia of Systems Biology,* eds. W. Dubitzky, O. Wolkenhauer, K.-H. Cho & H. Yokota. (New York, NY: Springer), 892-895.

Sroufe, L.A. (1995). *Emotional Development: The Organization of Emotional Life in the Early Years.* New York, NY: Cambridge University Press.

Stern, D.N. (1985). *The Interpersonal World of the Infant - A View from Psychoanalysis and Developmental Psychology.* New York, NY: Basic Books.

Stevens, G.T., and Zhang, J. (2009). A dynamic systems model of infant attachment. *IEEE Transactions on Autonomous Mental Development* 1(3), 196-207.

Stevens, J.P. (2009). *Applied multivariate statistics for the social sciences.* Routledge.

Stievenart, M., Roskam, I., Meunier, J.C., and Vandemoortele, G. (2012). Assessment of preschoolers' attachment security using the Attachment Q-set and the Attachment Story Completion Task. *International Journal of Education and Psychological Assessment* 12(1).

Stovall-McClough, K.C., and Dozier, M. (2016). "Attachment states of mind and psychopathology in adulthood," in *Handbook of attachment. Theory, research, and clinical applications,* eds. J. Cassidy & P.R. Shaver. 3rd ed (New York, NY: The Guilford Press), 715-738.

Sullivan, R.M., and Holman, P.J. (2010). Transitions in sensitive period attachment learning in infancy: the role of corticosterone. *Neuroscience and biobehavioral reviews* 34(6), 835-844. doi: 10.1016/j.neubiorev.2009.11.010.

Suomi, S.J., Harlow, H.F., and Novak, M.A. (1974). Reversal of social deficits produced by isolation rearing in monkeys. *Journal of Human Evolution* 3(6), 527-534.

Sutton, T.E. (2019). Review of Attachment Theory: Familial Predictors, Continuity and Change, and Intrapersonal and Relational Outcomes. *Marriage & Family Review* 55(1), 1-22. doi: 10.1080/01494929.2018.1458001.

Szepsenwol, O., and Simpson, J.A. (2019). Attachment within life history theory: an evolutionary perspective on individual differences in attachment. *Current opinion in psychology* 25, 65-70.

Talevich, J.R. (2017). "The Whole Elephant," in *Computational Social Psychology,* eds. R.R. Vallacher, S.J. Read & A. Nowak. (New York, NY: Routledge).

Target, M., Fonagy, P., and Shmueli-Goetz, Y. (2003). Attachment representations in school-age children: The development of the Child Attachment Interview (CAI). *Journal of child psychotherapy* 29(2), 171-186.

Tasca, G.A., and Balfour, L. (2014). Attachment and eating disorders: A review of current research. *International Journal of Eating Disorders* 47(7), 710-717. doi: 10.1002/eat.22302.

Thagard, P. (ed.). (2007). *Philosophy of psychology and cognitive science.* Amsterdam, NL: Elsevier.

Thagard, P. (2019). "Cognitive Science", in: *The Stanford Encyclopedia of Philosophy.* (ed.) E.N. Zalta. (https://plato.stanford.edu/archives/spr2019/entries/cognitive-science/: Metaphysics Research Lab, Stanford University).

Thelen, E., and Smith, L.B. (1994). *A Dynamic Systems Approach to the Development of Cognition and Action.* Cambridge, MA: MIT Press.

Thompson, R.A. (2016). "Early attachment and later development: Reframing the questions," in *Handbook of attachment: Theory, research, and clinical applications,* eds. J. Cassidy & P.R. Shaver. 3rd ed (New York, NY: The Guilford Press), 330-348.

Timpano, K.R., Keough, M.E., Mahaffey, B., Schmidt, N.B., and Abramowitz, J. (2010). Parenting and obsessive compulsive symptoms: Implications of authoritarian parenting. *Journal of Cognitive Psychotherapy* 24(3), 151-164.

Tooby, J., and Cosmides, L. (1992). "The psychological foundations of culture," in *The Adapted mind: Evolutionary Psychology and the Generation of Culture,* eds. J. Barkow, L. Cosmides & J. Tooby. (Oxford, UK: Oxford University Press), 19–136.

Trochim, W.M.K., Dionnelly, J.P., and Arora, K. (2015). *Research Methods: The Essential Knowledge Base.* Belmont, CA: Wadsworth Publishing.

Troller-Renfree, S., and Fox, N.A. (2017). "Sensitive Periods of Development. Implications for Risk and Resilience," in *Handbook of Preschool Mental Health. Development, Disorders, and Treatment,* ed. J. Luby. 2nd ed (New York, NY: The Guilford Press), 3-26.

Turnbull, O., and Solms, M. (2003). "Memory, amnesia and intuition: a neuro-psychoanalytic perspective," in *Emotional development in psychoanalysis, attachment theory and neuroscience,* ed. V. Green. (New York, NY: Routledge), 63-92.

van den Boom, D.C. (1995). Do first-year intervention effects endure? Follow-up during toddlerhood of a sample of Dutch irritable infants. *Child development* 66(6), 1798-1816.

van der Hart, O., Nijenhuis, E., and Steele, K. (2006). *The haunted self: Structural dissociation and the treatment of chronic traumatization.* New York, NY: W. W. Norton & Company.

van Geert, P.L.C. (2019). Dynamic Systems, Process and Development. *Human Development* 63(3-4), 153-179. doi: 10.1159/000503825.

