Early infant environment: A comparative perspective

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Thesis abstract

Characterising early infant environment is important for understanding how experience can impact development and also allows us to understand the context children develop within, however there is limited quantitative research in this realm. This thesis seeks to address this gap by investigating the role culture and biology may play in fostering social behaviour by taking a longitudinal approach to aspects of social development in two cultural groups (from the UK and Uganda), and comparing human behaviour to other non-human primates (specifically chimpanzees and crested macaques).

Study 1 presents a cross-cultural investigation of mother's attitudes and behaviours, and their effect on infant early life experience from 3- to 15-months. As predicted by previous research, I found UK mothers had more autonomous parenting attitudes, whereas Ugandan mothers showed more relational attitudes. At a group level, UK and Ugandan infant experience broadly aligned with predictions from autonomous-relational maternal attitudes. However, there were also unexpected mismatches, where specific maternal attitudes did not always predict their infant's experiences.

Study 2 investigated whether there were sex differences in infant social experience in humans, chimpanzees, and crested macaques. I found consistent sex differences in early social experience across both human cultures and across species. This suggests sex differences in social experience in these species are more likely to be evolutionarily old traits, and less likely driven by species-specific characteristics (e.g., cultural drivers in humans; dispersal pattern in non-human primates).

Finally, study 3 investigated whether infant experience or factors inherent to the infant predicted joint attention event engagement at 11- and 15-months. I found no clear predictors of joint attention, suggesting a more nuanced approach is required to understand its development.

Overall this thesis sets important groundwork to understanding the environment in which infants develop and how that may influence later cognitive development.

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Author declaration

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References.

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Preliminary results from data in Chapter 3, were also presented as a poster at the Association for the Study of Animal Behaviour Easter meeting 2021, entitled: “Similarities in the early social environment and social behaviour of male and female infant crested macaques *(Macaca nigra)* and chimpanzees *(Pan troglodytes schweinfurthii)“.*

Chapter 1: General introduction

Humans are inherently social beings, we interact with others regularly and show interest in social stimuli from a very young age (Cassia, Simion, & Umilta, 2001; Valenza, Simion, Cassia, & Umilta, 1996; Vouloumanos & Werker, 2007). Social skills develop dramatically within infancy – infants begin using social information to make decisions, following others' gaze and pointing gestures, and even imitate actions and engage in joint attention all within the first year and a half of life (e.g., Boccia & Campos, 1989; Carpenter & Call, 2013; Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Deák & Triesch, 2006; Feinman & Lewis, 1983; Striano & Rochat, 2000; Waismeyer & Meltzoff, 2017; Zmyj & Daum, 2009). Understanding how infants develop these skills is important because they have knock on effects on the more complex social skills that develop during childhood, such as theory of mind and cooperation (e.g,. Adamson, Bakeman, Suma, & Robins, 2019; Carpenter et al., 1998; Charman et al., 2000; Mundy & Gomes, 1998; Tomasello, Carpenter, Call, Behne, & Moll, 2005; Wu, Pan, Su, & Gros-louis, 2013). In particular, understanding the context and environment in which infants are developing is important because it allows us to understand how we can nurture children in the best way and give them the best possible start in life. Valuable, but currently underused approaches to understand infant development include on a broad level, cross species and cross cultural research work. On a finer grained level, studies which adopt multiple methodologies, naturalistic methodologies and longitudinal methods are particularly important for furthering understanding of early infant environments. In this chapter I will discuss in more detail why understanding infant development is important, how and why these approaches (cross-cultural, cross species) and methodologies (naturalistic, longitudinal) are important to understanding infant development, before introducing my empirical chapters.

1.1 Development of social cognition in infants

Humans are social beings – and during infancy children develop important skills which set them up for later life, such as understanding the dynamics of social interactions, social referencing, and joint attention behaviours. From birth infants are predetermined to pay attention to social stimuli – they show preferences for orienting to faces and listening to speech over attending to non-social stimuli (Cassia et al., 2001; Valenza et al., 1996; Vouloumanos & Werker, 2007), and are able to detect mutual gaze from a young age (Farroni, Csibra, Simion, & Johnson, 2002). Infants' dyadic social skills make notable steps around 2- to 3-months: they show more social engagement from this age (Lavelli & Fogel, 2002), they start showing social smiling (Super & Harkness, 2010), and begin initiating dyadic interactions (Striano & Reid, 2006). Around this age infants also seem to show social expectations about how interactions should proceed – they expect to receive contingent reaction from their partners, and if the partner becomes unresponsive, they can become wary or distressed (Striano, Henning, & Stahl, 2005; Tronick, Als, Adamson, Wise, & Brazelton, 1978). Other important social skills also develop early in infant life, such as engaging in dyadic interactions with partners where they take turns in exchanging vocalisation with partners (from around 2- to 3-months). These interactions are referred to as proto-conversations (Gratier et al., 2015), and have the characteristics of generally avoiding overlap in speech while minimising the silence between conversational turns (Stivers et al., 2009) – which is an important feature of adult conversation. Infants play an active role in turn-taking social game routines from 4- to 6-months (Nomikou, Leonardi, Radkowska, Raczaszek-Leonardi, & Rohlfing, 2017), and by the end of their first year, infants are capable of, not only reacting to, but also initiating social game routines (Bruner & Sherwood, 1976; Ratner & Bruner, 1977), which also have a typical 'turn-taking' structure important to adult conversational engagement, such as peek-a-boo.

As well as infants making progress in their dyadic social skills in early infancy, their triadic social skills – that is interactions with others about object and events – also develop. Infants are sensitive to triadic interactions from 3-months (Striano & Stahl, 2005), and by 6-months, infants also use social information to disambiguate ambiguous events (Mireault et al., 2014). By about 8- to 10-months infants use the affective response of others to regulate their behaviour towards ambiguous situations that may provoke uncertainty, also known as social referencing (Boccia & Campos, 1989; Feinman & Lewis, 1983; Striano & Rochat, 2000). For example, in a 'false cliff' task, infants are placed on an opaque platform which is next to a transparent platform, giving the impression that they may fall if they moved over the boundary, thus giving the effect of a false cliff – infants check the response of their caregiver, and if the infant's caregiver shows a negative response, infants are less likely to crawl over the transparent floor than if the caregiver gives positive encouraging response (Sorce, Emde, Campos, & Klinnert, 1985). Additionally, by 10-months infants seem to be able to take into account peoples attentional states when social referencing (Striano & Rochat, 2000).

Another important triadic social skill infants learn is to be able to follow the attention of others, because this allows infants to coordinate their attention with a partner around an object or event. While from 4- to 6-months, infants' attention starts to be biased by the direction of others' eye gaze (Reid & Striano, 2005), and they begin finding the focus of eye gaze and pointing gestures by 6- to 9-months (Cleveland, Schug, & Striano, 2007; Deák &

Triesch, 2006; Gredeback, Fikke, & Melinder, 2010), and reliably show these skills by 11- to 13-months (Carpenter et al., 1998). Infants at 8- to 9-months may try to direct others' attention towards an object by alternating their gaze between the person and object (Beuker, Rommelse, Donders, & Buitelaar, 2013). While partners may follow infants' attention during infant gaze alternation between their partners face and objects at younger ages, by 10- to 12-months infants are capable of more actively directing people's attention towards objects by using pointing and showing (Carpenter et al., 1998; Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004; Liszkowski, Carpenter, & Tomasello, 2007).

When infants' ability to follow points, alternate gaze, and communicate positive affect about objects come together, infants can engage in 'joint attention events' with their partners – this is when individuals jointly attend and share the engagement of attending to an object or event together. Joint attention events start to be seen when infants are 9- to 12-months old, and their combination of gaze alternating and communication about objects indicate infants know they are sharing an experience with their partner (Carpenter & Call, 2013; Liszkowski, Carpenter, & Tomasello, 2007). Infants' joint attention and communication skills continue maturing through the second year of life, which support engagement in increasingly complex joint attention events (Carpenter et al., 1998; Liebal, Behne, Carpenter, & Tomasello, 2009; Liebal, Carpenter, & Tomasello, 2010; Liszkowski et al., 2007; Moll, Richter, Carpenter, & Tomasello, 2008; Mundy et al., 2007). Research has shown that joint attention skills have important downstream consequences on other aspects of infant development such as word learning, theory of mind, and cooperation (Adamson et al., 2019; Carpenter et al., 1998; Charman et al., 2000; Mundy & Gomes, 1998; Tomasello, 1988; Tomasello et al., 2005; Tomasello, Farrar, Tomasello, & Farrar, 1986; Wu et al., 2013). Joint attention is thus an important social ability to understand when considering development of children past infancy.

So far I have summarised some of the important social milestones infants reach in their first year of life. This summary provides an overview of the main findings to date, however there are remaining questions to be addressed. Not all infants reach the same milestones at the exact same age, and there is currently limited exploration into reasons for this. In this thesis I explore potential sources of variation in infant development which may be related to variation in early experience linked to infant culture or sex. Specifically, I take a longitudinal look at how culture may impact infant early experience, and I explore the potential role of biology on sex differences in early social environment. I also look at how variation in experience may be linked to joint attention development. In the next sections, I briefly introduce some relevant background on each of these topics.

1.2 Infant early life, learning opportunities, and individual differences in milestone achievement

As outlined above, there are many aspects of social cognition which infants gain in their first year to year and half of life, and these social skills lay important foundations which have downstream consequences as infants develop further. While there is a lot of research looking at the social milestones that infants reach, there is comparatively less research on what causes individual variation in the ages that infants reach these milestones. It is broadly agreed upon that development of social skills is partially due to innate skills which emerge as infants mature, but also that these skills may be nurtured differently depending on infants' experiences, and so experience may also impact the age at which infants reach developmental milestones (Geary, 2006; Sameroff, 2010). Indeed, even from as early as 2- to 3-months we see interactions between infants' experience and social behaviour – for example, we see culture-specific responsiveness patterns at this age (Kartner, Keller, & Yovsi, 2010) and interactions between maternal affect mirroring and infant social attention and positive behaviours (Legerstee & Varghese, 2001). Understanding what aspects of experience support different areas of development can help caregivers provide learning opportunities, which are appropriate for stimulating and nurturing the developing child. Ultimately understanding sensitivity of social cognition development to environmental factors can importantly also form the foundation for successful interventions for at-risk children or those with developmental delay. One starting point for understanding the causes for variation in infant social development is to understand the environment in which children grow up, and the learning opportunities the environment affords infants.

What do we already know about infants' early environment? There is a lot of variation in the early life environment that infants experience. Infants rely on others for basic care such as feeding and hygiene, and care interactions along with other active social interactions (such as social play), likely play a large part of infants' early waking life. However, the amount of interactions with others, and the style of these interactions likely vary from infant to infant depending on their caregivers' attitudes and availability. This can impact infant learning opportunities because the types of interactions infants have with others can support the development of skills in different ways (e.g., Bigelow, Maclean, & Proctor, 2004). Some infants may have a caregiver (most commonly their mother) who is their primary interaction partner, however others may experience more distributed caregiving from other individuals (Keller, 2013), or a wider variety of social interactions, for example those with siblings or peers. Parenting and socialisation attitudes likely contribute towards the experience of infants in terms of how proximal caregivers are to their infant, how quickly they react to infant distress, how much infants are socialised with others, and how much physical stimulation infants are given (Kagitcibasi, 1996; Keller, 2007; Keller et al., 2009; Keller, Kärtner, Borke, Yovsi, & Kleis, 2005; Keller et al., 2006; Keller, Lohaus, et al., 2004; Keller, Yovsi, et al., 2004 – more detail in *Chapter 2*). These differences in parenting and socialisation attitudes have been linked to the age at which infants develop behaviours and skills like compliance and self-recognition (Keller et al., 2005; Keller, Yovsi, et al., 2004). There is also some evidence that parental interaction style, such as how responsive or 'sensitive' parents are to their infants, or how much they express affection is linked to infant skills and/or behaviour (Bornstein, Putnick, Park, Suwalsky, & Haynes, 2017; Gaffan, Martins, Healy, & Murray, 2010; Hobson, Patrick, Crandell, Garcia Perez, & Lee, 2004; Osório, Martins, Meins, Martins, & Soares, 2011). Within their first 15-months, infants will also develop an attachment style (Bowlby, 1958) to their primary caregivers. This attachment style characterises infants relationship with their caregivers and can determine how they react in unfamiliar situations, which can have far-reaching influences on their social relationships throughout life (Waters, Merrick, Treboux, Crowell, & Albersheim, 2000).

Whilst research has shown that the attitudes and behaviour of the primary caregiver can affect infant early life experiences and environment, it is common, particularly in non-Western societies, for children to be cared for by multiple individuals (Keller, 2013). The balance of caregiving among individuals, and infants relationships with those people will shape infant experiences. Infants who have multiple regular caregivers are also likely to develop attachment in a different way to those with a main caregiver, and so approaches which extend beyond the traditional methods of measuring attachment need to be taken on board to apply attachment theory to the global population (Keller, 2013). Infants who are cared for by multiple individuals, or who interact with more individuals are more likely to engage with more people with different interaction styles, and this is also likely to influence their development. However, there is limited characterisation in the literature of the levels of interaction infants have with different caregivers and non-caregivers. Additionally, infants can learn from being in proximity to others (e.g., through observing others interact, or overhearing words; Akhtar, 2005; Akhtar, Jipson, & Callanan, 2001; Osofsky & O'Connell, 1977; Waismeyer & Meltzoff, 2017), and these learning opportunities are likely affected by the identity and number of people nearby. This is another area of infant environment which is lacking quantitative description in the literature.

Overall, the parenting infants receive, their interactions with others, and opportunities to observe others can influence their learning opportunities, however there is limited research into what specifically drives variation. While there is data about the critical age ranges in which infants reach milestones, there is little quantitative analysis of the environmental factors and learning opportunities typically provided to infants. In addition to limited characterisations of overall infant experience, there is also limited research into what causes variation in infant experience. For example, since aspects of infant experience are likely different depending on infant age, or sex (Broesch et al., 2021; Landau, 1976; Lavelli & Fogel, 2002; Lew-levy, Reckin, Lavi, Cristóbal-Azkarate, & Ellis-Davies, 2017; Lytton & Romney, 1991; Mesman & Groeneveld, 2018; Rosen, Adamson, & Bakeman, 1992), what is it that drives these differences in experience? Are there human-wide patterns which drive us to interact with infants of different ages or sexes in different ways? Or are these patterns driven by social factors associated with the culture infants are raised in?

1.3 Approaches to quantifying infant environment and the drivers for differences in experience

Differences in infant early life environment can be caused by various factors: there may be innate drivers within parents to treat infants differently depending on factors such as their infant's age, sex, or birth order; and there may be sociocultural drivers to treat infants differently in one culture versus another. One approach to examining whether there are innate predispositions for parents to treat individuals differently is to take a cross-species approach. Modern humans evolved over many millions of years and shared a last common ancestor with our closest living relatives (chimpanzees and bonobos) about 7-million years ago (Langergraber et al., 2012). A comparative approach with other closely related species can be used to identify homologous traits, which were likely present in our last common ancestor (Meredith, 2015). Cross species approaches, comparing humans to our closest living primate relatives, have previously been used to understand topics such as human spatial cognition, social norm transmission, and attachment style (e.g., Haun, Rapold, Call, Janzen, & Levinson, 2006; Haun, Rekers, & Tomasello, 2012; Meredith, 2015). However there is limited research examining whether the general social environment that human infants experience is similar to that of our closest relatives. This approach can be used to investigate whether sex differences in infant early life experience are driven by historic evolutionarily beneficial sex-specific parenting strategies. For example, mother chimpanzees with male infants seem to be more gregarious than mothers with female infants (Murray et al., 2014). If the same pattern is seen in humans, then we could infer that this sex-specific parenting may be a relic of our evolution which afforded male infants more fitness benefits from socialising more than female infants.

While doing cross species work allows us to compare patterns of human behaviour to that of species which do not have cultural stereotypes, and thus allows us to identify biologically specified drivers of behaviour, it is important to also consider that variation in human infant early life environment may be driven by culturally varying practices and views. Infants in different cultures have shown differences in their cognitive processing due to factors such as how their language is structured (e.g. in spatial cognition; Haun et al., 2006). Parents across cultures are likely to have different parental goals (Keller, 2007; Liamputtong, 2007) and parenting practices, which can influence learning opportunities both directly (e.g. extent of socialisation with non-mothers; Broesch et al., 2021; Leyendecker, Lamb, Scholmerich, & Fracasso, 1995) and indirectly (e.g. precocious physical development creates new opportunities for social interactions; Kretch, Franchak, & Adolph, 2014; Mohring & Frick, 2013; Slone, Moore, & Johnson, 2018). So far, however, there is limited characterisation of what human infants have in common or the range that typical infant experiences fall within. Much of developmental psychology research is focused on Western, Educated, Industrialised, Rich and Democratic (or 'WEIRD') cultures (Henrich, Heine, & Norenzayan, 2010; Nielsen, Haun, Kärtner, & Legare, 2017), but these samples are not representative of humans as a species. Given that parenting style and infant experience is likely to vary more across different populations than within them, and given infant experience can influence the attainment of developmental milestones, it is important to extend our research so that non-WERID cultural groups are also considered when trying to describe the path of development and experience for human infants.

In terms of understanding factors that influence early life experiences it is also important to consider the age of the infant and the environment data is collected in. As discussed above, infants gain a lot of skills in their first years of life. Infancy is a particularly important time of life to consider age dynamically because during the first 15-months there is rapid development in many areas including physical development, communication, social understanding, and social skills. Depending on infants' stage of development, they have different skills and needs so rely on others in different ways as they develop, and other people can also act in different ways towards infants who have different skills (Brazelton & Als, 1979; Lagerspetz, Nygard, & Strandvik, 1971; Rubin, Daniels-beirness, & Hayvren, 1982).

Infants of different ages also have different opportunities for interacting or observing others (Broesch et al., 2021; Lew-levy et al., 2017). Given that infant experience changes with age, when examining differences between groups such as cultures or sex, it is important to consider infants across ages to get a fuller idea of how infants in different groups experience their early life.

In developmental psychology, many findings are based upon experimental or lab-based studies, and many of these findings have not been tested or examined within infants' natural early environments. Lab-based studies are important to examine, for example, the capacity of infants at a certain age or to understand certain concepts and demonstrate specific skills. They afford the opportunity to carefully control the situation, so that there is less 'noise' in the data, and allow researchers to have well designed stimuli to elicit responses from infants which may allow researchers to infer causation. However, it is important not to sacrifice ecological validity in the face of experimental control. Some researchers aim to understand infant cognition which is relevant for understanding how infants navigate the world in their every-day life (Dahl, 2017), yet results from experimental lab studies may be low in ecological validity and only applicable to specific contexts and thus limited in their applicability to every-day life. The field of developmental psychology could thus be strengthened by utilising naturalistic research to complement lab-based studies and understand the context in which infants are developing. For example, when doing social research with infants in a lab-setting, partners are usually parents (especially mothers) or unfamiliar experimenters (e.g., the Early Social Communication Scales; Mundy et al., 2013). However, while mothers are often primary caregivers, naturalistic data on the identity of other important infant interaction partners could inform future experimental design, and allow us to understand how variation in partner identity may influence infant behaviour.

In summary, cross-species approaches can be used to try to understand biological variation in infant social experience such as sex differences, by comparing and contrasting to human's closest living relatives. Cross cultural approaches can also be used to investigate whether the culture in which infants are raised is affecting their experiences and learning opportunities. Infant experience is unlikely to be consistent across development, and biological and cultural influences may interact with infant age, so by using longitudinal methods to look at early life environment we can understand how experience may change with infant age and how that may interact with infant culture or sex. Naturalistic approaches are also important to consider when doing developmental research as it allows us to understand the context in which infants are developing, and know what context we may want to attempt to generalise findings from lab-based research to. Overall, when we can understand the environment in which infants are developing we can then also see if variation in experience is linked to development of social skills like joint attention. In the next section I will cover how my thesis takes these elements into consideration to explore infant development.

1.4 Thesis outline

In this thesis I address three research questions relating to infant social development and the experiences they have in early life. In Chapter 2, I ask how infant experience can vary across the first 15-months in two cultural groups, and how this may be shaped by maternal attitudes. In Chapter 3, I ask if social experience may be different for male or female infants in these cultural groups, and also compare this to experience in two non-human primate species (chimpanzees and crested macaques), with the aim of identifying whether any sex differences are consistent across cultures and/or species. In my final study, in Chapter 4, I examine how infant experience may be linked to the development of joint attention in human infants. Throughout the thesis I use data sampled from two human populations. One set of participants was sampled from within or close to a UK city (York). These families had limited ethnic diversity, and were mostly monolingual, they had moderate to high socioeconomic status and relied on income to sustain themselves, and fit into the description of a 'WEIRD' population. The second set of participants were sampled from a rural area of Uganda (Nyabeya Parish in the Masindi district), where most families were subsistence farmers with low socioeconomic status. This sample included people from multiple ethnolinguistic groups (characteristic for that area) and families were often multilingual. In Chapter 3, I compared the social experience of human infants from these two samples, to that of chimpanzees (*Pan troglodytes*) and crested macaques (*Macaca nigra*). Chimpanzees were chosen as a study species because they are one of humans closest living relatives (Langergraber et al., 2012), and have a similar maturational timeline as humans (Charvet, 2021). Crested macaques were chosen as an example of an 'out-group' primate species to compare humans and chimpanzees to because features of their life-history vary in many ways from that of chimpanzees. For example, in chimpanzees, at maturity females will migrate to another community, but in crested macaques males will migrate once they reach maturity. Having differences in life history patterns like this can be used to infer whether a characteristic of a species life history may be the driver for patterns, or if the pattern may be a more general 'primate' feature. Having introduced my research questions and study populations, I will now cover in more detail the outlines for the following chapters.

In order to address the relative lack of research characterising infant early life environment and experience and the persistent sampling bias towards WEIRD populations (Dahl, 2017; Nielsen et al., 2017), in Chapter 2 I aimed to take a cross-cultural approach to describe and compare key features of early infant life in two different populations. As outlined above, when doing cross-cultural developmental research it is important to understand the environment in which children are being raised. Understanding this environment can help us understand individual differences in how and when infants develop certain skills, and allows us to investigate ways in which parents can best facilitate development in their children. In this second chapter I took a longitudinal, quantitative approach using a mixture of questionnaires and naturalistic observational methods to quantify aspects of infant early environment and experience. I took a broad approach to characterise the early environment up to when infants were 15-months old, with the aim of understanding which areas of infant early experience are similar and different across the two samples. I looked at parenting and socialisation attitudes in the two samples, as well as detailing cross-cultural differences and similarities in variables such as the age of reaching physical milestones, how childcare is distributed among the mother and other people, as well as describing infant social experience. I also looked at whether mothers parenting and socialisation attitudes are related to infant experience.

Having examined how early life experience is different and similar in two different cultural contexts, I was then keen to identify if there were biologically specified drivers of variation in infant development. In Chapter 3 I took a cross-species approach and implement longitudinal methods, which were comparable across species, to ask whether there are evolutionarily inherited sex differences in infant social experience. Sex differences are seen in many areas of child social development – for example, girls are more likely to engage in dyadic play, and boys are more likely to play in larger groups (Benenson, 1993; Benenson, Apostoleris, & Parnass, 1997). However the causes for these differences are unknown, it is unclear if it is due to socio-cultural socialisation, or whether there are innate sex-specific drivers for the expression of sex-specific tendencies. By comparing male and female early life experience in a diverse sample of humans, with the early life experiences of male and female infant chimpanzees and crested macaques, I hoped to identify 1) shared sex-type patterns that may be driven by evolved psychological mechanisms either in the infants or parents and 2) species-specific sex-type patterns that may more likely to be driven by socio-cultural attitudes (humans) or dispersal patterns (non-human primates).

Having examined variation in infant early life experience in Chapters 2 and 3, in Chapter 4 I aimed to investigate how early life experience can influence the development of one important aspect of social cognition: joint attention. As outlined previously, joint attention is the ability to *coordinate* and *share* attention about objects or events, and is an ability which develops towards the end of infants first year (Bakeman & Adamson, 1984; Carpenter & Call, 2013; Liszkowski et al., 2007). Joint attention has been linked to development of skills such as more advanced play, language acquisition, and cooperation (Adamson et al., 2019; Bigelow, Maclean, & Proctor, 2004; Carpenter et al., 1998; Mundy & Gomes, 1998; Tomasello, 1988; Tomasello et al., 2005, 1986; Wu et al., 2013), so understanding the factors that promote or inhibit its emergence is important. While most previous research has looked for predictors of infant coordination of attention skills (e.g. Hobson et al., 2004; Leavens & Bard, 2011; Salley & Dixon, 2007; Todd & Dixon, 2010; Vaughan et al., 2003), individual joint attention skills are not sufficient to explain variation in actually engaging in joint attention events. Thus, I used a rigorous definition for what constitutes a joint attention event which encompasses 'sharing' and took a broad approach to identifying potential predictors, which encompassed factors which are both inherent to the infant, and which describe their early life experience. I did this in humans sampled from two different cultural groups (UK and Uganda) since there is more likely to be more variation in infant experience across cultures than within. I used a naturalistic experiment at 11- and 15-months, conducted in infants' home environment to assess engagement in joint attention events, and used a mixture of naturalistic observational methods and questionnaires to characterise inherent infant characteristics and infant early life environment that may predict engagement in joint attention.

In my final chapter, I bring together general themes and findings of the thesis and discuss and highlight strengths of the research in this thesis in the context of the wider literature, as well as future directions which this thesis lays the groundwork for.

Chapter 2: Maternal attitudes and behaviours differentially shape infant early life experience in infants from the UK and Uganda

2.1 Abstract

Differences in infants' physical development and social environment afford different learning opportunities, and parents and caregivers play a fundamental role in shaping these early life experiences. Variation in maternal attitudes and parenting practices is likely to be greater between than within cultures, however, there is limited cross cultural work characterising exactly how the early life environment differs across populations. This chapter examined the early life environment of infants from two cultures where attitudes towards parenting and infant development were expected to differ. I studied maternal attitudes and infant early life environment longitudinally in 53 UK and 44 Ugandan mother-infant dyads when infants were aged 3- to 15-months old. As expected, questionnaire data revealed that the Ugandan mothers had more relational attitudes towards parenting than the mothers from the UK, who had more autonomous parenting attitudes. Using questionnaires and observational methods, I examined whether infant development and experience aligned with maternal attitudes. I found that the Ugandan infants experienced a more relational upbringing than the UK infants: Ugandan infants experienced more distributed caregiving, more body contact with the mother, more proximity to their mothers at night, and precocious physical development compared to the UK infants. Contrary to expectations, however, Ugandan infants were not in closer proximity to their mother during the day, did not have more people in proximity or more partners for social interaction compared to UK infants. In addition, I examined attitudes towards specific behaviours and found that mothers' attitudes rarely predicted infant experience in related contexts. Taken together, my results highlight the importance of measuring behaviour, rather than extrapolating expected behaviour based on attitudes alone. I found that infants' early life environment varies in many important ways in the UK and Uganda and future research should investigate the downstream consequences of these differences on later development.

2.2 Introduction

Early life experiences can affect infant learning opportunities and behavioural development, and parents and caregivers play a large role in shaping these early life experiences. There is considerable cultural variation in parenting practices, for example, parents in different cultures vary in their feeding practices, and in how they promote motor development and socialisation of infants (Bril & Sabatier, 1986; Cassidy & El Tom, 2015; Hopkins & Westra, 1990; Keller, 2007; Riordan, 2005; Super, 1976). There is broad agreement that being brought up in different societies affects infant development (e.g. Bril & Sabatier, 1986; Cole, Lingeman, & Adolph, 2012; Han, Leichtman, & Wang, 1998; Hopkins & Westra, 1990; Keller, 2007; Keller, Kärtner, Borke, Yovsi, & Kleis, 2005; Keller, Yovsi, et al., 2004; Rogoff, 2003; Super, 1976), but there is limited quantitative work characterising the naturalistic context in which infants develop and how this may be similar or different across populations (Dahl, 2017). This chapter explores if and how early life environment varies between two groups, one from the UK and one from Uganda, specifically examining: 1) infant physical and social environment, and how infant early life experience changes from birth to 15-months, and 2) maternal attitudes towards physical and social development.

Physical development affords infants new learning opportunities (Adolph & Hoch, 2019; Campos et al., 2000; Iverson, 2010), and the attainment of physical milestones has downstream effects on key areas of socio-cognitive development. As infants develop motor skills that, for example, enable sitting and walking, their viewpoint of the world changes (Daniel & Lee, 1990; Fausey, Jayaraman, & Smith, 2016; Gibson, 1988; Jayaraman, Fausey, & Smith, 2015; Kretch, Franchak, & Adolph, 2014). When infants are very young, their experiences are largely determined by their caregiver – their visual input is limited to what they can see from their immediate position, and opportunities for learning are determined by where they are placed or held, and who and what is nearby. Through reaching different physical milestones, infants' experience of the world changes (Adolph & Hoch, 2019; Iverson, 2010), and infants who begin sitting stably or moving earlier will have different learning opportunities than infants who develop these skills later (Adolph & Franchak, 2017; Karasik, Tamis-lemonda, & Adolph, 2011; Schwarzer, Freitag, & Schum, 2013). Once infants develop a stable sitting position, they are able to conduct bimanual exploration of objects which supports an understanding of object properties (Mohring & Frick, 2013; Slone, Moore, & Johnson, 2018; Soska, Adolph, & Johnson, 2010). Stable sitting also facilitates social looking and interaction (Adolph & Franchak, 2017; Franchak, Kretch, & Adolph, 2018). Thus, an infant who develops this skill earlier may learn more about the physical and social world before those who develop the ability to sit later. Once infants learn to crawl and walk, their visual field changes again (Kretch et al., 2014), and they gain new opportunities for who they socialise with, or how they interact with their environment. For example, being able to walk allows infants to pick up objects and bring them to show others (Karasik et al., 2011), which in turn facilitates triadic interactions between infant, partner and object – a key social skill linked to other complex social abilities (Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Charman et al., 2000; Tomasello, 1988; Tomasello, Carpenter, Call, Behne, & Moll, 2005). Before independent locomotion, caregivers determine what infants can interact with or how much they interact with things in their environment, and while physical development can affect how much infants can explore their environment, parenting can also influence the age at which infants reach physical milestones (Cole et al., 2012; Lagerspetz, Nygard, & Strandvik, 1971; Majnemer & Barr, 2005 – more on this below).

The social environment also plays an important role in early life experience, as an infant can only reap the benefits from early physical development if there are social opportunities available to exploit. For example, if an infant spends their days with just a single caregiver, then opportunities to observe or engage in diverse social interactions are limited compared to an infant who spends their day with additional people in their environment. Interacting with others has clear benefits for infant learning (Csibra & Gyorgy, 2006; Tomasello et al., 2005), for example social play with objects can promote more advanced behaviours through scaffolding in contrast to solo object play (Bigelow et al., 2004). Social learning is another important way for infants learn about the world around them. Infants show social orientation from birth (Cassia et al., 2001; Connellan, Baron-Cohen, Wheelwright, Batki, & Ahluwalia, 2000; Valenza et al., 1996; Vouloumanos & Werker, 2007), and can learn from observation of others interacting with each other and the environment (e.g. how to use objects, local social norms, and words; Akhtar, 2005; Akhtar, Jipson, & Callanan, 2001; Osofsky & O'Connell, 1977). However, opportunities for social interactions, and social learning are constrained by the number of people who tend to be in the vicinity of the infant.

The literature shows that infant early life experience can affect learning and social development, but it falls victim to the persistent sampling bias in developmental psychology of being based on limited, mostly Western Educated Industrialised Rich and Democratic (or 'WEIRD'; (Henrich, Heine, & Norenzayan, 2010) populations (Nielsen *et al.*, 2017 - *North America*: Bigelow, Maclean and Proctor, 2004; Soska, Adolph and Johnson, 2010; Kretch, Franchak and Adolph, 2014; Jayaraman, Fausey and Smith, 2015; Fausey, Jayaraman and Smith, 2016; Franchak, Kretch and Adolph, 2018; Slone, Moore and Johnson, 2018; *Western Europe*: Lagerspetz, Nygard and Strandvik, 1971; Daniel and Lee, 1990; Mohring and Frick, 2013; Schwarzer, Freitag and Schum, 2013). This is particularly problematic because the cross cultural research that is available shows important developmental differences across diverse populations that are likely mediated by parenting practices. For example, the age of reaching physical milestones such as sitting or walking varies across children from different cultural settings (Hopkins & Westra, 1990; Lohaus et al., 2011; Super, 1976; Vierhaus et al., 2011). This variation has been linked to parenting practices such as diaper use, or infant handling practices like physical stimulation, stretching, and postural support (Bril & Sabatier, 1986; Cole, Lingeman, & Adolph, 2012; Hopkins & Westra, 1990; Super, 1976). Additionally, Bornstein *et al.* (2017) found that parents from 11 different societies, including WEIRD and non-WEIRD cultures (Argentina, Belgium, Brazil, Cameroon, France, Israel, Italy, Japan, Kenya, South Korea, and United States), encouraged exploration of the physical environment at different rates, and this correlated with cross cultural differences in exploration of the environment by infants. They also found cross cultural differences in infants' social behaviour (e.g., looks to their mother, smiling, communication) and mothers' social behaviour (e.g., nurturance behaviour, communication, expression of affection and social play). Additionally, some social behaviours shown by mothers and infants were found to correlate with each other (i.e., maternal expression of affection and encouragement of attention to herself was positively correlated with infant smiling and looks to mother). Thus infants from one culture may experience different early life environments to those from another culture as a result of developing physical skills at different rates, and/or engaging with caregivers who interact and scaffold behaviours differently. One problem with not understanding the infant early environment is that many psychological theories are based on limited samples whose experience is not representative of the majority of infants worldwide. For example, attachment theory, which has implications for children's social development, posits that infants develop a special bond with their mother and this 'attachment' determines how they react in unfamiliar situations (Bowlby, 1958). However, the preposition that children are mostly cared for by a single caregiver only represents a small portion of infant experience, as it is more common that infants are cared for by multiple caregivers (Keller, 2013). Cross-cultural work characterising infant's caregiving experience would thus give a basis to further examine theories such as attachment.

Cross cultural differences in parental behaviour which can drive differences in infant experience, may be underpinned by varying attitudes towards parenting and infant development. One broad distinction made in the literature is between parenting attitudes which value interdependence or those which value independence, and these attitudes differentially align with a *relational* (*'Proximal'*) model or an *autonomous ('Distal')* model respectively (Kagitcibasi, 1996; Keller, 2007; Keller et al., 2009, 2005, 2006; Keller, Lohaus, et al., 2004; Keller, Yovsi, et al., 2004). Rural agricultural communities commonly adopt the relational model where social context (e.g. social hierarchy, interpersonal relationships and group goals), body contact, and physical stimulation are considered important (Kagitcibasi, 1996; Keller, 2007; Keller et al., 2009, 2005, 2006; Keller, Lohaus, et al., 2004). Infant socialisation within this model stresses obedience and the infant's relation to others, and infants who have parents with relational attitudes develop compliance earlier than those with autonomous/distal parenting (Keller et al., 2005; Keller, Yovsi, et al., 2004). The autonomous model, on the other hand, stresses object stimulation, face-to-face contexts and mutual gaze, agency, independence, and competition, and is common in WEIRD societies (Kagitcibasi, 1996; Keller, 2007; Keller et al., 2009, 2005, 2006; Keller, Lohaus, et al., 2004). Parents with autonomous attitudes stress infant self-development and autonomy and their infants develop self-recognition earlier than those with relational/proximal parenting (Keller et al., 2005; Keller, Yovsi, et al., 2004). Although parental attitudes have been found to differ across cultural contexts, the correspondence between attitudes and parental behaviour and the subsequent influence on infants' early life experience is less well understood.

Previous cross cultural research has provided some important insight into how early life environment of infants may vary in different societies, however, there are several areas which remain unexplored. Firstly, the contribution of non-mothers (e.g. other adults, children) to infant early life experience is poorly understood. Landau (1976) found that in some cultures, the proportion of overall social stimulation received from the mother decreases as infants age, and by the end of their first year, over half of infants' social stimulation during play is made up of interactions with non-mother individuals. Other researchers also found that the composition of children's social opportunities changes with age (Broesch et al., 2021; Lew-levy et al., 2017). These findings highlight the important role non-mothers may play in the infant social environment, and how their contribution to the infant's experience might change over time. Infants in different cultures can also have different opportunities for socialisation with non-mothers (Leyendecker, Lamb, Scholmerich, & Fracasso, 1995), which further emphasises the importance of considering infants' socialisation with non-mothers in cross cultural research. However, to date in most of the cross cultural research on socialisation, there is a strong focus on mother-infant interactions (Bornstein et al., 2017; Keller et al., 2009, 2005; Keller, Lohaus, et al., 2004; Keller, Yovsi, et al., 2004), and most studies are limited to a single age point (Bornstein et al., 2017; Keller et al., 2009, 2005, 2006; Keller, Lohaus, et al., 2004; Keller, Yovsi, et al., 2004). Research which considers infants' social interactions with both their mother and non-mother individuals over the first years of life would add to our understanding of infant early life social environment.

Secondly, while one would expect cultural attitudes to match up to behaviours, studies examining autonomous and relational parenting tend to focus either on attitude questionnaires or observations of behaviour in a single context (often mother-infant play) (Keller et al., 2009, 2005, 2006; Keller, Lohaus, et al., 2004; Keller, Yovsi, et al., 2004). It is therefore unclear whether parental behaviour in play contexts is representative of their behaviour in other contexts, and crucially previous studies have not linked parental attitudes to expressed behaviour. It would be useful to use a mixed methods approach to see if, and how, reported attitudes match up to behaviour cross culturally as well as investigating features of these parenting styles across different behavioural contexts.

In summary, differences in infants' physical development and social environment afford different learning opportunities, and thus the early life environment is important for understanding the context in which infants develop. However, previous research is limited in its cross cultural applicability: thus far cross-cultural research concerning caregiver influences on the early life environment tends to focus exclusively on mother-infant relations, and is often limited to single age-points. Furthermore, these studies either focus on a single behavioural context of mother-infant life, or only report parental attitudes without linking them to behaviour. The main aim of this study was to bring together different aspects of early life environment which could be linked to infant learning and socialisation, using a longitudinal, mixed methods approach, to give a cross cultural description of the early life environment and maternal attitudes in two cultural groups. More specifically, I examined mothers' attitudes towards infant independence and social environment, to establish the degree of alignment mothers had with relational and autonomous socialisation goals and parenting practices. I then considered infant attainment of physical milestones (which changes opportunities for social and non-social learning), infant exploration of the environment, the social environment (e.g. number and identity of caregivers and individuals in the infant's vicinity) and social interactions (e.g. the amount and type of social interactions) in the two populations. I could then assess the extent to which relational or autonomous maternal attitudes were reflected in expressed behaviour. Using these aspects of infant early life experience I present a case study comparison following infants between 3- and 15-months of age in two cultural contexts in the UK and Uganda. The UK participants were mother-infant dyads with limited ethnolinguistic diversity, living in, or close to, a WEIRD UK city, who rely on income to sustain themselves (similar characteristics to groups typically categorised as having autonomous parenting: cf. Kaller, 2012; Keller, 2007). The Ugandan participants came from an ethnolinguistically diverse rural area of Uganda, where subsistence farming is common (with characteristics more similar to groups typically categorised as having relational parenting: cf. Kaller, 2012; Keller, 2007). This study aimed to describe aspects of the early infant environment that is shared and that varies between these two groups of mothers and infants, and critically how infant early life environment relates to maternal attitudes.

In order to address these aims, observational methods were used to categorise mother-infant distance, activities and social environment, in addition to demographic, developmental, and parenting attitude questionnaires to answer four key research questions. For my first research question: “Do the UK and Ugandan participants form two distinct groups?”, I determined whether it was justified to consider participants from the samples as two distinct groups. I investigated if overall there was separation between Ugandan and UK participants in maternal attitudes and infant early life experience. Given that some societies are diverse in terms of people’s background, and parenting practices can vary across small geographical regions (Javo, 2007; Opolot, 1982), I also looked to see whether, within the ethnolinguistically diverse Ugandan sample, if there were any natural clusters of data to avoid making an assumption that our geographically similar samples were ‘uni-cultural’.

For my second research question: “Do the UK and Ugandan mothers have different attitudes towards parenting and socialisation goals for their infants?”, I examined questionnaire data to characterise the maternal attitudes towards parenting and their socialisation goals for their infants. I expected the mothers from the UK sample to have more autonomous attitudes, and those from the Ugandan sample to have more relational attitudes given the similarities of these groups to those previously described (cf. Kaller, 2012; Keller, 2007). Given that these two ‘styles’ are not always appropriate ways of categorising parenting, and predicted membership can sometimes be wrong (Keller et al., 2009, 2003), it is thus important to test assumptions to understand or confirm *how* cultures may differ in parenting style when working with new study groups, in both observed behaviours as well as their attitudes.

Thus, for my third research question: “Does cultural group and infant age influence early life environment?”, I examined measures of infant early life experience and maternal behaviour, and predicted that several aspects of this would differ with infant age, cultural group, and mothers’ expected alignment to autonomous or relational parenting models. As well as describing physical development, environment exploration, mother-infant relations, and other-infant socialisation, across the first 15-months, I linked appropriate variables to autonomous and relational parenting styles. More specifically, in light of previous research, I expected infants in the Ugandan sample to reach physical milestones at earlier ages than in the UK sample, given a) I expected them to have mothers with more relational parenting attitudes which would emphasise physical stimulation of their infants, and b) given results from other comparable cultures (Ainsworth, 1967; Bornstein et al., 2017; Keller, 2007; Lagerspetz et al., 1971; Majnemer & Barr, 2005; Super, 1976). As infants aged and became more mobile I expected them to explore their environment more, via active movement around or playing alone without the stimulation of others. Given that I expected the Ugandan infants to reach physical milestones at earlier ages, and that reaching physical milestones facilitates environmental exploration, I also expected to see more exploration behaviours from Ugandan than UK infants.

Since parents with relational attitudes value the social context (e.g. social hierarchy, interpersonal relationships, and group goals) more than those with autonomous attitudes (Hollos & Leis, 2001; Kagitcibasi, 1996; Keller, 2007; Keller et al., 2005, 2006; Keller, Lohaus, et al., 2004), and given household sizes were larger in the Ugandan sample, I predicted there may be cross cultural differences in terms of social environment and interactions. More specifically I predicted that the group of Ugandan infants would have a larger number of caregivers than the UK infants, as distributed child care is associated with more relational parenting models (Kagitcibasi, 1996). I predicted, in terms of social environment and interactions, that Ugandan infants would have more people in proximity and although rates of social activity including play would be similar in UK and Uganda, Ugandan infants would have more social partners than UK infants. I also expected that as infant’s aged that they would experience more variety in their social interaction partners (Lagerspetz et al., 1971; Landau, 1976). Since parents with autonomous attitudes promote more independence in infants, and those with relational attitudes value more prompt responses to infant cues, I expected less proximity between mother and infant during the day and night in the UK sample in comparison to the Ugandan sample. Moreover, infants rely on others being close by for this care (e.g. for feeding and comfort), but as they age, close proximity with mothers may be less necessary as they become less dependent (e.g. as they learn to feed themselves, and as they start sleeping through the night). Additionally, as infants become more independent I expected less infant directed behaviour from mothers (Landau, 1976). I also expected that I might see less infant directed behaviour from mothers if caregiving is shared more in Uganda compared to the UK. Relational parenting values stress body contact so I expected more mother-infant body contact in the Ugandan sample, especially during play, but with a reduction in body contact in both groups as infants age and become more independent.

For my fourth and final research question I asked "Are parental attitudes associated with observed or reported parenting behaviour?". Given that there is limited research looking at how parental attitudes translate into behaviour and shaping of the infant's early life experience, I investigated whether specific mothers' attitudes matched up with their behaviour on an individual level.

2.3 Methods

2.3.1 Participants

Participants were 53 UK mother-infant dyads (infants: 25 female, 28 male; 4 of which were twins, two pairs), and 44 Ugandan mother-infant dyads (infants: 24 female, 20 male; 1 of which was a twin). We extend our condolences to the family who lost one of their twins at 12-months-old, and we do not include data for this infant who passed away. Two further Ugandan mother-infant dyads were excluded from this study because limited data was collected before they discontinued with the study. Participants were part of a larger longitudinal project of the evolutionary and developmental origins of joint attention (JointAtt Project) between 3-months and 2-years. This study focuses on infants up to 15-months old. Participant background and demographic information was extracted from questionnaires (details of questionnaire administration procedure below; full questionnaires in *appendix A2.1*).

2.3.1.1 UK Participants

Participants for the UK sample were recruited in the York area through adverts at local children centres, adverts on York Mumbler (a website advertising events and opportunities for parents in York), a Facebook page advert, researcher presentations at baby sensory classes explaining our project, and through word of mouth. Participants were recruited during the mother's pregnancy or when the infant was up to 5 months of age.

Fifty-one mothers from the UK sample were born in the UK, 1 in Romania, and 1 in Australia, and all were raised in the UK (ethnicity: 44 white British, 1 mixed British, 7 British undisclosed, and 1 undisclosed). All mothers were fluent English speakers and only spoke English with their infant. Two fathers spoke an additional language with their infant.

All UK mothers were literate. Seven UK mothers' highest education level were secondary-school qualifications (or equivalent, e.g., A-levels, GSCEs), 25 mothers had undergraduate (or equivalent) degrees, and 21 had postgraduate qualifications. Most (94%) UK mothers and all fathers had a profession. The mean Hollingshead SES score (possible range=0-66) of the infants parents was 53.5 (range=24.5-66.0; *SD*=10.3).