van Gelder, T.J., and Port, R. (1995). "It's about time: An overview of the dynamical approach to cognition," in *Mind as Motion: Explorations in the Dynamics of Cognition,* eds. R. Port & T.J. van Gelder. (Cambridge, MA: MIT Press), 1-43.

van Ijzendoorn, M.H. (1995). Adult attachment representations, parental responsiveness, and infant attachment: a meta-analysis on the predictive validity of the Adult Attachment Interview. *Psychological bulletin* 117(3), 387.

van Ijzendoorn, M.H., and Bakermans-Kranenburg, M.J. (2019). Bridges across the intergenerational transmission of attachment gap. *Current opinion in psychology* 25, 31-36.

van Ijzendoorn, M.H., and Sagi, A. (1999). "Cross-cultural patterns of attachment: Universal and contextual dimensions," in *Handbook of attachment: Theory, research, and clinical applications.* (New York, NY, US: The Guilford Press), 713-734.

Varin, D., Crugnola, C.R., Molina, P., and Ripamonti, C. (1996). Sensitive periods in the development of attachment and the age of entry into day care. *European journal of Psychology of Education* 11(2), 215-229.

Verhage, M.L., Schuengel, C., Madigan, S., Fearon, R.M.P., Oosterman, M., Cassibba, R., et al. (2016). Narrowing the transmission gap: A synthesis of three decades of research on intergenerational transmission of attachment. *Psychological Bulletin* 142(4), 337-366.

Verschure, P.F.M.J. (2012). Distributed Adaptive Control: A theory of the Mind, Brain, Body Nexus. *Biologically Inspired Cognitive Architectures* 1(1), 55–72.

Verschure, P.F.M.J., Pennartz, C.M.A., and Pezzulo, G. (2014). The why, what, where, when and how of goal-directed choice: neuronal and computational principles. *Philosophical Transactions of the Royal Society B: Biological Sciences* 369(1655), 1–14.

Vukasović, T., and Bratko, D. (2015). Heritability of personality: A meta-analysis of behavior genetic studies. *Psychological bulletin* 141(4), 769-785.

Wang, S., Yu, R.J., Tyszka, J.M., Zhen, S.S., Kovach, C., Sun, S., et al. (2017). The human amygdala parametrically encodes the intensity of specific facial emotions and their categorical ambiguity. *Nature Communications* 8, 1-13. doi: 10.1038/ncomms14821.

Waters, E., Merrick, S., Treboux, D., Crowell, J., and Albersheim, L. (2000). Attachment security in infancy and early adulthood: A twenty-year longitudinal study. *Child development* 71(3), 684-689.

Waters, H.S., and Waters, E. (2006). The attachment working models concept: Among other things, we build script-like representations of secure base experiences. *Attachment & human development* 8(3), 185-197.

Westwood, H., Kerr-Gaffney, J., Stahl, D., and Tchanturia, K. (2017). Alexithymia in eating disorders: Systematic review and meta-analyses of studies using the Toronto Alexithymia Scale. *Journal of Psychosomatic Research* 99, 66-81. doi: https://doi.org/10.1016/j.jpsychores.2017.06.007.

Whalen, D.J., Sylvester, C.M., and Luby, J.L. (2017). Depression and Anxiety in Preschoolers: A Review of the Past 7 Years. *Child and adolescent psychiatric clinics of North America* 26(3), 503-522. doi: 10.1016/j.chc.2017.02.006.

Whalen, P.J., Raila, H., Bennett, R., Mattek, A., Brown, A., Taylor, J., et al. (2013). Neuroscience and Facial Expressions of Emotion: The Role of Amygdala-Prefrontal Interactions. *Emotion Review* 5(1), 78-83. doi: 10.1177/1754073912457231.

Whipple, N., Bernier, A., and Mageau, G.A. (2011). A dimensional approach to maternal attachment state of mind: Relations to maternal sensitivity and maternal autonomy support. *Developmental Psychology* 47(2), 396-403.

Widiger, T.A., Gore, W.L., Crego, C., Rojas, S.L., and Oltmanns, J.R. (2017). "Five Factor Model and Personality Disorder," in *The Oxford handbook of the five factor model,* ed. T.A. Widiger. (New York, NY: Oxford University Press), 449-478.

Wilson, S.P. (2017). Modelling the emergence of rodent filial huddling from physiological huddling. *Royal Society Open Science* 4(11). doi: 10.1098/rsos.170885.

Yakeley, J. (2018). Psychoanalysis in modern mental health practice. *The Lancet Psychiatry* 5(5), 443-450.

Young, E.S., Simpson, J.A., Griskevicius, V., Huelsnitz, C.O., and Fleck, C. (2019). Childhood attachment and adult personality: A life history perspective. *Self and Identity* 18(1), 22-38.

Young, J.E. (2002). "Schema-focused therapy for personality disorders," in *Cognitive Behaviour Therapy: A Guide for the Practising Clinician,* ed. G. Simos. (London, UK: Routledge), 201-222.

Zeanah, C.H., Gunnar, M.R., McCall, R.B., Kreppner, J.M., and Fox, N.A. (2011). Sensitive periods. *Monographs of the Society for Research in Child Development* 76(4), 147-162. doi: 10.1111/j.1540-5834.2011.00631.x.

Zeanah, C.H., Mammen, O.K., and Lieberman, A.F. (1993). "Disorders of attachment," in *Handbook of infant mental health,* ed. C.H. Zeanah. (New York, NY: The Guilford Press), 332–349.