At the beginning of the study all infants' father's lived with them and household members were consistent across the 15-months for all except one mother-infant dyad (mean household size including infant: 3.7 individuals; range=3-8; *SD*=0.91). Fathers were listed as caregivers for all infants, and spent on average 39.3 hours per week (*SD*=18.3) with the infant. Mothers were only separated from infants for an average of 12.9 hours per week (*SD*=10.6).

Forty-seven percent of the UK study infants were the mothers' first child (including one set of twins), the remaining 53% of study infants had older siblings. Mothers mean age at birth of the study infant was 32.6 years (range=25-41; *SD*=3.7).

All UK mother-infant dyads lived in permanent structures with mains plumbing and electricity, and on average spent more than half of their time during daily activities indoors.

2.3.1.2 Ugandan Participants

Participants for the Ugandan sample were recruited in the Nyabyeya parish, Masindi district, Uganda. Mothers, pregnant women, and interested villagers were invited to local information meetings. Invites to the information meetings were given verbally at village and church meetings in the area, and via word of mouth. Women who were interested in participating in the study were asked to register the birth date of their infant with local research assistants. Participants from this list were invited to join the study based on projected work load given infant birth date, the sex of the infant, and whether we had a translator for the main language of the mothers.

For participants where the information was available, 87% (of 39) were born in Uganda, 10% in Congo, and 2% in Sudan. Of 41 participants where ethnolinguistic group was available 41% were Alur, 32% were Lugbara, and 27% identified as part of another ethnolinguistic group (Banyoro, Kakwa, Kaliko, Akebu, Balendru, or Madi). Mothers spoke an average of 1.6 languages (range=1-5) with their infants. Of 44 mothers 89% spoke Swahili, 57% spoke Alur, 21% spoke Lugbara, 14% spoke Ruyuro, 14% spoke English, and 2% spoke Kakwa. Where known, 29% of fathers spoke an additional language with their infant, and 5% spoke an additional two languages with their infant.

Twenty-one percent of the Ugandan mothers reported being able to read and write, 42% could not read or write, and the remaining 37% reported at least some level of reading or writing skills. Eighteen percent of the Ugandan mothers reported having no education, 66% had at least some primary school education, and 16% had at least some secondary school education. Many of the Ugandan families were solely subsistence farmers that had no other profession (91% of mothers had no profession and 41% infants fathers had no profession). The mean Hollingshead SES score (possible range=0-66) of the infants' parents was 6.3 (range=0-28; *SD*=6.9).

For 20% of the Ugandan infants, their father was never a permanent household member, for 55% of infants their father was always a permanent household member, and for the remaining participants the father was a permanent household member at some, but not all of the time-points that we visited the families. Household membership was more dynamic in the Ugandan sample, for 82% of the participants, at least one person left or joined the household during the study period. The mean household size for the Ugandan participants (including study infant) was 6.4 people (range=2-17; *SD*=2.8). Fathers were listed as a caregiver for at least one time-point for 41% of participants. Mothers were only separated from their infants for an average of 7.8 hours a week (*SD*=8.9).

Twenty-five percent (of 40 known) of the Ugandan study infants were the mothers' first child, the remaining 75% had older siblings. The mean age of mothers at birth of the study infant was 27 years (range=15-42; *SD*=7.0). Ugandan mother-infant dyads lived in mud or brick houses with straw or iron sheet roofs. Their homes consisted of a compound with two or more buildings for different purposes (e.g. sleeping, cooking). None had mains electricity but some had small personal solar panels. Their water source and latrines were outside the house. On average when infants were 3- to 6-months old they spent more than half of their time for daily activities indoors, but from 9- to 15-months both mothers and infants spent more than half of their time for daily activities outdoors.

2.3.2 Materials

2.3.2.1 Observational data collection materials

Observational data was gathered using data sheets, and targeted information regarding the following points during a *full-day follow* (procedure described in *section 2.3.3*):

- Mother Activity
- If activity social: Mother social partner
- Infant Activity
- If activity social: Infant social partner
- Mother-infant distance
- How many people are in five metres of the infant
- Identity of individuals in five metres of the infant

Datasheets depicting the full list of information collected can be found in *appendix A2.2* (altered from Kaller, 2012).

2.3.2.2 Questionnaire materials

Five questionnaires were used in this study: a Background questionnaire, a Developmental questionnaire, a Parenting practices questionnaire, a Socialisation goals questionnaire, and a Warm-up questionnaire. All questionnaires were presented as English hard copies for UK participants to fill in. In Uganda, some questionnaires were presented using audio recordings, and others were translated real-time. For the *Socialisation goals questionnaire*, *Parenting practices questionnaire*, and *Warm-up questionnaire,* consistency in the phrasing of questions was deemed important because mothers were being asked their opinion of a statement, and slight differences in phrasing may influence their interpretation of the statement. Thus, to ensure consistency across Ugandan participants, voice recordings of statements in Alur, Lugbara, and Kiswahili were made by local research assistants. These were back-translated by a different local research assistant and checked for meaning retention by a third person. If meaning was not retained then this process was repeated. The recordings were stored on a smartphone and presented to participants via a small portable Bluetooth speaker.

A Background questionnaire was used to collect background information from participants (altered from Kaller, 2012, based on information collected in Ainsworth, 1967; full questionnaire in *appendix A2.1)*. This was a 50-item questionnaire covering background and demographic information for the participants including topics such as parents' ethnicity, education and languages, household members, infant caregivers, and infant sleeping and feeding habits. The information used from this questionnaire in this study were mother ethnolinguistic group and infant sleeping arrangements.

A 26-item Developmental questionnaire (edited from Kaller & Slocombe, unpublished data) was used to record the developmental milestones infants had reached, such as recognising family members, physical milestones, and communication milestones. Mothers were asked to indicate which of a list of abilities their baby showed at their current age (full questionnaire in *appendix A2.3*). The abilities of interest to this study were: sitting without support; crawling; and walking alone a few steps.

A Parenting practices questionnaire was composed of 10 statements from Keller (2007) and Keller et al. (2006), plus 29 other statements designed by Kaller and Slocombe (unpublished data) on what mothers consider appropriate parenting behaviour. Each statement was accompanied by a 5-point Likert scale ranging from strongly disagree to strongly agree (see full questionnaire in *appendix A2.4)*. The ten Keller (2006; 2007) statements (*Table 2.1*) have been previously categorised as referring to relational or autonomous parenting, creating an autonomous and relational subscale. When presented to participants with diverse ecocultural environments, these measures were considered reliable (autonomous subscale: Cronbach's α= .78; relational subscale: Cronbach's α= .86) and were negatively correlated with each other ($r = -.25$, $p < .01$). The ten Keller (2006; 2007) statements (*Table 2.1*) and one Kaller and Slocombe statement "It is important to devote a lot of time exclusively to the baby (only asked in UK)" were analysed in this study.

Table 2.1: Ten Parenting practices statements (Keller, 2007; Keller et al., 2006) and their categorisation as autonomous or relational. *The instructions were "please think of a baby of about 11-months of age and express your agreement or disagreement with these statements".*

Parenting practices statement presented	Categorised as autonomous or relational
1. It is important to rock a crying baby in your arms in order to console him/her.	Relational
2. Sleeping through the night should be trained as early as possible.	Autonomous
3. It is not necessary to react immediately to a crying baby.	Autonomous
4. It is never too early to direct the baby's attention towards objects and toys.	Autonomous
5. Babies should be encouraged to be as physically active as possible so that they become strong.	Relational
6. If a baby is fussy, he/she should be picked-up immediately.	Relational
7. It is good for a baby to sleep alone.	Autonomous
8. When a baby cries, he/she should be nursed immediately.	Relational
9. Babies should be left crying for a moment in order to see whether they console themselves.	Autonomous
10. A baby should always be in close proximity with his/her mother, so that she can react immediately to his/her signals.	Relational

A Socialisation goals questionnaire was composed of 10 statements from Keller (2007). This questionnaire was presented with a five-point Likert-style with responses ranging from strongly agree to strongly disagree (full questionnaire in *appendix A2.5)*. The ten statements have been previously categorised as referring to relational or autonomous parenting, creating an autonomous and relational subscale. When presented to participants with diverse ecocultural environments, these measures were considered reliable (autonomous subscale: Cronbach's α= .93; relational subscale: Cronbach's α= .89). The autonomous and relational measures did not correlate with each other (r = .01, p = .904). Some questions could not be appropriately translated/back translated into the Ugandan languages, so were not presented in Uganda, and were thus excluded from this study. These excluded statements were: "*During the first three years of life it is really important that children develop a sense of self"; and* "*During the first three years of life it is really important that children develop a sense of self-esteem".* Thus the statements analysed for this study are the eight statements shown in *Table 2.2.*

Table 2.2: Table of Socialisation goals statements (Keller 2007) and their categorisation as autonomous or relational. *The instructions were "Please read or listen to the following statements that describe different characteristics that children should acquire during the first three years of their life. We would like you to indicate how much you agree with each of these statements".*

Socialisation goals statements presented During the first three years of life it is really important that children…	**Categorised as autonomous or relational**
1. learn to cheer-up others.	Relational
2. learn to obey parents.	Relational
4. develop self-confidence.	Autonomous
5. learn to control emotions.	Relational
6. learn to obey elderly people.	Relational
8. develop competitiveness.	Autonomous
9. learn to care for the well-being of others.	Relational
10. develop independence.	Autonomous

A 'Warm-up questionnaire' was designed to familiarise participants with the concept of 5-point Likert scales (see *appendix A2.6*). The purpose of the questionnaire was to try to demonstrate to participants that it is possible to have different levels of agreement with a statement, and 'warm them up' to the 5-point Likert scale used in subsequent questionnaires, thus responses were not analysed in this study. Local people were consulted on the cultural appropriateness of the statements included in the Warm-up questionnaire.

2.3.3 Procedure

Full-day follows, Background questionnaires, and Developmental questionnaires were conducted at five time-points: when the infants were 3-months (if they had been recruited before this time), 6-, 9-, 12-, and 15-months. Parenting practices questionnaires and Socialisation goals questionnaires were administered at 11-months. See *Table 2.3* for sample size, and specific age summary of infants when data were collected at each time-point.

2.3.3.1 Observational data collection procedure - Full-day follows

Observational data was collected during a 'full-day follow' which was a sample day of mother-infant dyads' life where information regarding the mother's and infant's activities and social environment was collected. Specific information was collected at set intervals, constituting instantaneous '*scan samples',* throughout 8 hours of this day, (Altmann, 1974). UK mothers were phoned and were asked to report the requested information every 30 minutes. If a UK infant was being supervised by someone other than the mother, we would ask these questions to this caregiver if they were available. We would also ask the caregiver if they knew the mother's activity. In Uganda, full-day follows were conducted through direct observation.

Full-day follow information was collected on paper data-sheets in both the UK and Uganda (described in *section 2.3.2*). For UK participants, full-day follows were conducted by project collaborators or research assistants. Before conducting data collection alone, data collectors were made familiar with the data collection sheet, and the behaviour categories of interest (see a*ppendix A2.7* for these training materials). After this, the new data collector observed a trained collector conducting the full-day follow phone calls and entering the data, where they had a chance to ask any questions. New data collectors were supervised while they conducted their first full-day follow phone calls and a trained collector would step in to correct any mistakes. New data collectors were not permitted to collect data unsupervised until their performance was highly accurate.

In Uganda, I trained two local research assistants (PJ and AS) to collect *scan samples* every 15 minutes across an 8 hour period during one day. Training consisted of practicing data collection on theoretical situations, as well as observing real-life situations. When training, we discussed answers and why we chose them, I gave feedback to PJ and AS if

Table 2.3: Mean infant age, spread, and sample size for participants included at each time-point. *Participants were excluded from analyses if their data were collected outside one month either side of their time-point month birthday (with the exception of 11-month questionnaires since these were not part of the repeated aspect of this study). *11-month time-point questionnaires were only the Parenting practices questionnaire and the Socialisation goals questionnaire*

	Full-day follows						**Questionnaires**					
	UK			**Ugandan**			**UK**			**Ugandan**		
Time-point	**Mean age in months *(SD)***	**Range**	**N**	**Mean age in months *(SD)***	**Range**	**N**	**Mean age in months *(SD)***	**Range**	**N**	**Mean age in months *(SD)***	**Range**	**N**
3-month	3.1 *(0.34)*	*2.5-4.0*	39	3.3 *(0.30)*	*2.6-3.8*	31	2.9 *(0.34)*	*2.5-3.8*	39	3.1 *(0.37)*	*2.2-3.9*	40
6-month	6.0 *(0.25)*	*5.2-6.4*	53	6.2 *(0.20)*	*5.8-6.5*	35	5.9 *(0.28)*	*5.3-6.6*	53	6.0 *(0.26)*	*5.6-6.5*	43
9-month	8.9 *(0.26)*	*8.5-9.6*	50	9.3 *(0.23)*	*8.8-9.9*	40	9.0 *(0.27)*	*8.5-9.7*	51	9.1 *(0.29)*	*8.6-9.9*	43
11-month*	-	-	-	-	-	-	11.0 *(0.28)*	*10.5-11.7*	51	11.3 *(0.25)*	*10.8-12.3*	41
12-month	12.0 *(0.53)*	*11.5-14.9*	48	12.4 *(0.19)*	*12.0-13.0*	38	12.0 *(0.34)*	*10.6-12.9*	49	12.2 *(0.36)*	*11.1-13.4*	40
15-month	15.0 *(0.27)*	*14.4-15.6*	45	15.1 *(0.26)*	*14.6-15.6*	42	15.0 *(0.45)*	*14.2-16.7*	49	15.1 *(0.2)*	*14.6-15.5*	42

situations were categorised differently (see *appendix A2.8* for training materials). After training, PJ, AS, and I conducted three days of reliability visits where we observed the same mother-infant dyad and recorded data without consultation with one another (total 52 scan samples). The data collected by PJ and AS were compared to the data collected by myself for each variable, and Cohen's Kappas calculated (Cohen, 1960). The mean Cohen's Kappas were .73 or above for both research assistants for all variables used in this study, indicating good inter-observer reliability.

Given the higher frequency of scan samples in full-day follows in the Ugandan data set (15 minute in Ugandan full-day follows versus 30 minutes in UK full-day follows), for any analysis using summary variables from a full-day follow, the Ugandan data was split to create two sets of data (Set1 and Set2) with scan samples separated by 30minutes. Set1 or Set2 of the Ugandan data was randomly chosen for each full-day follow summary variable that was used in analysis.

2.3.3.2 Questionnaire data collection procedure

In the UK, questionnaire data were collected as part of a 1.5- to 2-hour research session at the participants' homes, usually run by two researchers. In Uganda, questionnaire data were collected as part of a 2- to 4-hour research session at the participants' homes, with at least two researchers (including at least one local research assistant). The local research assistant who attended each visit had at least one language in common with the participant mother so that they could also act as a translator.

Home visits were done on a different day to the participants' full-day follow, and included other data collection which were part of the larger *JointAtt Project*. Full questionnaires were administered to mothers, however in this study, only questions detailed in the materials section above were analysed. The Warm-up questionnaire was always presented before the Parenting questionnaire and Socialisation goals questionnaire so that mothers could become familiar with the format of the Likert-scale questions. There was no fixed order for the presentation of other questionnaires.

UK mothers were given hard copies of all questionnaires in English to complete themselves. Due to low literacy rate in the Ugandan mothers, the Background questionnaire and Developmental questionnaire were asked to the mothers by local research assistants in a language the mother was fluent in. Mothers responded verbally, and the mothers' answers were noted on hard copies of the questionnaires by research assistants. The research assistants were familiar with the questionnaires, and the information we wanted to extract from them to ensure the correct questions were asked.

The Parenting questionnaire, Socialisation goals questionnaire, and Warm-up questionnaire were presented to Ugandan mothers using pre-recorded voice recordings (in a language of their choice from Lugbara, Alur, or Kiswahili). Mothers were asked to tell us how much they agreed or disagreed with statements using the 5-point Likert scale classifications. Research assistants translated mothers' responses to the questions in real-time and filled in a paper copy of the questionnaire.

Each of the ten Keller (2007) statements from in the Parenting questionnaire and all statements from the Socialisation goals questionnaire were categorised as relating to relational or autonomous parenting attitudes (*Table 2.1* and *Table 2.2).* Each questionnaire answer was given a score of 1 to 5 which correlated with the 5-point Likert scale. For each participant, for each questionnaire separately, I took the mean scores from autonomous questions and relational questions respectively to give a mean autonomous score and a mean relational score. UK mothers more often used the full spectrum of the Likert scale of the Parenting practices questionnaire and Socialisation goals questionnaire than the Ugandan mothers, who more often answered with the extremes of the scale (i.e. strongly disagree or strongly agree). To reduce the effects of the different response styles between the UK and Ugandan participants, I calculated a 'difference score' to characterise the relative relational and autonomous parenting attitudes for each participant instead of characterising mothers relational and autonomous views separately (Kärtner et al., 2007; Kartner et al., 2008; Keller, 2007). The difference score was the mean autonomous score minus the mean relational score (with potential values ranging from -4 to +4; where >0 categorises opinions as overall 'more autonomous' and <0 as 'more relational'). For the Parenting practices questionnaire, difference scores were calculated from the first ten questions, and difference scores for the Socialisation goals questionnaire were calculated for all eight questions.

2.3.4 Data Analysis

All analyses were run in *R* version 4.0.1 (R Core Team, 2020).

2.3.4.1 Research Question 1: Do the UK and Ugandan participants form two distinct groups?

A principal component analysis (PCA) was conducted to determine if the early life environment for infants: a) fell into two distinct groups (UK dyads and Ugandan dyads), b) fell into more than two distinct groups (e.g., there is separation by ethnolinguistic group within Ugandan participants), or c) indicate universality, i.e., no separation between cultural groups. Variables were included to describe the following aspects of infant early life environment: mothers' attitude towards infant independence and social environment, infant attainment of physical milestones, infant exploration of the environment, the infants' social environment and social interactions. The specific measures included in the PCA are described in *Table 2.4*.

Corpcor (Schafer et al., 2017), GPArotation (Bernaards & Jennrich, 2005), and psych (Revelle, 2020) *R* packages were used. All measures were not available for all participants, thus, a Pearson's correlation matrix was made which omitted individuals only for the specific pairwise correlation where they had a missing value. The PCA was conducted on this correlation matrix. Checks were made to determine how appropriate variables were for inclusion in the PCA. First, a Bartlett's test was run on the correlation matrix. The results were highly significant ($chi^2_{(253)}$=1576, p<.001), indicating the matrix was not an identity matrix. The matrix was also checked for whether any variables shared very little variance with others, or most variance with another (i.e. above R=.9). No variables fit these criteria, so all variables were considered appropriate to include in the PCA. Finally, a Kaiser-Meyer-Olkin (KMO) test was conducted, the overall Measure of Sampling Adequacy (MSA) was .73, and no individual MSAs were below .5, which also indicates factors were adequate for inclusion. A six Principal Component (PC) solution was deemed adequate since the first six components had eigenvalues above 1 (Kaisers criterion: Kaiser, 1960), and the last 'step' in eigenvalues was between PC 6 and PC 7 (See *appendix A2.9*). The PCA was then re-run with only these 6 components following advice from Field, Miles, and Field (2012).

For example:

$$
\begin{aligned}
Participant_n\ PC1\ score
&= (PC1\ loading_{variable1} \times standardised\ participant_n\ score_{variable1}) \\
&+ (PC1\ loading_{variable2} \times standardised\ participant_n\ score_{variable2}) \\
&+ (PC1\ loading_{variable3} \times standardised\ participant_n\ score_{variable3}) \\
\dots up\ to &+ (PC1\ loading_{variable\ 23} \times standardised\ participant_n\ score_{variable\ 23})
\end{aligned}
$$

Where *n*=participant dyad ID, and *variable* = a measure from *Table 2.4.*

In cases where dyads did not have values for all variables, the mean value was used in calculations. Participant dyad scores for each PC were graphed against each other and visually inspected for participant clusters.

Table 2.4: Details of measures included in PCA. *The domain that the variable is aimed to measure is specified for each variable (Mothers attitudes towards infant independence and social environment, infant attainment of physical milestones, infant exploration of the environment, infant social environment, and infant social interactions). The average was taken across time-points (maximum five) available per participant using the method described in variable description. *Key: FDF=Full-day follow; Devo. Q.=Developmental questionnaire; BG. Q.=Background questionnaire; Soc. Goals Q.=Socialisation goals questionnaire; Parent. Q.=Parenting practices questionnaire. ** Median was taken as the value for the number of people in proximity to avoid occasions when mothers were in a crowd for one scan sample, which would not be representative of their full-day, having a large effect on the mean for that participant. ***Time-points were pooled for cases where the scan samples were subset into only infant social activity scan samples, due to the relatively infrequent nature of these social activity scans.*

Specific measure (Domain grouping)	Variable description	Data source*	Variable structure	Inclusion Criteria
Parenting practices attitude *(Mothers' attitude)*	Difference score calculated from Parenting Questionnaire answers	Parent. Q.	Numeric: difference score -4 to 4	All available included
Socialisation goals attitude *(Mothers' attitude)*	Difference score calculated from Socialisation Goals Questionnaire answers	Soc. Goals Q.	Numeric: difference score -4 to 4	All available included
Sit *(Attainment of physical milestones)*	Time-point at which infant was first reported as being able to sit unsupported	Devo. Q.	Ordinal: 3, 6, 9, 12, 15months or not yet	All available included
Crawl *(Attainment of physical milestones)*	Time-point at which infant was first reported as being able to crawl	Devo. Q.	Ordinal: 3, 6, 9, 12, 15months or not yet	All available included
Walk *(Attainment of physical milestones)*	Time-point at which infant was first reported as being able to walk unsupported	Devo. Q.	Ordinal: 3, 6, 9, 12, 15months or not yet	All available included
Amount of environment exploration	Mean % of scan samples in a FDF across time-points where infant activity is solo-play or explore	FDF	Numeric: Mean % scans per time-point (maximum 5)	All available included
Number of caregivers *(Social environment)*	Mean number of non-mother caregivers during a FDF across time-points	FDF	Numeric: Mean of count values per time-point (maximum 5)	Minimum of at least 11 scans per time-point

Specific measure (Domain grouping)	Variable description	Data source*	Variable structure	Inclusion Criteria
Adult caregiver *(Social environment)*	Proportion time-points where a non-mother adult caregiver was present during the FDF	FDF	Numeric: Proportion out of maximum 5 time-points	Minimum of more than 10 scans per time-point
Child caregiver *(Social environment)*	Proportion of time-points where a child caregiver was present during the FDF	FDF	Numeric: Proportion out of maximum 5 time-points	Minimum of more than 10 scans per time-point
Number of people in proximity *(Social environment)*	Median number of non-mothers in proximity of the infant across scan samples at all time-points	FDF	Numeric: Median** number of people in proximity (pooled time-points***)	All available included
Adults in proximity *(Social environment)*	Mean % of scan samples in a FDF across time-points where there is a non-mother adult within 5 metres of the infant	FDF	Numeric: Mean % scans per time-point (maximum 5)	All available included
Children in proximity *(Social environment)*	Mean % of scan samples in a FDF across time-points where there is a child within 5 metres of the infant	FDF	Numeric: Mean % scans per time-point (maximum 5)	All available included
Proximity with mother *(Social environment)*	Mean % of scan samples in a FDF across time-points where dyad are within 5 metres of one another	FDF	Numeric: Mean % scans per time-point (maximum 5)	All available included
Contact with mother *(social interactions)*	Mean % of scan samples in a FDF across time-points where dyad are in contact with one another	FDF	Numeric: Mean of % scans per time-point (maximum 5)	All available included
Mother activities for Infant *(social interactions)*	Mean % of scan samples in a FDF across time-points where mothers activity is solely for the purpose of caring or interacting with the infant	FDF	Numeric: Mean of % scans per time-point (maximum 5)	All available included

Specific measure (Domain grouping)	Variable description	Data source*	Variable structure	Inclusion Criteria
Amount social activities *(social interactions)*	Mean % of scan samples in a FDF across time-points where infant activity is a social activity	FDF	Numeric: Mean of % scans per time-point (maximum 5)	All available included
Amount social play *(social interactions)*	Mean % of scan samples in a FDF across time-points where infant activity is social play	FDF	Numeric: Mean of % scans per time-point (maximum 5)	All available included
Contact during play *(social interactions)*	% of dyad play instances where mother and infant are in contact across scan samples at all time-points	FDF	Numeric: % of play activity scan samples in contact (pooled time-points***)	Minimum of 3 scan samples where activity is mother-infant play across time-points
Number of social partners *(social interactions)*	Mean across time-points of proportion of non-mother social partners per number of scans during a FDF	FDF	Numeric: Mean of proportion value	All available included
Adult social partners *(social interactions)*	% of social events across scan samples across time-points where partner is a non-mother adult	FDF	Numeric: % of scan samples (pooled time-points***)	Minimum of 3 scan samples where activity is social across time-points
Child social partners *(social interactions)*	% of social events across scan samples across time-points where partner is a child	FDF	Numeric: % of scan samples (pooled time-points***)	Minimum of 3 scan samples where activity is social across time-points
Shared bedroom *(Social environment)*	Proportion time-points where infants were reported to share a bedroom with somebody else at night	BG. Q.	Numeric: Proportion out of maximum 5 time-points	All available included
Shared bed *(Social environment)*	Proportion time-points where infants were reported to share a bed with somebody else at night	BG. Q.	Numeric: Proportion out of maximum 5 time-points	All available included

2.3.4.2 Research Question 2: Do the UK and Ugandan mothers have different attitudes towards parenting and socialisation goals for their infants?

To see if there was an effect of cultural group on parenting and socialisation attitudes, two Kruskal-Wallis tests were run: one with Parenting practices difference score (Numeric: score -4 to 4) as the dependent variable; and the second with Socialisation goals difference score (Numeric: score -4 to 4) as the dependent variable. The independent variable in both Kruskal-Wallis tests was cultural group (UK or Uganda). Kruskal-Wallis tests were chosen over Mann-Whitney-U tests because the difference scores for both Socialisation goals and Parenting practices were differently distributed for UK and Ugandan samples.

2.3.4.3 Research Question 3: Does cultural group and infant age influence early life environment?

Generalized Linear Mixed Models (GLMMs) were run using the lme4 package (Bates, Maechler, Bolker, & Walker, 2015) to examine associations between cultural group, infant age, and the interaction between group and age on infants': attainment of physical milestones; exploration of the environment; social environment; and social interactions (details of models run can be found in *Table 2.5)*. Infant age was entered in months, calculated with the following formula:

$$Infant\ age\ (months) = \frac{Number\ of\ days\ old\ on\ day\ of\ data\ collection}{\left(\frac{Number\ of\ days\ in\ a\ year}{Number\ of\ months\ in\ a\ year}\right)}$$

Likelihood ratio tests were used to compare the full models (model with all fixed and random factors) and null models (model with only random factors) to determine whether the full model was better at explaining the variance in the data than a model including random factors and intercept alone. Overdispersion was checked for non-binomial GLMMs using an 'overdisp test' function kindly provided by Roger Mundry. Model stability was checked by looking for influential cases indicated by Cooks distance (calculated using the Influence.ME package: Nieuwenhuis, te Grotenhuis, & Pelzer, 2012) greater than 4/*n* (where *n*=number participants). To understand the effect of influential cases, models were rerun excluding influential cases to see if it changed interpretation of the model. *Appendix A2.10* contains a summary of the number of influential cases in each model and the results of rerunning the models without the influential cases. In the majority of cases the interpretation of the model was not changed by rerunning the model, providing confidence in the stability of the model reported in the results. Where exclusion of the influential participants affected the interpretation of the model, the results of the alternate model are also presented in the results. Results from both models are presented to give transparency

Table 2.5: Details of measures included and error structure used for each GLMM. *FDF=full-day follow; Devo. Q.=Developmental questionnaire; BG. Q.=Background questionnaire. 'Scan samples' are the individual data points collected during a FDF. Given that more infants would be able to perform physical milestones with time, infant age was included as a random factor. * Fixed and random factor descriptions: Infant age was a continuous variable in months (unless otherwise specified varies from 2 to 16months). Culture is binary variable describing the cultural group (Uganda or UK). Participant is a nominal factor depicting each individual participant dyad. **Model error structure decisions: Count variables were checked for zero-inflation and overdispersion. For 'Number of Caregivers' the number of zeros was within expected range for a Poisson distribution and was not overdispersed, thus this model was run with Poisson error structure. The variable 'Number of people in Proximity' was zero inflated and overdispersed, thus a negative binomial error structure was used.***Chance of having a novel non-mother social partner: As a measure of how many individuals infants were likely to interact with in a day, each scan sample was scored as whether the infant was interacting with a novel individual. A novel individual was considered an individual that the infant had not yet interacted with in that FDF, e.g. if an infant interacted with their sibling twice within the full-day follow, only one of the two scan samples would be graded as having a novel social partner. If the infant interacted with two new individuals in one scan sample then the second individual was considered a novel individual in the next scan sample.*

Dependent variable	**Level of analysis**	**Dependent variables description (structure)**	**Model error structure**	**Fixed factors (Random factors) ***	**Inclusion criteria**
Sit *(attainment of physical milestones)*	Questionnaire answer (n=260)	In the Devo. Q. was infant reported to be able to sit unsupported (Binary: Yes/No)	Binomial	Culture + (Infant Age) + (Participant)	Only 3, 6, 9month age-groupings
Crawl *(attainment of physical milestones)*	Questionnaire answer (n=270)	In the Devo. Q. was infant reported to be able to crawl (Binary: Yes/No)	Binomial	Culture + (Infant Age) + (Participant)	Only 6, 9, 12month age-groupings
Walk *(attainment of physical milestones)*	Questionnaire answer (n=262)	In the Devo. Q. was infant reported to be able to walk unsupported (Binary: Yes/No)	Binomial	Culture + (Infant Age) + (Participant)	Only 9, 12, and 15month age-groupings
Amount of environment exploration *(Non-social experience)*	Scan samples (n=9373)	In the scan sample was the infant's activity exploratory ('solo play' or 'explore')? (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	All available included

Dependent variable	**Level of analysis**	**Dependent variables description (structure)**	**Model error structure**	**Fixed factors (Random factors) ***	**Inclusion criteria**
Number of caregivers *(social environment)*	FDF (n=396)	Count of how many caregivers were present during the FDF (Numeric: Count)	Poisson**	Infant Age + Culture + Infant Age*Culture + (Participant)	Minimum of more than 10 scan samples per FDF
Adult caregiver *(social environment)*	Scan samples (n=9322)	In the scan sample was non-mother adult noted as the infant’s caregiver (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	Minimum of more than 10 scan samples per FDF
Child caregiver (UG only) *(social environment)*	Scan samples (n=5382)	In the scan sample was someone <17years noted as the infants caregiver? (Binary: Yes/No)	Binomial	Infant Age + (Participant)	Minimum of more than 10 scan samples per FDF. Only run for Ugandan sample due to no variation in UK (i.e. in 3944 scan samples, no UK participants ever had a child as their caregiver).
Number of people in proximity *(social environment)*	Scan samples (n=9419)	In the scan sample how many non-mothers in proximity of the infant (Numeric: Count)	Negative Binomial **	Infant Age + Culture + Infant Age*Culture + (Participant)	All available included
Adults in proximity *(social environment)*	Scan samples (n=9411)	In the scan sample, was there a non-mother adult within 5 metres of the infant? (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	All available included

Dependent variable	**Level of analysis**	**Dependent variables description (structure)**	**Model error structure**	**Fixed factors (Random factors) ***	**Inclusion criteria**
Children in proximity *(social environment)*	Scan samples (n=9405)	In the scan sample, was there somebody <17years within 5 metres of the infant? (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	All available included
Amount social play *(social interactions)*	Scan samples (n=9407)	In the scan sample was the infant's activity social play? (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	All available included
Amount social activities *(social interactions)*	Scan samples (n=9390)	In the scan sample was the infant's activity a social activity? (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	All available included
Chance of novel social partner *(social interactions)*	Scan sample (n=9308)	Did the infant have an interaction with a novel non-mother partner in the scan sample*** (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	All available included
Adult social partners *(social interactions)*	Scan samples where activity is social (n=2175)	In the scan sample did the infant's social partners include a non-mother adult? (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	Minimum of 3 scan samples where activity is social across time-points
Child social partners *(social interactions)*	Scan samples where activity is social (n=2175)	In the scan sample did the infant's social partners include someone <17years? (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	Minimum of 3 scan samples where activity is social across time-points
Mother activities for infant *(social interactions)*	Scan samples (n=9260)	In the scan sample was the mother's activity exclusively for the infant? (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	All available included

Dependent variable	**Level of analysis**	**Dependent variables description (structure)**	**Model error structure**	**Fixed factors (Random factors) ***	**Inclusion criteria**
Proximity with mother *(social environment)*	Scan samples (n=9384)	In the scan sample were the mother and infant in 5 metres of one another? (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	All available included
Mother-infant physical contact *(social interactions)*	Scan samples (n=9515)	In the scan sample were the mother and infant in physical contact with one another? (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	All available included
Contact with mother during play *(social interactions)*	Scan samples when infants activity was social play with mother (n=553)	When infants activity was social play with mother in the scan sample, were mother and infant in physical contact with one another? (Binary: Yes/No)	Binomial	Infant Age + Culture + Infant Age*Culture + (Participant)	All available included
Shared bedroom (only UK) *(social environment)*	Questionnaire answer (n=240)	In the BG. Q. was infant reported to share a bedroom at night? (Binary: Yes/No)	Binomial	Infant Age + (Participant)	Only UK sample due to no variation in Ugandan sample (i.e. of 200 UG questionnaires none reported the infant sleeping in a room alone).

to the reader regarding the confidence and robustness of patterns seen in the data when inclusion or exclusion of specific participants changes the interpretation of the model. Where interactions between infant age and cultural group were found, to further understand these interactions, post-hoc models were run separately for each culture and alpha level was Bonferroni corrected for multiple comparisons.

2.3.4.4 Research Question 4: Are parental attitudes associated with observed or reported parenting behaviour?

To test if maternal attitudes at 11-months were associated with observed or reported parenting behaviour at 12-months, Kruskal-Wallis and Fisher's exact tests were conducted (see *Table 2.6*). As participants from the UK and Uganda used the Likert scale differently, answers were collapsed to binary low (two disagreement options and neutral) and high (two agreement options) agreement categories.

Table 2.6: Analyses run to investigate if parental attitudes were associated with observed or reported behaviour. **Kruskal Wallis tests were chosen for Infant/mother proximity 1, Infant/mother proximity 2, and Mother Infant time, over Mann-Whitney U tests due to unbalanced variance across groups.*

Topic	Attitude Question	Behaviour at 12 months (source)	Test type*
Infant/mother proximity 1	Parenting Q10. A baby should always be in close proximity with his/her mother, so that she can react immediately to his/her signals.	UG and UK pooled: Proportion of scans samples where mother and infant are in 5 metres of each other (full-day follows)	Kruskal-Wallis test
Infant/mother proximity 2	Socialisation goals - Infants should develop independence during the first 3 years of life.	UG only: Proportion of scan samples where mother and infant are in 5 metres of each other (full-day follows)	Kruskal-Wallis test
Sleep location	Parenting Q7. It is good for a baby to sleep alone.	UK only: Does infant share bedroom (Background questionnaire)	Fisher's exact test
Mother Infant time	Parenting Q35. It is important to devote a lot of time exclusively to the baby. (This question was not asked in Uganda, so only analysing UK here).	UK only: Proportion of scan samples where mother activity is exclusively for the infant? (full-day follows)	Kruskal-Wallis test

2.3.5 Ethical note

Ethical approval was obtained for data collection from the University of York Psychology department ethics committee. Additionally we obtained ethical permission from the Regional Ethics Committee at the Ugandan Virus Research Institute, and permits from the Ugandan National Council for Science and Technology for data collection conducted in Uganda.

2.4 Results

2.4.1 Research Question 1: Do the UK and Ugandan participants form two distinct groups?

The six Principal Components (PCs) from the PCA explained 74% of variance in the data, with the first two PCs explaining 24% and 12% of variance respectively (See *Table 2.7* for eigenvalues and variance explained by each component; appendix *A2.11* shows PC loadings). *Figure 2.1* shows the first two Principal Components plotted, indicating a distinct separation between Ugandan and UK participants – only one individual falls within the area for both UK and Ugandan participants, however this Ugandan participant dyad did not have information available for all variables. This graph also shows that participants from different ethnolinguistic groups in Uganda do not show distinct clusters. Plotting all pairwise comparisons of PCs 1-6, confirmed there was no separation within the Ugandan data with any of the PCs (see appendix *A2.12*). Given this, it was deemed appropriate to regard the Ugandan data set as one cultural group for subsequent analyses.

Table 2.7: Principal Component summaries

Principal Component	% of Variance explained	Eigenvalues
PC1	24	5.43
PC2	12	2.65
PC3	10	2.31
PC4	10	2.36
PC5	10	2.27
PC6	8	1.93

2.4.2 Research Question 2: Do the UK and Ugandan mothers have different attitudes towards parenting and socialisation goals for their infants?

Mothers' Parenting practices and Socialisation goals attitudes were overall significantly more relational/less autonomous in the Ugandan than the UK participants (see *Figure 2.2*; Kruskal-Wallis test: Parenting practices: $\chi^2_{(1)}$=47.4, *p*<.001; Socialisation goals:$\chi^2_{(1)}$=24.3, *p*<.001). However the range within each culture was larger than the mean difference between cultures, indicating that there was a lot of individual variation. UK mothers' attitudes showed a range spanning 'more autonomous than relational' to 'more relational than autonomous' in both questionnaires. No individual Ugandan mother was categorised as having attitudes which were 'more autonomous than relational' in the Parenting practices questionnaire. In the Socialisation goals questionnaire three Ugandan mothers' attitudes could be categorised as 'more autonomous than relational'.

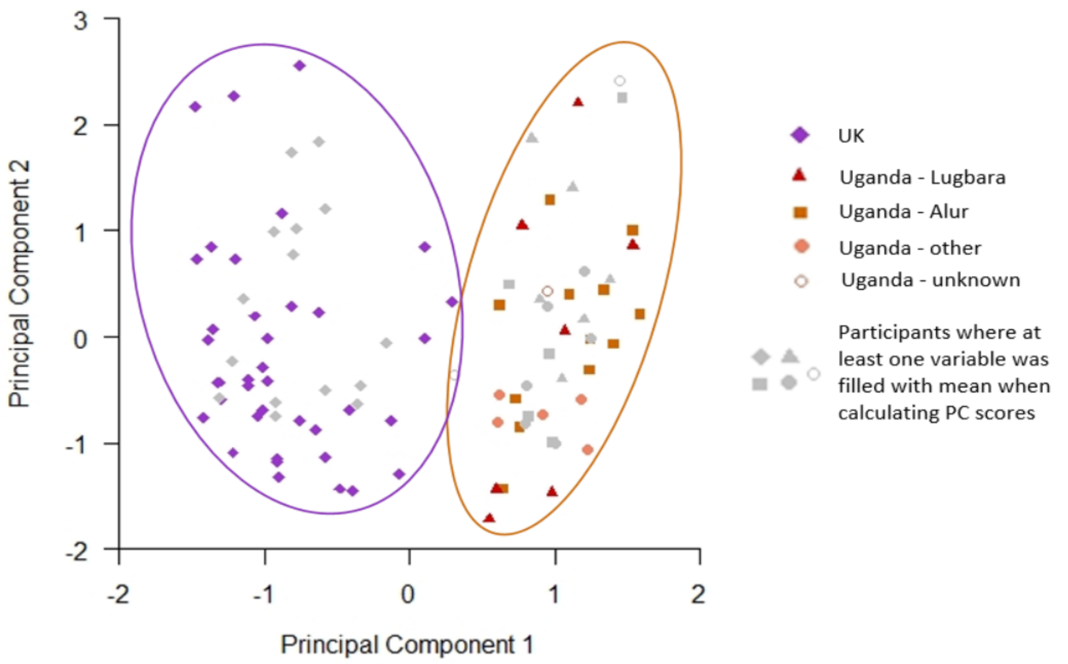


Figure 2.1: Standardised individual dyad scores for principal component 1 and principal component 2. *Points colour and shape coded for UK mothers and Ugandan mothers ethnolinguistic group. The purple oval encompasses all UK participants and the orange oval encompasses all Ugandan participants. Where all variables were not available to calculate the PC scores for a participant, overall means were used for the variable, individuals where this happened are plotted in grey.*

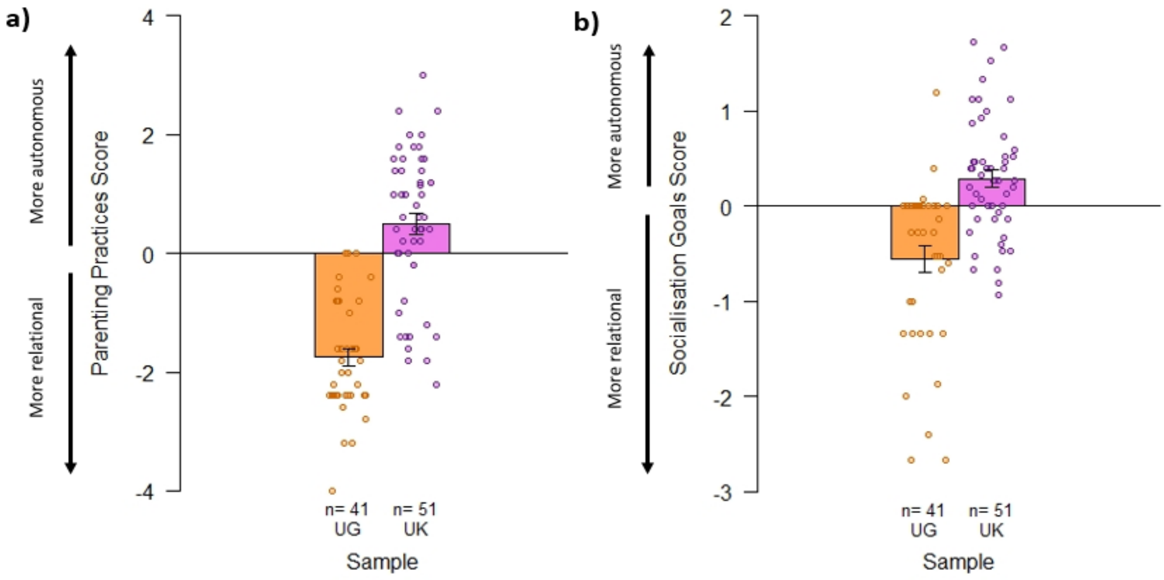


Figure 2.2: Graphs of difference scores for a) Parenting practices, and b) Socialisation goals attitudes. *Points show individual participant difference scores and n shows the number of participants in each group.*

2.4.3 Research Question 3: Does cultural group and infant age influence early life environment?

GLMMs were run to see if there was an effect of culture or infant age on infant physical development, infant activities, infant caregivers, infant social environment, mother-infant relations, and infant social partners, to cover the domains of infant attainment of physical milestones, infant exploration of the environment, infant social environment, and infant social interactions. For all GLMMs except one (number of people in proximity), the full model explained significantly more variance than the null model (Likelihood Ratio Test results in *Tables 2.8 to 2.15*).

2.4.3.1 Infant physical development

More infants in Uganda reached physical milestones at earlier ages than UK infants (*See Figure 2.3*). Some infants in both cultures were reported to be able to sit unsupported by 3-months, all Ugandan infants could sit unsupported by the 9-month time-point, and all UK infants could sit by the 15-month time-point. At least one infant in both cultures were reported to be able to crawl by the 6-month time-point, and all were reported to be able to crawl by 15-months. At least one infant in both cultures was reported to be able to walk unsupported by the 9-month time-point, and there were infants in both cultures who were not able to walk unsupported by 15-months.

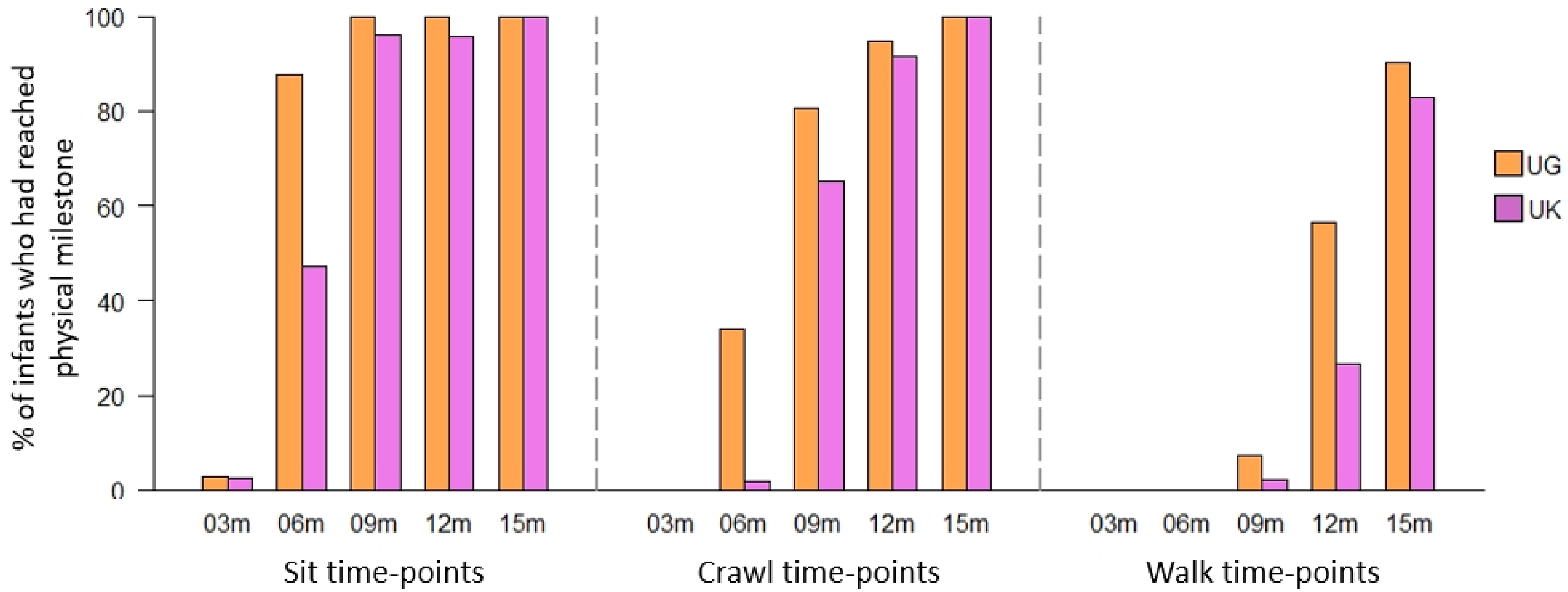


Figure 2.3: Graphs showing % of infants who could a) sit unsupported b) crawl unsupported, and c) walk unsupported, for each age/culture grouping. *UG=Ugandan participants. UK=UK participants. The number of Ugandan participants at time-points 3-, 6-, 9-, 12-, and 15-months was 37, 41, 41, 39, and 41 respectively. The number of UK participants at 3-, 6-, 9-, 12-, and 15-months was 39, 53, 49, 47, and 47 respectively, except for walking at 12-months where n=45.*

A GLMM showed Ugandan infants were more likely than UK infants to be able to sit when considering them from 2- to 10-months (with probability of .70 that a child sampled in this age range from the Ugandan group could sit and probability of .39 in UK infants; *Table 2.8*), implying that overall Ugandan infants reach this milestone at an earlier age than UK infants.

A GLMM showed Ugandan infants were more likely than UK infants to be able to crawl when considering them from 5- to 13-months (with probability of .82 that a child sampled in this age range from the Ugandan group could crawl and probability of .53 in UK infants; *Table 2.8*), implying that overall Ugandan infants reach this milestone at an earlier age than UK infants.

A GLMM showed infants in Uganda infants were more likely than UK infants to be able to walk when considering them from 8- to 16-months (with probability of .54 that a Ugandan infant sampled in this age range could walk and probability of .23 in UK infants; *Table 2.8*), implying that overall infants in Uganda reach this milestone at a younger age than in the UK.

Table 2.8: Model parameters for physical milestone GLMMs*. The reference level for Culture was UK. The reference level for physical milestones was 'not able to' (e.g. for Sit, the reference level was 'not able to sit'). LRT = Likelihood Ratio Test. * indicates significance at <.05 level, ** indicates significance at <.01 level, *** indicates significance at <.001 level.*

	Model parameters					
Model (LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Sit GLMM ($\chi^2_{(1)}$=6.95, *p*=.008**)	(Intercept)	.870	.461	1.89	-.052 to 2.08	.059
	Culture	-1.30	.458	-2.85	-2.39 to -.379	.004**
Crawl GLMM ($\chi^2_{(1)}$=12.7, *p*<.001***)	(Intercept)	1.49	.412	3.63	.754 to 2.36	<.001***
	Culture	-1.39	.419	-3.31	-2.24 to -.608	<.001***
Walk GLMM ($\chi^2_{(1)}$=6.03, *p*=.014*)	(Intercept)	.139	.406	.343	-.738 to 1.09	.731
	Culture	-1.07	.504	-2.12	-2.48 to -.209	.035*

2.4.3.2 Infant exploratory activity

There was an interaction between culture and infant age as to how likely infants were to show explorative behaviour: Ugandan and UK infants both were more likely to show explorative behaviour as they aged but this effect was stronger in the Ugandan sample, i.e., as children got older, Ugandan infants were more likely to show explorative behaviour than UK infants (see *Figure 2.4, Table 2.9*; Bonferroni adjusted posthoc models: UG age *Est=.095*, *SE*=.009, *z*=11.1, *p*<.001; UK age *Est=.047*, *SE*=.012, z=4.05, *p*<.001).

Table 2.9: Model parameters for infant explorative activity GLMM. *The reference level for Culture was UK. The reference level for Environment exploration was 'not exploring'. LRT = Likelihood Ratio Test. *** indicates significance at <.001 level.*

	Model parameters					
Model (LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Environment Exploration GLMM ($\chi^2_{(3)}$=189, *p*<.001***)	(Intercept)	-2.23	.109	-20.6	-2.47 to -2.03	<.001***
	Culture	-.097	.168	-.579	-.425 to .220	.563
	Infant age	.095	.009	11.1	.078 to .112	<.001***
	Culture*Infant Age	-.049	.014	-3.35	-.077 to -.021	<.001***

2.4.3.3 Infant social environment – Caregivers

In both the UK and Uganda mothers were the primary caregivers (mothers were caregiver for 96% of scan samples in the UK, and for 79% in Uganda). In terms of the number of different caregivers responsible for the infant in a day, a GLMM showed that Ugandan infants had a significantly higher number of caregivers in a day than in the UK (See *Table 2.10, Figure 2.5a*). There was no effect of infant age on the number of caregivers an infant would have during a day and no significant interaction between culture and age.

Table 2.10: Model parameters for infant caregivers GLMMs. *The reference level for Culture was UK. The reference level for Adult Caregiver and Child Caregiver was 'caregiver not a non-mother adult' and 'caregiver was not a child' respectively. LRT = Likelihood Ratio Test. * indicates significance at <.05 level, ** indicates significance at <.01 level, *** indicates significance at <.001 level.*

	Model parameters					
Model (LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Number of Caregivers GLMM ($\chi^2_{(3)}$=106, *p*<.001***)	(Intercept)	.418	.160	2.61	.108 to .728	.009**
	Culture	-1.59	.347	-4.57	-2.33 to -.921	<.001***
	Infant age	.010	.014	.694	-.019 to .034	.488
	Culture *Infant Age	-.043	.035	-1.22	-.115 to .029	.223
Non-mother Adult Caregiver GLMM ($\chi^2_{(3)}$=12.6, *p*=.005**)	(Intercept)	-3.38	.278	-12.2	-3.94 to -2.79	<.001***
	Culture	-1.05	.428	-2.46	-2.04 to -.231	.014*
	Infant age	.019	.014	1.32	-.010 to .044	.186
	Culture *Infant Age	.002	.026	.061	-.052 to .059	.952
Child Caregiver UG GLMM ($\chi^2_{(1)}$=7.03, *p*=.008**)	(Intercept)	-2.28	.175	-13.1	-2.65 to -1.93	<.001***
	Infant age	.027	.010	2.66	.006 to .047	.008**

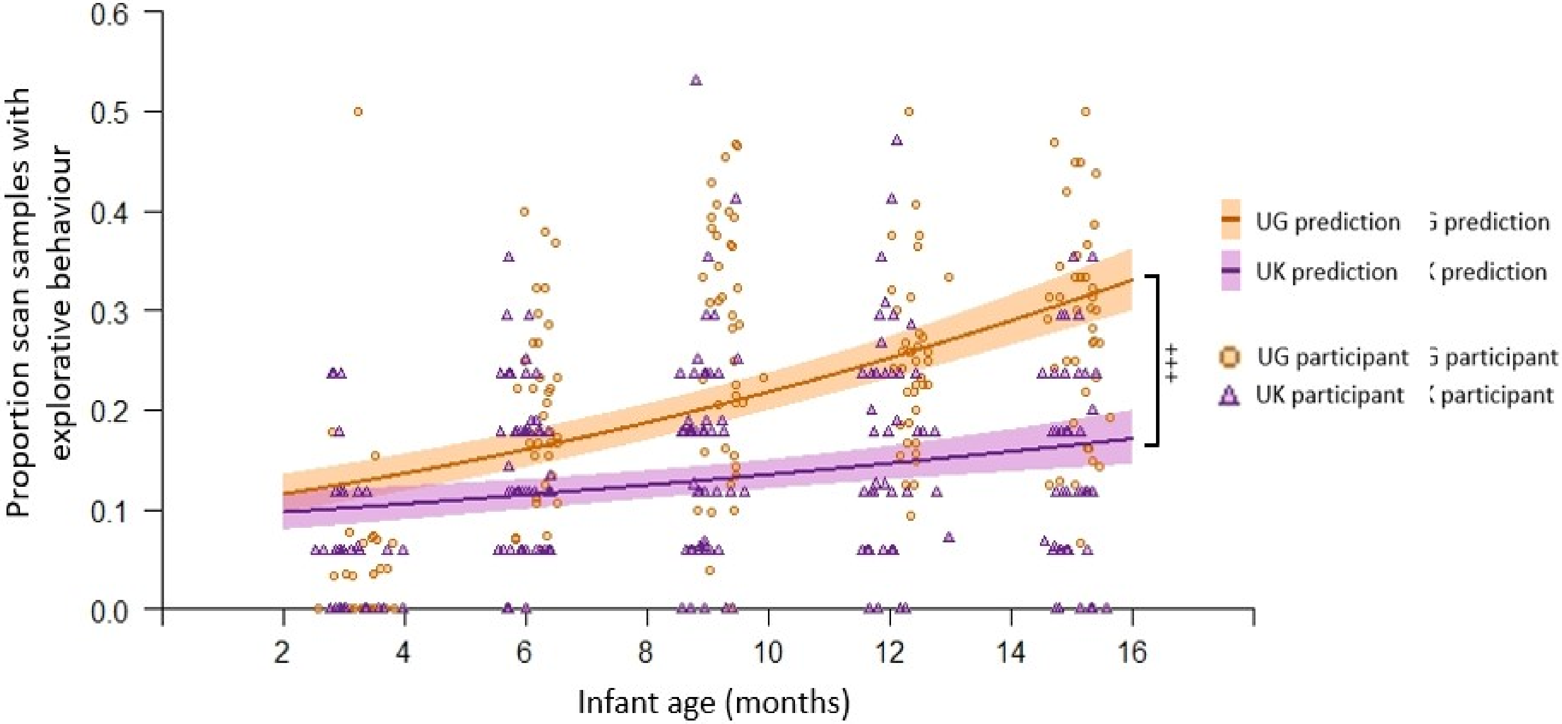


Figure 2.4: Graph showing actual proportion of scan samples where individual participants showed explorative behaviour (circles/triangles) and the expected probabilities of infants showing explorative behaviour given GLMM results (lines). *UG=Ugandan. Shading around the lines show 95% confidence intervals. The number of scan samples in the UK where infant activity was known was more standard across participants, hence why clusters are more commonly seen in the observed values for individual UK participants.+++ indicates significant interaction effect at p<.001 level.*

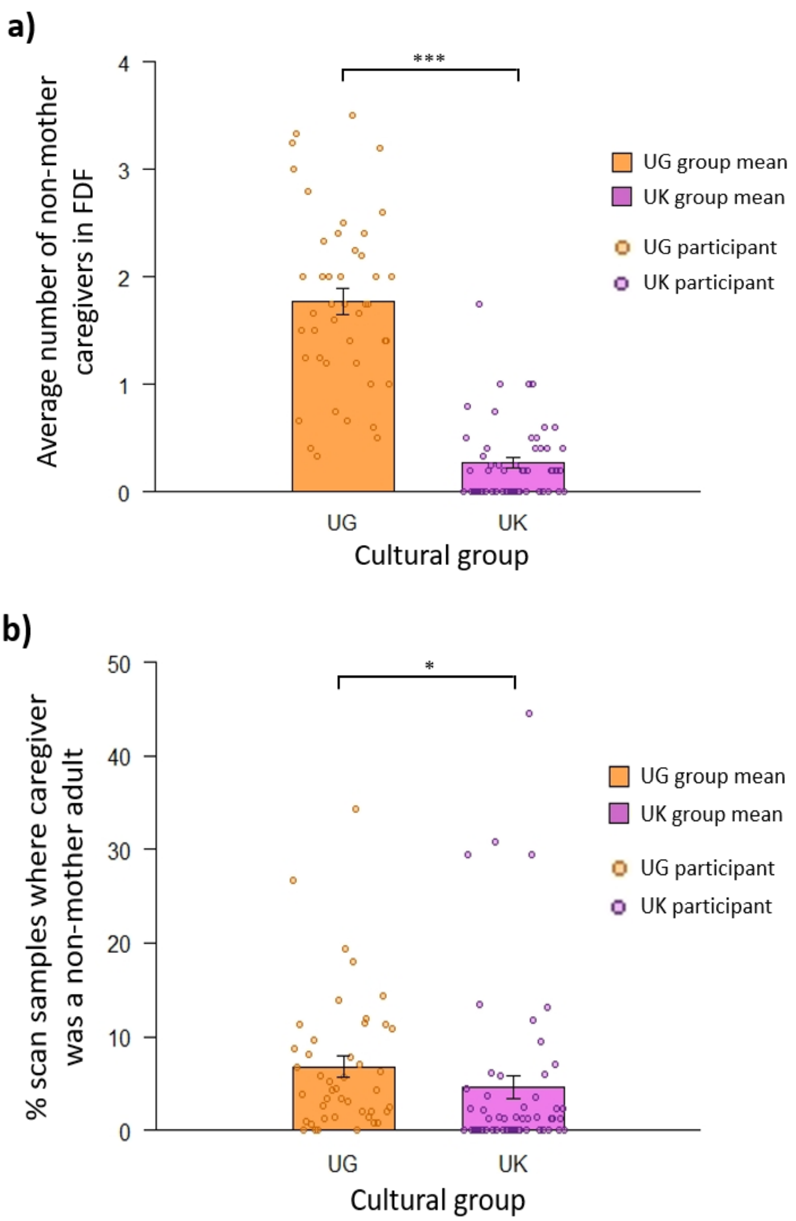


Figure 2.5: Graphs indicating significant effects found in caregiver GLMMS: a) Individual (dots) and group (bar) means of number of non-mother caregivers in a full-day follow with standard error bars; b) Individual (dots) and group means (bar) of proportion of scan samples where caregiver was a non-mother adult with standard error bars. *UG=Ugandan. FDF=full-day follow. * indicates significant group difference at <.05 level, *** indicates significant group difference at p<.001 level.*

Non-mother adult caregivers were recorded at least once for 91% Ugandan participants and at least once in 57% UK participants. Fathers were recorded as a caregiver at least once for 40% of Ugandan and 37% of UK infants. Fathers constituted 24% of non-mother adult caregivers in Uganda, and 40 % of non-mother caregivers in the UK. The GLMM showed that in Uganda, compared to in the UK, infants were significantly more likely to have a non-mother adult caregiver during their full-day follow (See *Figure 2.5b, Table 2.10*). There was no effect of age on how likely infants were to have a non-mother adult caregiver and no significant interaction between culture and age.

No UK infant participants were ever recorded as having a caregiver who was below 17-years-old, whereas this was common in Uganda (seen at least once in all Ugandan participants and in 79% of full-day follows) indicating an effect of culture. In Uganda, children aged 5 years or less were recorded as a caregiver at least once for 66% of participants, children aged 6-10 were recorded as a caregiver at least once for 84% of participants, and children aged 11-16 were recorded as a caregiver at least once for 64% of participants. The GLMM indicated that infant age had a significant effect on the likelihood that an infant was cared for by a child (*Table 2.10*), with *Figure 2.6* illustrating that as infants aged, Ugandan infants were more likely to have a caregiver who was a child.

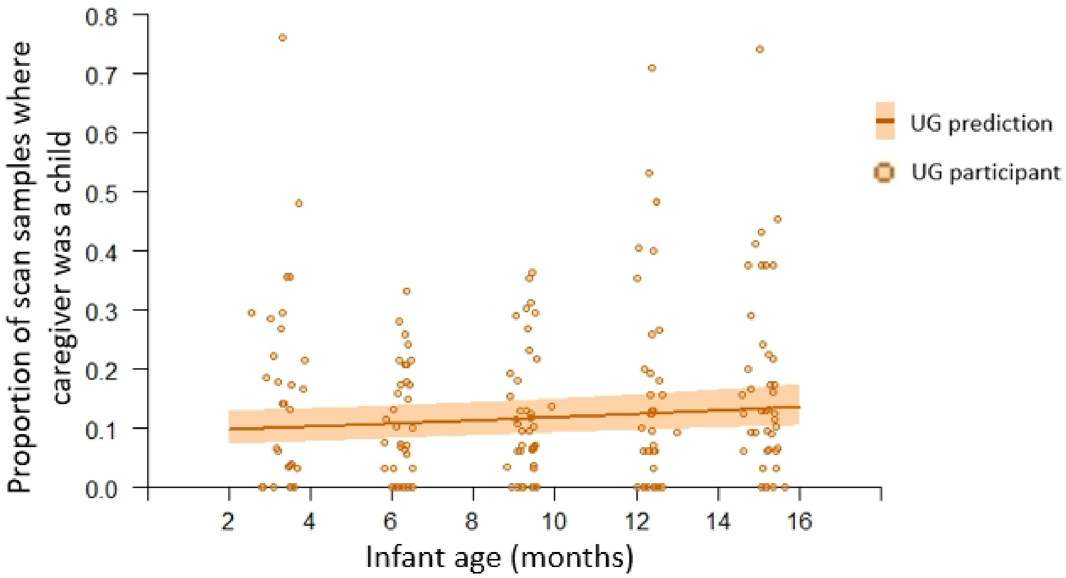


Figure 2.6: Actual proportion of scan samples where individual Ugandan participants had a child caregiver (dots) and the expected probabilities of infants having a child caregiver given GLMM results (lines) as they age. *Shading around the line shows 95% confidence intervals. UG=Ugandan.*

2.4.3.4 Infant social environment – People in proximity of infant

Next I considered the availability of non-mother adults and children in proximity to infants. There was no effect of culture or infant age, or an interaction between culture and age on the number of non-mothers in five metres of an infant, as indicated by the full model explaining no additional variance to a model containing only the random effect variable of participant (LRT: $\chi^2_{(3)}$=3.99, *p*=.262). As infants aged the likelihood of having a non-mother adult within five metres decreased (See *Figure 2.7, Table 2.11*). There was no effect of culture on the likelihood for there to be a non-mother adult in five metres of the infant and there was no significant interaction between culture and age.

Table 2.11: Model parameters for non-mother adults and children n proximity of infant GLMMs. *The reference level for Culture was UK. The reference level for individuals in proximity was 'not in five metres'. LRT = Likelihood Ratio Test.*** indicates significance at <.001 level. ~** indicates an unstable effect with significance at <.01 level (i.e. when model was run without overly influential participants this effect was no longer significant)*

	Model parameters					
Model (LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Adults in Proximity GLMM ($\chi^2_{(3)}$=22.2, *p<.001****)	(Intercept)	-.757	.138	-5.47	-1.01 to -.489	<.001***
	Culture	.243	.191	1.27	-.123 to .612	.203
	Infant age	-.033	.008	-4.11	-.048 to -.018	<.001***
	Culture *Infant Age	.000	.012	.036	-.022 to .023	.972
Children in Proximity GLMM (all participants) ($\chi^2_{(3)}$=20.8, *p<.001****)	(Intercept)	-.052	.213	-.244	-.459 to .355	.807
	Culture	-1.21	.299	-4.03	-1.78 to -.623	<.001***
	Infant age	-.002	.007	-.234	-.016 to .014	.815
	Culture *Infant Age	.036	.013	2.88	.012 to .060	.004~**

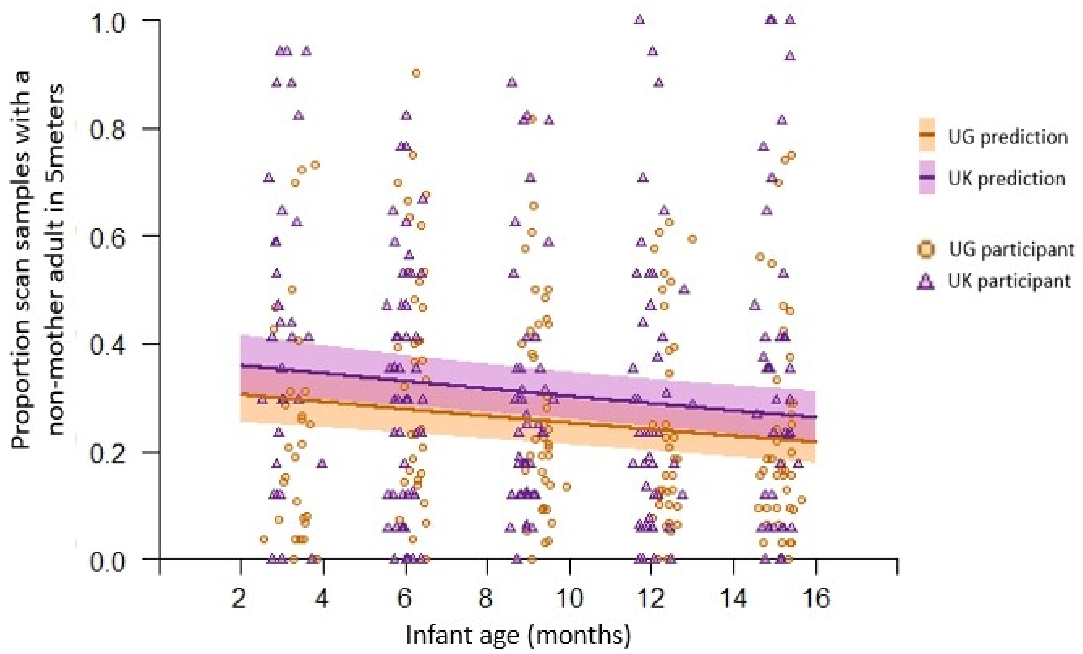


Figure 2.7: Proportion of scan samples where there was a non-mother adult in five metres of the infant (circles/triangles) and the expected probabilities of this given GLMM results (lines) as infants age*. Downward trend over time was significant at the p<.001 level.*

There was an interaction between culture and infant age with how likely it was for there to be a child within five metres of the infant (See *Figure 2.8*, *Table 2.11)*. Whilst Ugandan infants were more likely to have a child in proximity than UK infants across all ages, the likelihood of being in proximity to another child varied more with age in UK infants, than Ugandan infants, where proximity to another child was relatively stable as the infant aged (Posthoc models: UK age *Est=.036*, *SE*=.010, z=3.43, *p*<.001; UG age *Est=-.002*, *SE*=.007, *z*=-.327, *p*=.743). Nine Ugandan participants and nine UK participants were deemed overly influential in the GLMM indicating instability in the model. To further understand the effects of these participants, the GLMM was rerun without these participants. The model parameters were similar for the main effect of culture (model including all participants: culture *Est*=-1.21, *SE*=.299, *z*=-4.04, *p*<.001; model without overly influential participants: culture *Est*=-1.35, *SE*=.925, *z*=-4.57, *p*<.001), however the interaction effect of age and culture was no longer significant (model including all participants: interaction *Est*=.036, *SE*=.013, *z*=2.88, *p*=.004; model without overly influential participants: interaction *Est*=.015, *SE*=.014, z=1.07, *p*=.284): there was no longer an age effect on the chances of having child in proximity in the UK when these participants were excluded (*Figure 2.8*).

Further investigation of the values for these participants shows: UK participants which were overly influential were more likely to have more children in proximity to them than participants that were not overly influential, and overly influential participants in both cultures were more likely to have data collected at more time-points than those which were not. A conservative interpretation of these results would be that there is a main effect of culture on whether there is a child in proximity to infants, that there is no age effect in Ugandan participants, and that there is also no true age effect in UK participants.

2.4.3.5 Infant social experience – Infant social activities

There was an interaction between culture and infant age on how likely infants were to be engaged in social play (*Table 2.12*). As *Figure 2.9a* suggests*,* post-hoc models confirm that UK participants were more likely to show social play as they age, but there was no effect of age on Ugandan participants frequency of social play behaviour (Posthoc models: UK age *Est=.030*, *SE*=.011, *z*=2.64, *p*=.008; UG age *Est=-.012*, *SE*=.013, *z*=-.091, *p*=.361). Overall, infant social play was more common in the UK than in Uganda.

There was no culture difference between Ugandan and UK infants regarding how likely they were to be engaged in social activities (including play) and there was no significant interaction between culture and infant age. However, as infants age, the chances that they would be engaged in a social activity reduced (See *Figure 2.9b, Table 2.12*).

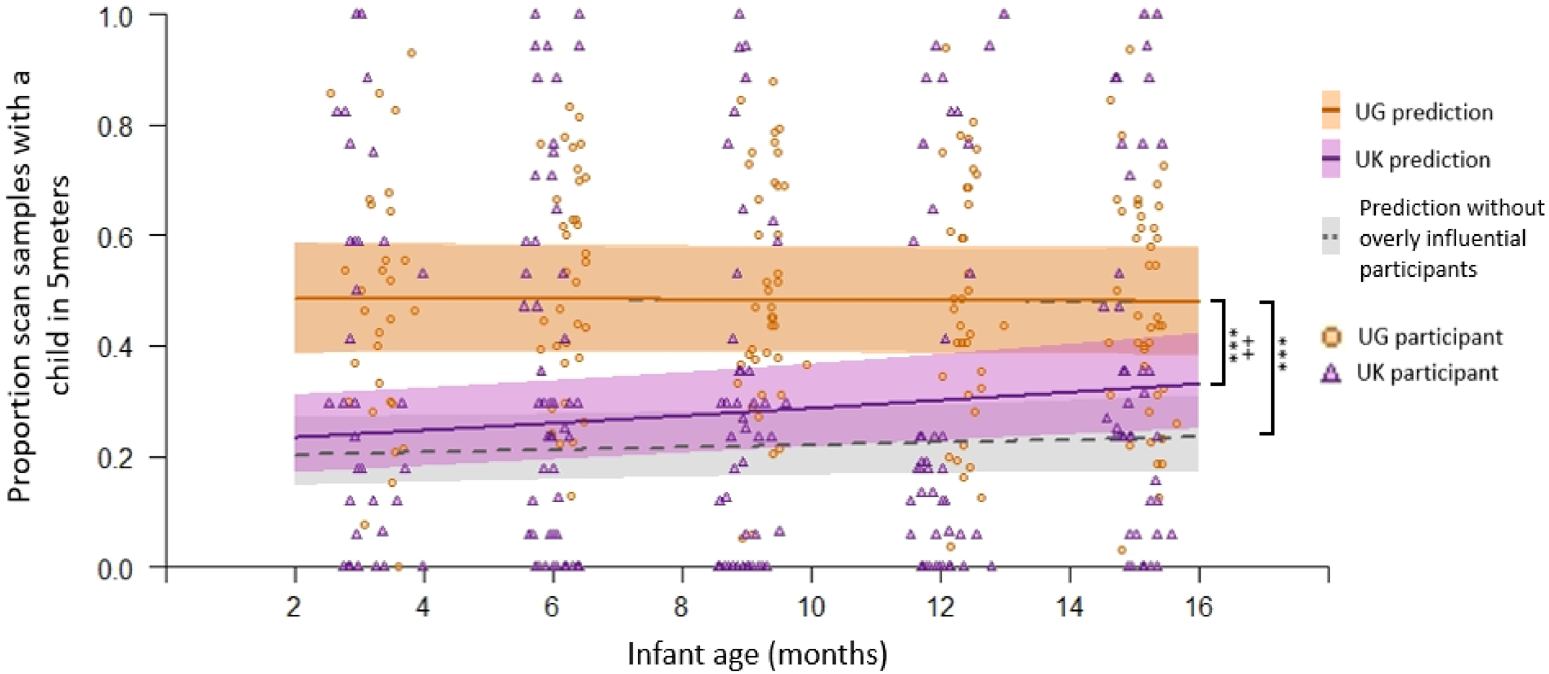


Figure 2.8: Proportion of scan samples where there was a child in 5m of the infant (circles/triangles) and the expected probabilities of this given GLMM results (lines) as infants age. *Predications from full model (orange and purple shading and solid lines) is laid over the prediction for the model excluding overly influential participants (grey shading and dotted line). Prediction with and without influential participants for Ugandan sample is almost identical. Age effects in UK participants disappear when overly influential participants are excluded. In both the full and reduced models there is a significant main effect of Culture. *** indicates significant main effect of Culture at p<.001 level. ++ indicates significant interaction at p<.01 level.*

Table 2.12: Model parameters for infant social activities GLMMs. *The reference level for Culture was UK. The reference level for Social Play was 'not engaged in play'. The reference level for Mother-Infant Contact during play was 'not in contact'. The reference level for mother activities for infant was 'not for infant'. The reference level for Social Activity was 'not engaged in a social activity'. LRT = Likelihood Ratio Test. * indicates significance at <.05 level, *** indicates significance at <.001 level.*

	Model parameters					
Model (LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Social Play GLMM ($\chi^2_{(3)}$=69.2, *p*<.001***)	(Intercept)	-2.59	.149	-17.4	-2.88 to -2.32	<.001***
	Culture	.464	.192	2.41	.082 to .845	.016*
	Infant age	-.011	.013	-.826	-.038 to .014	.409
	Culture *Infant Age	.041	.018	2.35	.008 to .077	.019*
Social Activities GLMM ($\chi^2_{(3)}$=39.7, *p*<.001***)	(Intercept)	-.947	.090	-10.5	-1.13 to -.773	<.001***
	Culture	.124	.128	.966	-.131 to .374	.334
	Infant age	-.034	.008	-4.20	-.049 to -.018	<.001***
	Culture *Infant Age	.014	.012	1.20	-.008 to .037	.231

2.4.3.6 Infant social experience – Infant interaction partners

Descriptively, mothers were the primary interaction partner for all infants except one UK participant (who had an equal number of interactions with their mother and grandmother; UK mean % social interactions with mother =79, *SD*=13.6; Ugandan mean % social interactions with mother =83, *SD*=10.4). Father-infant interactions were recorded at least once for 23% of Ugandan infants, and 48% of UK participants. Fathers made up 30% (*SD*=41.6) of non-mother social interactions in the UK, and 4% (*SD*=16.7) in Uganda.

A GLMM revealed a significant interaction between culture and age on the likelihood of infants having a novel interaction partner (see *Figure 2.10a; Table 2.13*). Post-hoc models confirm patterns from Figure 2.10a, that the likelihood of infants having a novel interaction partners did not change with age in Uganda (Posthoc model: Uganda age *Est*=-.002., *SE*=.017, *z*=-.119, *p*=.905), but that in the UK the chances of having a novel interaction partner increased with age (Posthoc model: UK age *Est*=.075, *SE*=.017, *z*=4.40, *p*<.001).

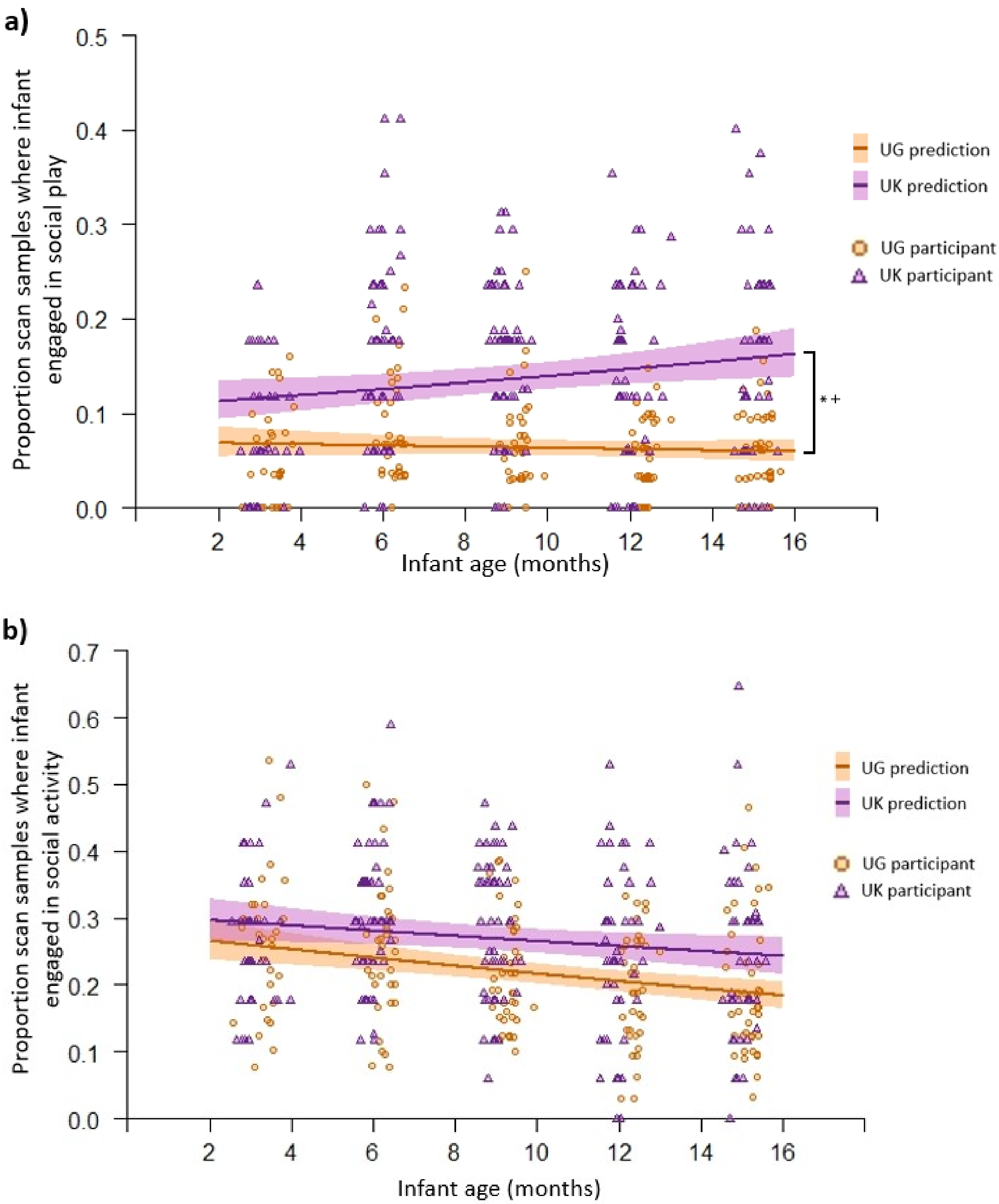


Figure 2.9: a) Proportion of scan samples where infant engaged in social play (circles/triangles) and the expected probabilities of this given GLMM results (lines) as they age. b) Proportion of scan samples where infant engaged in a social activity (circles/triangles) and the expected probabilities of this given GLMM results (lines) as they age. *UG=Ugandan. Shading around the lines show 95% confidence intervals. The number of scan samples in the UK where infant activity was known was more standard across participants, hence why clusters are more commonly seen in the observed values for individual UK participants. * indicates significant interaction effect at p<.05 level, + indicates significant interaction effect at p<.05 level.*

There was an interaction between culture and infant age on the probability that infants' social partners would include a non-mother adult (*Table 2.13)*. Post-hoc models confirm trends shown in *Figure 2.10b,* that the likelihood of infant interaction partners to be a non-mother adult did not change with age in Uganda (Posthoc model: Uganda age *Est*=-.065., *SE*=.036, *z*=-1.84, *p*=.065; bonferroni corrected alpha level = .025), however UK infants' interaction partners were significantly more likely to be an adult as they aged (UK age *Est=.064*, *SE*=.023, *z*=2.82, *p*=.005). Three Ugandan participants and three UK participants were deemed overly influential in the main model. These participants all had a high proportion of their social interactions with non-mother adults compared to less influential

Table 2.13: Model parameters for infant social partners GLMMs. *The reference level for Culture was UK. The reference level for non-mother adult and child social partners was 'no'. LRT = Likelihood Ratio Test. ** indicates significance at <.01 level, *** indicates significance at <.001 level. . ~** indicates an unstable effect with significance at <.01 level (i.e. when model was run without overly influential participants this effect was no longer significant)*

	Model parameters					
Model (LRT Chi-Square)	**Factor**	**Estimate**	***SE***	***Z***	***95% confidence interval***	***P***
Chance of novel social partners GLMM ($\chi^2_{(3)}$=31.3, *p*<.001***)	(Intercept)	-3.29	.197	-16.7	-3.68 to -2.96	<.001***
	Culture	-.260	.274	-.948	-.794 to .251	.343
	Infant age	-.001	.018	-.079	-.034 to .033	.937
	Culture *Infant Age	.075	.024	3.06	.028 to .124	.002**
Adult social partner GLMM ($\chi^2_{(3)}$=35.5, *p*<.001***)	(Intercept)	-2.69	.374	-7.20	-3.41 to -2.04	<.001***
	Culture	.175	.455	.384	-.625 to 1.11	.701
	Infant age	-.065	.035	-1.84	-.139 to .001	.065
	Culture *Infant Age	.129	.042	3.06	.052 to .211	.002~**
Child social partners GLMM ($\chi^2_{(3)}$=61.8, *p*<.001***)	(Intercept)	-2.52	.268	-9.40	-3.12 to -2.01	<.001***
	Culture	-1.36	.411	-3.31	-2.21 to -.557	<.001***
	Infant age	.062	.022	2.86	.019 to .109	.004**
	Culture *Infant Age	.119	.034	3.51	.055 to .188	<.001***

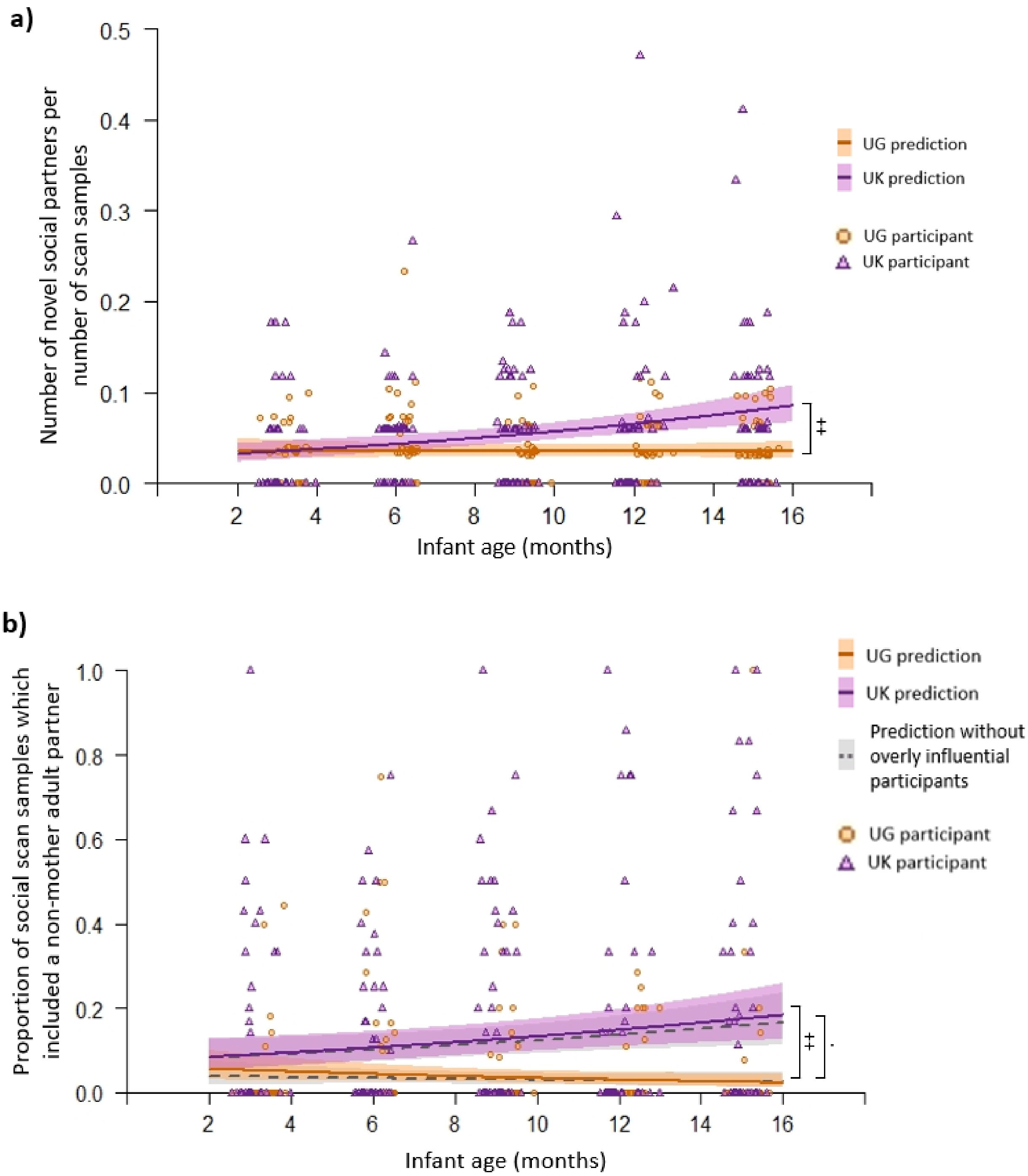


Figure 2.10: a) Ratio of number of social partners to number of scan samples (circles/triangles) and the expected probabilities of this given GLMM results (lines) as they age. b) Proportion of social activity scan samples where social partner included a non-mother adult social partner (circles/triangles) and the expected probabilities of this given GLMM results (lines) as they age. *UG=Ugandan. Shading around the lines show 95% confidence intervals. The number of scan samples in the UK where infant activity was known was more standard across participants, hence why clusters are more commonly seen in the observed values for individual UK participants. · indicates interaction effect at p<.1, ++ indicates significant interaction effect at p<.01 level, +++ indicates significant interaction effect at p<.001 level.*

cases, and all increased over time. When the model was re-run without these participants, the interaction was a non-significant trend (interaction *Est*=.088, *SE*=.046, *z*=1.90, *p*=.058): the trend of increased chances of having a non-mother adult partner with age in the UK was less strong when the overly influential participants were not included (*Figure 2.10b).* This indicates this effect is unstable, and should be interpreted with caution.

There was an interaction between culture and infant age on how likely infants' interaction partners were to include a child (*Table 2.13*). *Figure 2.11* illustrates that engaging in social activities with a child partner was more common in Uganda at young ages, but more common in the UK at older ages. Post-hoc models show that both UK and Ugandan infants were more likely to have a child interaction partner as they aged, however this effect was stronger in the UK sample, starting lower, and ending higher than in the Ugandan sample (Posthoc models: UK age *Est*=.191, *SE*= .027, *z*=6.94, *p*<.001; Uganda age *Est*=.057, *SE*= .021, *z*=2.67, *p*=.008).

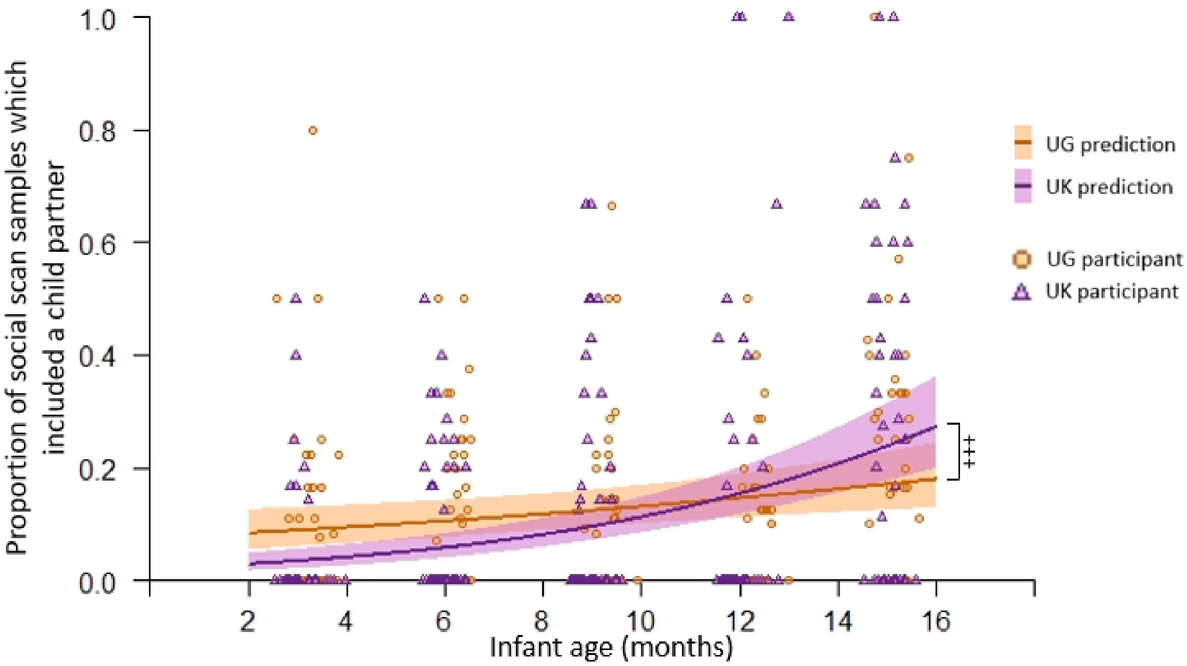


Figure 2.11: Proportion of social activity scan samples where social partner included a child social partner (circles/triangles) and the expected probabilities of this given GLMM results (lines) as they age. *UG=Ugandan. Shading around the lines show 95% confidence intervals. The number of scan samples in the UK where infant activity was known was more standard across participants, hence why clusters are more commonly seen in the observed values for individual UK participants. +++ indicates significant interaction effect at p<.001 level.*

2.4.3.7 Infant social experience – Infant-mother relations

As infants aged their mother was less likely to be conducting an activity that was exclusively for the infant (See *Figure 2.12, Table 2.14*). There was no effect of culture or any interaction between culture and infant age on the likelihood that mothers were conducting an activity exclusively for the infant.

Table 2.14: Model parameters for infant-mother relations GLMMs. *The reference level for Culture was UK. The reference level for mother-infant contact was 'not in contact'. The reference level for mother activities for infant was 'not for infant'. LRT = Likelihood Ratio Test. * indicates significance at <.05 level, *** indicates significance at <.001 level.*

	Model parameters					
Model (LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Mother Activities for Infant GLMM ($\chi^2_{(3)}$=38.1, *p*<.001***)	(Intercept)	-1.25	.107	-11.7	-1.46 to -1.06	<.001***
	Culture	.256	.151	1.70	-0.03 to .539	.089
	Infant age	-.034	.009	-3.76	-.051 to -.016	<.001***
	Culture *Infant Age	-.010	.013	-.738	-.037 to .017	.460
Proximity with Mother GLMM ($\chi^2_{(3)}$=117, *p*<.001***)	(Intercept)	.976	.130	7.49	.723 to 1.22	<.001***
	Culture	.926	.192	4.82	.561 to 1.31	<.001***
	Infant age	-.054	.007	-7.31	-.069 to -.039	<.001***
	Culture*Infant Age	.004	.013	.297	-.020 to .028	.767
Contact with Mother GLMM ($\chi^2_{(3)}$=291, *p*<.001***)	(Intercept)	.007	.114	.060	-.221 to .233	.952
	Culture	-.094	.162	-.577	-.409 to .220	.564
	Infant age	-.088	.008	-11.7	-.104 to -.073	<.001***
	Culture *Infant Age	-.027	.012	-2.19	-.051 to -.003	.029*
Contact with mother during play GLMM ($\chi^2_{(3)}$=55.9, *p*<.001***)	(Intercept)	2.75	.668	4.11	1.57 to 4.18	<.001***
	Culture	-1.75	.733	-2.39	-3.24 to -.492	.017*
	Infant age	-.116	.059	-1.98	-.232 to -.014	.047*
	Culture *Infant Age	-.008	.066	-.128	-.126 to .123	.898

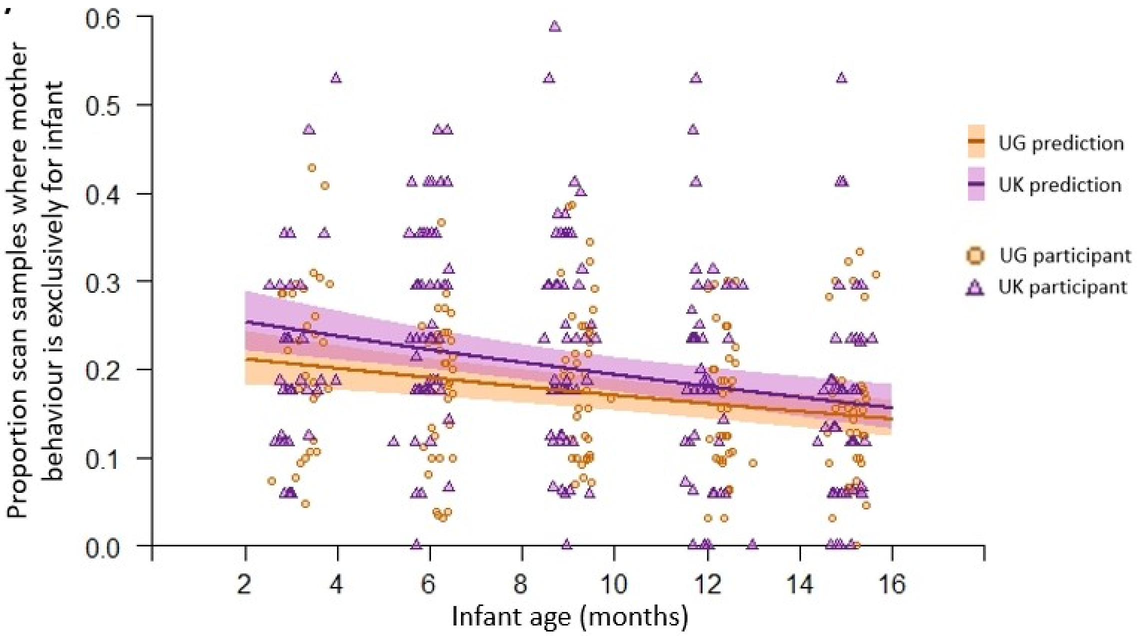
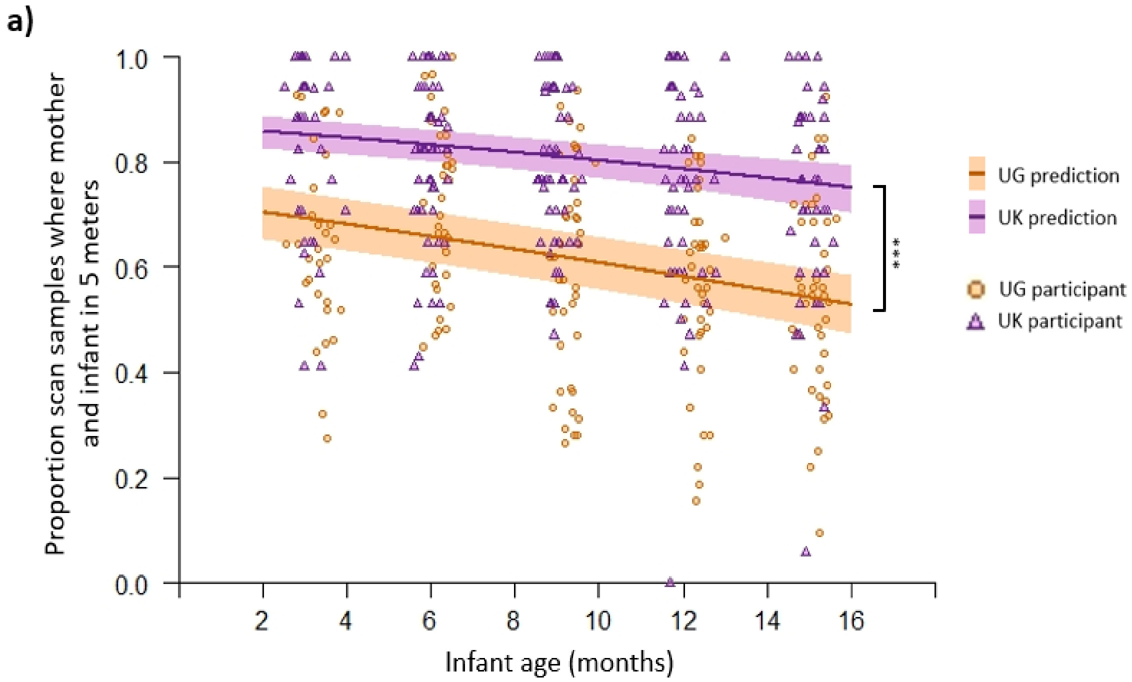


Figure 2.12: Proportion of scan samples where mother's behaviour was exclusively for their infant (circles/triangles) and the expected probabilities of this given GLMM results (lines) as they age. *UG=Ugandan. Shading around the lines show 95% confidence intervals. The number of scan samples in the UK where infant activity was known was more standard across participants, hence why clusters are more commonly seen in the observed values for individual UK participants. Graph shows significant downward trend at p<.001 level.*

Mothers and infants in the UK were more likely to be in five metres of one another than dyads in Uganda (See *Figure 2.13a*, *Table 2.14)*. Dyads in both cultures were less likely to be within five metres of one another as the infant aged. There was no interaction between culture and age of the infant. A follow-up model focusing only on scan samples where the mother was the carer can be found in appendix A2.13 shows that when mothers were the caregiver the same patterns persisted.

There was an interaction between the culture and age on how likely infants were to be in physical contact with their mothers (*Table 2.14*): *Figure 2.13b* illustrates that Ugandan and UK infants were less likely to be in contact with their mother as they got older, but this effect of age was slightly stronger in the UK than Uganda (Posthoc models: UG age *Est=-.088*, *SE*=.008, *z*=-11.7, *p*<.001; UK age *Est=-.116*, *SE*=.010, *z*=-11.9, *p*<.001). This means that at about 3-months infants from the two cultures were similarly likely to be in contact with their mother, but by 15-months, Ugandan infants were more likely to be in body contact with their mothers. A follow-up model focusing only on scan samples where the mother was the caregiver can be found in appendix A2.13 shows that when mothers were the caregiver, Ugandan dyads were in more contact with one another across all ages as compared to UK dyads.



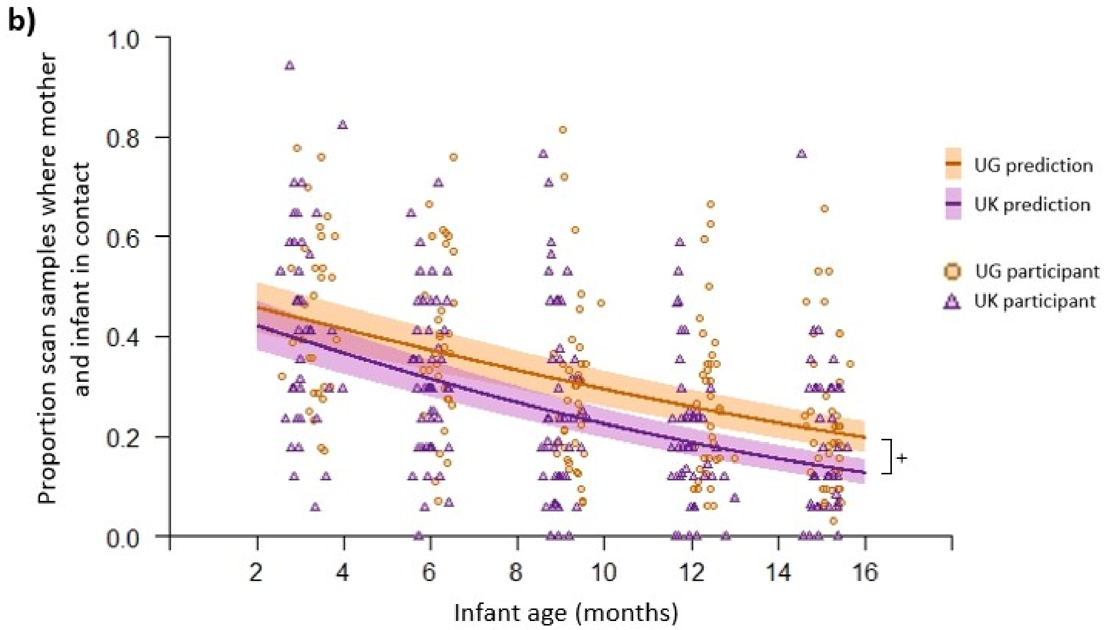


Figure 2.13: a) Proportion of scan samples where mother and infant in five metres proximity (circles/triangles) and the expected probabilities of this given GLMM results (lines) as they age. b) Proportion of scan samples where dyad were in contact (circles/triangles) and the expected probabilities of this given GLMM results (lines) as they age*. UG=Ugandan. Shading around the lines show 95% confidence intervals. *** indicates significant effect of culture at p<.001 level, + indicates significant age-culture interaction effect at p<.05 level.*

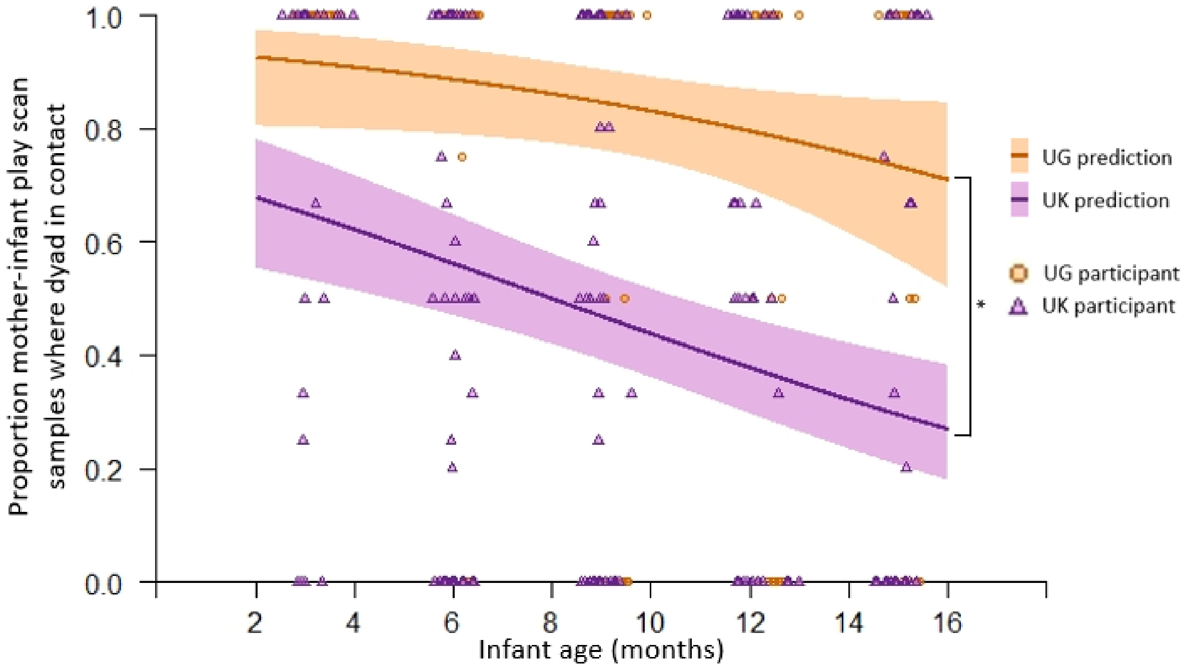


Figure 2.14: Proportion of mother-infant play scan samples where dyad were in contact (circles/triangles) and the expected probabilities of this given GLMM results (lines) as they age. *UG=Ugandan. Shading around the lines show 95% confidence intervals. The number of scan samples in the UK where infant activity was known was more standard across participants, hence why clusters are more commonly seen in the observed values for individual UK participants. * indicates significant effect of culture at p<.05 level.*

Ugandan infants were more likely to be in contact with their mothers during play than UK infants (See *Figure 2.14, Table 2.14*). Both Ugandan and UK infants were less likely to be in contact with their mother during play as they aged. There was no interaction between culture and age on the likelihood of dyads being in contact during play.

2.4.3.8 Infant social environment – Infant sleeping arrangements

Ugandan infants were more likely to share a bed and share a bedroom with somebody else at night than UK infants: no Ugandan infants ever slept in a room alone at night, and only one Ugandan infant (at two time-points) slept in a bed alone at night, however, sleeping in their own room and/or bed was common for UK infants. Due to limited variance in the Ugandan sample, culture effects were not tested inferentially for whether infants slept alone at night, and only tested for age affects in the UK sample. In the UK, infants were less likely to share a bedroom at night as they aged (*See Figure 2.15; Table 2.15*).

***Table 2.15: Model parameters for UK infant sleeping arrangement GLMMs**. The reference level for shared bedroom was 'slept in own room'. LRT = Likelihood Ratio Test. *** indicates significance at <.001 level.*

	Model parameters					
Model (LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Shared Bedroom GLMM ($\chi^2_{(1)}$=59.4, *p=<.001****)	(Intercept)	4.41	1.25	3.52	2.28 to 7.44	<.001***
	Infant age	-.565	.123	-4.60	-.869 to -.364	<.001***

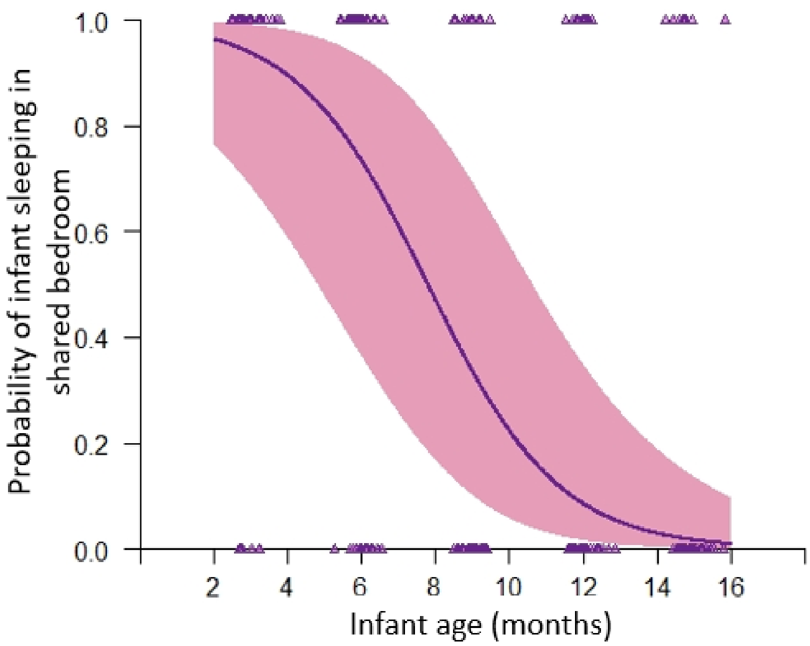


Figure 2.15: **Graphs showing predicted probability of *UK* infants sharing a bedroom across age. Triangles indicate whether individuals did (1) or didn't (0) share a room.** Shaded area indicates 95% confidence interval**.**

2.4.4 Research Question 4: Are parental attitudes associated with observed or reported parenting behaviour?

2.4.4.1 Mother-Infant Proximity 1

A Kruskal-Wallis test indicated that UK and Ugandan mothers who showed high agreement with the statement "*infants should be in close proximity to their mothers*" spent a lower proportion of their time within five metres of their infant (*n*=56; median = 0.60; IQR = 0.50-0.80) than mothers who showed low agreement to the statement (*n*=36; median = 0.76; IQR =0.60-0.87; $H_{(1)}$ =5.00, *p*=.025).

2.4.4.2 Mother-Infant Proximity 2

A Kruskal-Wallis test indicated that Ugandan mothers who showed high agreement to the statement *"infants should develop independence in the first 3 years of life"* spent a similar proportion of time within five metres of their infant (*n*=30; median=0.60; IQR=0.50-0.64) to mothers who showed low agreement to the statement (*n*=11; median=0.50; IQR=0.47-0.67;UG: $H_{(1)}$ =.157, *p*=.692). The association between UK mothers' attitudes towards this question and their proximity with their infant was not examined since only 2/51 mothers showed low agreement with the statement.

2.4.4.3 Sleep location

For UK mothers, a Fisher's exact test revealed an association between agreement with the statement that "*it is good for an infant to sleep alone*", and having an infant who slept in a room on their own (*p*<.001; 23/27 infants of high agreement mothers slept alone, but 13/22 infants of low agreement mothers slept alone). All Ugandan infants shared a room at night, and 32/38 Ugandan mothers had low agreement that it was good for an infant to sleep alone indicating a good correspondence between attitude and behaviour for the Ugandan participants too.

2.4.4.4 Mother-Infant Time

A Kruskal-Wallis test indicated that there was no difference in the proportion of time UK mothers spent caring for or socialising exclusively with her infant between mothers who showed high or low agreement with the view that mothers should devote a lot of time exclusively to the baby ($H_{(1)}$ =.992, *p*=.319).

2.5 Discussion

This chapter sought to explore if and how early life environment varies between UK and Ugandan infants up to 15-months old, and how that linked to autonomous and relational maternal attitudes. I aimed to examine (1) whether the UK and Ugandan participants formed two distinct groups when looking at mothers' attitudes and infant early life experience, (2) whether Ugandan mothers had more relational attitudes, and whether UK mothers had more autonomous attitudes, (3) how cultural group and infant age impacted infants' early life environment, and (4) whether specific parental attitudes matched with observed or reported parenting behaviour. I will go through these questions in turn to outline main findings and discuss the results in context.

For my first research question I aimed to establish if the UK and Ugandan participants formed distinct groups based on mothering attitudes and infant early life environment. I found that there was clear separation between UK and Ugandan participants when considering the measures examined together. There was no evidence of further subgroups within the Ugandan sample, suggesting at least on these measures that the Ugandan ethnolinguistic groups pattern together, thus indicating it was valid to consider the Ugandan participants as one cultural group for the purposes of this study.

2.5.1 Maternal attitudes

Given the clear groupings between Ugandan and UK participants, I further examined the data to understand specifically where differences emerged within parental attitudes, and infant environment and experience. Although there was considerable individual variation in attitudes regarding parenting practices and socialisation goals, overall there was a significant difference in attitudes between WEIRD UK and rural Ugandan mothers that were in line with previous findings: the group of Ugandan mothers in the present study held more relational and less autonomous views of both parenting practices and socialisation goals compared to the group of UK mothers. It is important to acknowledge that our measures may have underestimated the difference between the groups, as two questions regarding autonomous values and the concepts of 'self-esteem' and 'sense of self' could not be successfully translated in Uganda, so were not included in the questionnaire. Given the strong relationship between culture and language (Gumperz & Levinson, 1996; Imai, Kanero, & Masuda, 2016), it is possible that the difficulties in translating these concepts into single statements reflects that these autonomous concepts are not as relevant in this society (cf., Wierzbicka, 1996). If we had been able to include them, it is possible we would see even greater differentiation between groups in regards to their socialisation attitudes. Further research could explore this by using different methods, for example via interviews.

2.5.2 Infant experience

Parental attitudes are often assumed to influence parenting behaviour and interactions with infants, thus shaping the early life experiences of infants. However, few previous studies have taken an integrative approach to measure multiple aspects of infant early life environment as well as experiences spanning different stages of early development. In this study, I was able to rigorously characterise multiple aspects of early life at multiple time points from 3- to 15-months in families sampled from Uganda and the UK, and crucially test behavioural predictions of the relational-autonomous parenting models. Whereas some predictions were clearly supported by our behavioural data (e.g. more distributed infant care in Uganda), other predictions were only partially supported by some behavioural measures (e.g. mother-infant proximity), and other predictions were not supported at all (e.g. number of infant social interaction partners). I will now cover these results in more detail.

Some of the most clearly attested differences, consistent with the predictions of autonomous-relational parenting models, were found in the realm of physical development. Reaching physical milestones gives infants new opportunities to experience the world. At least one UK and one Ugandan infant were recorded as being able to attain each physical milestone at the youngest age that it was recorded (sitting at 3-months, crawling at 6-months, and walking at 9-months). However, at a group level as expected, more Ugandan infants reached physical milestones at younger ages than in the UK. As physical stimulation of infants is emphasised in more relational models of parenting (Keller, 2007), it is likely that the earlier attainment of physical milestones by Ugandan infants is driven by higher levels of physical stimulation by Ugandan mothers compared to UK mothers. Future studies should seek to systematically document how physical stimulation in play, diaper use and lifting, holding and carrying postures differ between groups to better understand what drives earlier achievement of physical milestones.

Given that more Ugandan infants reached physical milestones at an earlier age, they would have more opportunities for learning about their physical and social environment from a younger age (for example, more bimanual exploration of objects, more movement within their environment to places or people of interest, and a more stable posture for social looking: Adolph & Franchak, 2017; Adolph & Hoch, 2019; Franchak, Kretch, & Adolph, 2018; Iverson, 2010; Karasik, Tamis-lemonda, & Adolph, 2011; Kretch, Franchak, & Adolph, 2014; Mohring & Frick, 2013; Schwarzer, Freitag, & Schum, 2013; Slone, Moore, & Johnson, 2018; Soska, Adolph, & Johnson, 2010). Indeed as infants in both groups aged, non-social environment experience (as measured by play alone and exploration), increased as expected. Though this effect was stronger in the Ugandan sample – possibly because it was more common for these infants to reach physical milestones at an earlier age. To further understand this, one could explore whether individuals reaching physical milestones showed more exploration as they aged, or to examine if once infants in both groups can sit, crawl, and walk whether the levels of exploration even out across cultures. Since parental encouragement for infant exploration can be linked to how much infants explore (Bornstein et al., 2017), the differences in infants exploration, could be also feature of different levels of encouragement to explore at different ages in the different societies. The current study was limited in that it only looked at one measure of non-social environment experience, however different kinds of non-social environment experience may impact infant development in different ways. For example, playing alone with objects could be more linked to understanding object properties (Mohring & Frick, 2013; Schwarzer et al., 2013), whereas movement around exploring the environment could be linked to cognitive understanding of space (Clearfield, 2004). Additionally, cultures vary in the diversity and quantity of objects available in an infant's environment (Bornstein et al., 2017), looking at environmental outfitting would allow further understanding of infant non-social environment experience across age and cultures.

As well as physical milestones potentially affecting infants' social experience (Adolph & Franchak, 2017; Franchak et al., 2018; Karasik et al., 2011), infant accessibility to care or social interactions can also impact social development. Thus, infant caregivers, individuals in proximity to the infant, and whether infants sleep alone were examined as a measure of potential comfort, care, or social interactions. Mothers were the primary caregivers in both the UK and Uganda, however, in line with relational parenting valuing the social context of infants more, as expected Ugandan infants had more non-mother caregivers. When non-mother caregivers were divided into adults and children, Ugandan infants were more likely to have a non-mother adult caregiver than infants in the UK. A similar percentage of Ugandan and UK participants were cared for at least once by their fathers, however in the UK, fathers constituted a higher proportion of non-mother caregivers than in Uganda. Arguably the most striking difference between caregivers in the two groups was that child caregivers were common in Uganda, but were never recorded in the UK. Children under five years old were recorded as caregivers at least once in two-thirds of Ugandan participants, and child caregivers aged between six and sixteen were also common. The higher chances of having non-mother adult and child caregivers in Uganda may be due to the collectivistic nature of relational attitudes, and/or the fact that it is easier to share responsibility among members of larger households seen in Uganda. However there may also be other drivers for the difference in child caregivers which are not a product of parenting attitudes, but due to other cross cultural differences. For example, given the different living environments in the Ugandan and UK samples (Ugandans spending more time in outdoor home areas, and UK participants living in enclosed houses), it's possible that if something were to happen to a young infant (e.g. they were hurt) while a young child was their caregiver and extreme crying was heard, there would be someone more mature (e.g. another household member or neighbour) who would be able to step in and attend to the infant. Whereas in the enclosed housing of the UK this may not be possible, thus care is taken to make sure there is always an adult as the caregiver. As predicted, as Ugandan infants aged, they were more likely to have a child caregiver. This may be due to infant development of independence, (for example, being more able to feed themselves) so the responsibilities placed on a child caregiver may be less as infants age. The relative influence of maternal attitudes, practical considerations (such as availability of other household members), and cultural norms in relation to non-maternal caregivers could be addressed in future with semi-structured interviews on the topic.

As well as there being cultural differences between caregivers across groups, infants' opportunities for who to interact with, or who to observe, varied depending on cultural group and age. Mothers in the UK were more often in close proximity to their infants than in Uganda. This was in the opposite direction to the hypothesis that the UK mothers may spend less time in proximity due to the higher importance given to independence in autonomous parenting; and that Ugandan mothers may spend more time in proximity due to the higher importance given to responding immediately to infant cues in relational parenting. The difference between expected patterns that Ugandan mothers are less often in proximity to their infants than UK mothers, could be another feature of their housing environment. Given the compound structure of the Ugandan homes, mothers may be able to observe their infants from a further distance (i.e. outside five metres), compared to UK mothers, who would have to be in the same room (generally less than five metres) to observe their infants. As predicted, as infants aged, mothers and infants in both groups spent less time in close proximity.

Contrary to expectations, that Ugandan infants who are typically from larger households would have more individuals in proximity than UK infants, there was no significant difference between cultures in how many non-mother individuals were in proximity of infants, nor did this change with age. Our study only looked at proximity within five metres, however a better picture of infant social environment may be gleaned by also investigating proximity of people within a larger range (especially given the aforementioned differences in home layouts). Since the UK participants live in enclosed homes, but the Ugandan participants live in a compound, there may be more opportunities for individuals in a greater circumference to interact with the infant in the Ugandan sample. This may particularly influence interaction opportunities as infants become mobile and can move throughout their home spaces more freely. When looking at the identity of people in proximity, there was no difference across groups of how likely it was for there to be a non-mother *adult* in close proximity, however this decreased with age. Overall Ugandan infants were more likely to be in proximity of a child than UK infants. There was no effect of age on how likely Ugandan infants were to be in close proximity of a child, however, as UK infants aged they may be more likely to be in close proximity of a child.

Infant sleeping arrangements can affect how infants rely on others for comfort, or how they learn to comfort themselves during the night. In line with predictions, UK infants were more likely to sleep alone as they aged. The chance that infants would sleep alone in Uganda did not increase over time. Additionally, in line with predictions based on autonomous and relational parenting, Ugandan infants were less likely to sleep alone than UK infants. It is important to note here that the cross cultural difference in sleep location may not be driven by a different perception of infant needs, but a difference in resources available to mothers – electricity was available to all participants in the UK, and baby monitoring equipment may be more accessible, so parents may feel more comfortable with infants sleeping in separate rooms because they can be alerted remotely if the infant needs care during the night – which may influence the parenting attitudes towards whether it is appropriate to have an infant sleep alone.

The amount of physical contact with mothers can be a key characteristic of the mother-infant relationship and infant independence, and is theoretically stressed differently in autonomous and relational parenting. As predicted, infants in both cultures were less likely to be in contact with their mother as they aged. Previous literature looking at autonomous and relational parenting suggests stronger importance given to body contact in relational compared to autonomous parenting, however in the current study, Ugandan mother-infant dyads were only more likely to be in contact than UK mothers contingent on infant age. At about 3-months infants in both cultures were in contact with mothers a similar amount, however by the time infants reached about 15-months Ugandan infants were in more contact with mothers than UK participants. However, as predicted, when only considering mother-infant play contexts, Ugandan infants were more likely to be in contact with their mothers than UK infants across ages. Previous literature is limited to analysing mother-infant proximity during mother-infant play, at a single age-point (Keller et al., 2009, 2005, 2006; Keller, Lohaus, et al., 2004; Keller, Yovsi, et al., 2004), however while the results from the current study corroborate these results during play, the age effect when looking at all contexts highlight that a greater stress to physical contact in relational views may not be generalised to all situations: the importance of body contact in relational parenting may be limited to particular contexts depending on infant age. Practical explanations for why a higher level of body contact was not found universally across age points in the Ugandan infants may be because caring responsibilities are more shared in Uganda than in the UK. I thus investigated if the similarity in amount of time in contact at some ages, persisted when considering only time that mothers are the caregiver, and this idea was supported, as when mothers were caregivers across all ages, mothers were in more contact with infants in Uganda compared to the Uk.

Another key characteristic of the mother-infant relationship is how much time mothers spend exclusively interacting with, or caring for their infants. I predicted that if Ugandan mothers shared their caring responsibilities more, that they may show less infant directed behaviour, however this was not found: there was no difference in how likely mothers were to be conducting an activity exclusively for their infant between the UK and Ugandan participants. This could be due to the nature of how responsibility is shared in Uganda. For example, it could be that when the infants need more active care (e.g. feeding or bathing), Ugandan mothers are the caregiver, but in periods when this is not necessary, somebody else watches over the infant. This could be further examined by looking to see if mother and infant activity are related to whether mother is the active caregiver or not. As infants aged however, I did find support that mothers spent less time engaged in activities exclusively with their infant.

Play is one of the most interactive types of social interaction that infants engage in, and gives infants opportunities to show more advanced behaviours through scaffolding (Bigelow et al., 2004). Infants in the UK were found to spend more time in social play activities as they aged, but there was no effect of age in Ugandan infants. Overall infants in the UK were reported engaging in more social play activities than infants in Uganda. This means that UK infants may have more opportunities for showing more advanced behaviours through scaffolding by interaction partners, than Ugandan infants. Given that infants in Uganda are more often in contact with their mothers during play than UK infants, this also indicates that there is a difference in play style between the two cultures. Differences in play style and parental scaffolding behaviour could be further examined by looking at the types of play, such as object and non-object play, and the influence this may have for object understanding. It is also possible that the higher rate of exploration in Ugandan infants described before was driven by more solo-object play, and that earlier development of sitting, allowing more bimanual exploration and learning physical properties of object in Ugandan infants is balanced out by the higher opportunity for more scaffolded behaviour in UK infants – it could be that infants in the two cultures reach the same end goal through different means. As expected, as infants aged they were also less likely to be in contact with their mothers during play. This may be due to infants becoming more physically independent as they are able to support their posture alone more, and become better at manipulating objects alone without needing the help of their mothers.

Although infants in the UK were reported to engage in more play activities than in Uganda, there was no cultural difference in how likely infants were to show overall social activities (including play). It appears that when considering all social activities, the difference between frequencies of play in the two groups was evened out by Ugandan infants being more likely to be involved in other types of non-play social activity (such as being cared for e.g. being bathed or being breastfed). To understand how the difference in non-play social activity may affect development it would be interesting to examine the specific behaviours which even out the difference between chances of engaging in social play versus engaging in any kind of social activity across cultures. As infants in both groups aged, they were less likely to engage in social activities, potentially a feature of infants needing less care as they age, and/or mothers spending less time exclusively for the infant as they age.

The dynamics of infant actual social experience can be affected by who they are interacting with. Mothers were infants' primary interaction partner in both cultures, and fathers appeared to play less of a role in Uganda than in the UK. Although Ugandan infants were more likely to have more caregivers within a day, there was no overall difference between cultures regarding how many novel interaction partners they interacted with in a day. As expected, in the UK the number of novel social partners increased with age but this was not the case in Uganda, where there was no effect of age. Although there were more non-mother adult caregivers in Uganda, there was also no overall difference between groups on how likely their interaction partners were to be a non-mother adult. This supports the earlier idea that it is possible that non-mother caregivers in the Ugandan sample are more likely to be caregivers in times when the infants need less active care. In the UK the chances of having a non-mother adult interaction partner seemed to increase with age, but there was no effect of age in Uganda. Although infants in Uganda were more likely to have a child caregiver and were more likely to have a child in proximity to them, UK infants were more likely to have a child interaction partner at later ages. Both Ugandan and UK infants were more likely to have a child partner as they aged, but this effect was stronger in the UK. This is possibly a feature of cultural differences in how infants are socialised in the two groups, for example, it may be that socialisation is more actively arranged as UK infants get older, however in Uganda there is a stable number of other children around from birth and thus there is not as steep an increase in infant-child interactions as they age.

Although this study did not explicitly explore it, opportunity for social interactions does not seem to be linked with actual social partners. It seems that the number of caregivers a child has in a day, and how many people are in proximity of infants during a day, is not related to the amount of social partners infants have. In both cultures, as infants age they are not more likely to have more caregivers in a day, nor are they more likely to have more individuals in close proximity to them, however they are more likely to have more social partners as they age. The same pattern exists for non-mother adult social partners. This may be because either people are more interested in engaging with an infant as they age, or that infants are more likely to initiate interactions as they age. Further investigation conducting these comparisons on an individual rather than a group level would confirm this.

2.5.3 Links between maternal attitudes and specific infant experience

I tested whether mothers' answers to some specific questions matched up with recorded infant early life experience, expecting that mothers' attitudes would be linked to infant experience. Contrary to predictions, there did not appear to be a link between mothers' attitude on whether infants should be in close proximity to their infants and the amount of time mothers and infants were recorded in close proximity. Similarly there did not appear to be a link between mothers' opinions about infants developing independence at a young age and how much time the mothers spent in close proximity to infants. It is possible this disconnect could come from individuals having different definitions for what 'close proximity' means, as discussed above. Furthermore, the disconnect between attitudes regarding infants developing independence may be explained by opinions not impacting behaviour until a later age since this specific question specified within the first three years of life, however here I only examined proximity data from the 12-month time-point. The present study is also limited by the fact that I only test one way of fostering independence, physical distance, however a wider diversity of measures of independence (for example, doing tasks by themselves) in future research should be considered to fully rule out an association here between attitudes regarding opinions and behaviours of infant independence.

Mothers' attitudes regarding infant sleep location were associated with the reported infant sleeping location. Although parenting attitudes were linked to infants sleeping location, it was not consistent across all participants – in some dyads the mothers behaviour was not reflected in infant sleeping location, and these violations of opinions compared to actuality (particularly in the low SES Ugandan sample) may be explained by the fact that parents may be restricted in being able to provide alternative sleeping spaces

In the final comparison of maternal attitudes to reported behaviour, contrary to predictions, UK mothers' opinions about how important it was to spend lots of time exclusively for their infants did not appear related to the amount of time they were recorded spending time exclusively for their infants. It is possible that other parts of life, such as caring for siblings, or dealing with other commitments such as work, limits the amount of one-on-one time mothers would ideally spend with their infant. Alternatively, the mothers may have different interpretations of how long spending "*a lot* of time exclusively for their infants" is.

2.5.4 Summary and conclusions

In summary I found that infant early life environment varies in many ways across the two cultural groups examined. Many group level attitudes and behaviours fell in line with predictions that the Ugandan sample would be more relational (e.g. sharing parenting responsibilities) and the UK sample would be more autonomous. However there were also commonalities between the cultures, as not all aspects of early environment varied between groups (e.g. number of people in close proximity), as well as some differences being present in the opposite direction to predictions (e.g. mother-infant proximity). In each variable tested there was some overlap between individuals from both cultures. This indicates that parenting style is multifaceted and that individual aspects of parenting do not always fall along the same lines of overall parenting attitudes. Additionally this research shows that people should not assume that all individuals in WEIRD societies have autonomous views and behaviour, or that all individuals in non-WEIRD societies have more relational views and behaviour – and it is thus important to directly measure attitudes and specific behaviours before making assumptions. It is also important to note that although there was overlap in all specific variables when comparing dyads from the two groups, when all variables were considered together there was clear separation between individuals in the UK and Uganda, thus overall the combination of factors shows all infants in Uganda are having a different experience of early life compared to all individuals in the UK.

Where we had access to specific attitude questions with equivalent behavioural recordings, I looked to see if there was an association. When looking at these specific attitudes and whether they were associated with behaviour we found that only mothers opinions on infant sleep location were associated with where infants sleep, but did not find an association for the other comparisons. Again this highlights the importance of using mixed methods, and not assuming opinions reflect infant actual early life environment. However I have also discussed alternative reasons for not finding associations between the attitude and behaviours. Further research could be done to see how individuals overall attitudes match up with other specific behaviours, which may help us understand some drivers of cultural actions. For example, investigating whether individual mothers who reported highly relational attitudes show more distribution of care, or was this more related to household composition – and whether mothers who have more relational attitudes socialise their infants with more people, even though group differences were not found. Another example of understanding drivers of cultural similarities and differences would be to look at whether practices that can vary cross culturally, such as breastfeeding (Cassidy & El Tom, 2015; Riordan, 2005), may impact the amount of mother-infant interactions. This could, for example, explain why mothers in Uganda have the same amount of infant directed behaviour despite not being the caregiver as often as UK mothers – and/or do we see that time split between mothers and non-mothers as caregivers reflects different periods of active versus less active care for the infant.

I also found that infant early environment changes in many ways as infants develop, for example, infants are in less proximity with their mothers as they age, and their social partners are more likely to include a child as they age. This highlights and confirms the dynamic nature of infant development and experience. As infants age their experience of the world changes, and the way mothers parent (e.g. letting or encouraging their infant become more independent), and others around them act change depending on infant age. For example, infants had more interactions with other children as they aged, however in Uganda there was no effect of age on the number of children in proximity, thus there appears to be a change in dynamic as Ugandan infants age – this could be due to children showing more interest in the developing infant, or infants initiating more social interactions with other children. Some age effects on early life environment were consistent across our two groups (e.g. less adults in proximity as infants age), however some age effects varied with culture (e.g. the amount of social play increased with age in the UK, but not in Uganda). These interactions with age and culture highlight that people in different cultures may have different attitudes towards the developing child. These results highlight the importance of longitudinal approaches both when describing infant early life experience, and when investigating early environmental factors as predictors of development. Further understanding for these cultural differences across age could be gleaned from studying what the drivers are for these differences. For example, looking at how the different early life environment features link across time, e.g. is the feature that more infants reach physical development milestones in Uganda linked to possible different cultural practices such as physical stimulation or diaper wearing (Bril & Sabatier, 1986; Cole et al., 2012; Hopkins &

Westra, 1990; Super, 1976)? And is earlier physical development the driver for the differences seen in the steeper increase in the amount of environmental exploration seen in Ugandan infants, or is this driven by different levels of encouragement by caregivers?

This study shows that there are differences in how infants in two cultures experience their worlds, and that as they are developing, their environment and experience changes in different ways. Future research could investigate how these different early life environments link to the development of cognitive skills. Research has shown that developing skills like sitting at an earlier age is linked to object manipulation and learning about physical properties of objects (Mohring & Frick, 2013; Slone et al., 2018; Soska et al., 2010). Research has also shown that engaging in social play can facilitate more advanced behaviours (Bigelow et al., 2004). Given that we see a cultural difference in more infants developing sitting at a young age in Uganda, as well as infants engaging in social play more in the UK, do these early life differences influence object understanding in the same way or do they translate into a cultural difference of object understanding? Similarly, we see that infants who develop walking earlier have more opportunities for initiating triadic interactions about objects of interest (Karasik et al., 2011), an important feature of joint attention. The amount of social play infants have may also give infants more opportunities to learn more skills such as joint attention skills. Do the cultural differences seen in these two features of infant early life impact infant development or propensity to engage in joint attention in a similar way, or would these differences lead to a cultural difference in social skill development. Given there is more variety in early life environment when considering samples from two societies than when considering one, this gives us greater opportunity to understand driving factors for development of important cognitive skills, and further highlights the importance of longitudinal cross cultural research in the field of developmental psychology.

In conclusion, infants in the UK and Uganda will have very different early life experiences, with Ugandan infants generally having a more relational experience and UK infants having a more autonomous experience – however this did not translate over all measures. I show that in many aspects of infant early life there are cultural differences at the group level between UK and Ugandan participants. Additionally, although individuals may overlap in specific measures of early life environment, when combined, these measures show complete separation between Ugandan and UK infants. Considering multiple time-points when characterising infant behaviour is often overlooked, however this study highlights the importance of considering longitudinal approaches when looking at infant early life, especially in cross cultural contexts, because infant-other interactions and cross cultural differences can be dynamic with infant age – changes as infants age are not always uniform across cultures, and thus examining a single time-point when looking at features of infant life may not be adequate. Additionally I show that context can affect interpretation of infants early life environment, and that since attitudes and behaviours do not always match up, making assumptions about one from the other is difficult, and thus mixed methods greatly strengthen study design. The broad approach of this study, considering many factors of infant experience cross culturally, forms the basis for many aspects of future research, including considering the specific drivers for cultural difference in early life environment, as well as how differences in early life experience can impact development.

Chapter 3: Social experience and opportunity for interaction and social observation in male and female infant humans, chimpanzees, and crested macaques

3.1 Abstract

Psychological and behavioural sex differences are seen in sociality even from an early age. However, the drivers for many of these sex differences are unclear. Consistent sex differences across different cultural contexts in humans and across closely related primate species would indicate sex differences emerge in humans as a result of biological dispositions, rather than cultural constructs. In this study, I take a comparative approach to examine what aspects of early social environment are consistent or differ for human male and female infants from two cultural groups (from the UK and Uganda) up to 15-months old. I also investigate sex differences across humans and two non-human species (chimpanzees and crested macaques) up to 12-months old. For each mother-infant dyad in all species, observational data was collected across a whole day at multiple time-points across the first 12- or 15-months of infant life. Information was collected on infant activity, social partners, and individuals in proximity. Cross cultural comparisons revealed age-dependent sex differences in human infant social environment in terms of the likelihood of mother-infant contact and mother-infant interactions, as well as the number people in proximity and number adult males in proximity. These effects were consistent across the Ugandan and UK samples, indicating they are unlikely culturally driven. Sex differences found in cross species comparisons were also dynamic with infant age, and were consistent across species. For instance, as they aged, male chimpanzee and human infants experienced an increasing number of adult males and individuals overall in proximity, whereas as female infants aged they experienced a decreasing number of adult males and individuals overall in proximity. Comparisons of all three species revealed male infants were more likely than female infants to interact with non-mother female adults. The consistency of these effects across species indicates they are unlikely driven by species specific evolutionary pressures and are more likely driven by conserved, evolved psychological mechanisms. This work takes the first steps towards describing male and female infants' early social environment which sets the groundwork for understanding the context in which sex differences in social cognition, such as cooperation and prosocial behaviour, develop.

3.2 Introduction

Sex and gender differences in humans have been studied in many domains. Not only are cis-men and cis-women physically and physiologically different from one another, there is also evidence for psychological and behavioural sex differences (for example in *spatial skills, risky behaviour,* and *interest in infants;* Cross, 2010; Eals & Silverman, 1994; Joseph, 2000; Maestripieri & Pelka, 2002; Nazareth, Huang, Voyer, & Newcombe, 2019). In modern western society, gender equality is important – but even from an early age, we see differences between boys and girls in human social behaviour (for example, *in infants' interest in social stimuli*: Connellan, Baron-cohen, Wheelwright, Batki, & Ahluwalia, 2000; Osofsky & O'Connell, 1977; *and play types:* Fabes, Martin, & Hanish, 2003), which may affect how others act towards them (Meredith, 2015). Social behaviour is important for humans, and *sociality* can be seen as a suite of behaviours and tendencies including how often and for how long individuals spend time with others, who individuals spend time with, how they communicate, and how positive or negative interactions are. Human sociality underpins our remarkable cooperative and communicative behaviours that are thought to be some of our species' defining features. However, most current work on infant development focuses on specific skills in an experimental or lab-setting, and there is a lack of quantitative research on the naturalistic environment and context in which infants develop (Dahl, 2017). Moreover, there are individual differences both in social behaviours and sociality more broadly, yet it can be difficult to disentangle the contributing roles of genetics, evolutionary history, culture, and parenting on this variation (Confer et al., 2010; Meredith, 2015). In this chapter, I use a comparative approach to investigate male and female human infant social experience in the context of evolution by comparing patterns of social experience in a naturalistic environment in two cultural groups to that of two non-human primate species.

Before turning to the main research questions, it is critical to clarify some assumptions and terminology. It is important to note that while sex and gender correlate in cis individuals (i.e. cis-males identify as boys/men, and cis-females identify as girls/women), it is important to recognise that people can fall outside of these categories, and the full picture is more complicated (APA, 2019). Biologically some people are inter-sex, and many people identify outside of the gender associated with their sex assigned at birth. However, in published research, gender identity is often not mentioned, and participants are often referred to by their gender and sex interchangeably – indicating these participants at the time of research were likely identifying with the gender usually associated their sex assigned at birth. While referring to previous research in this study, I will use the terms used within those published papers. Given the focus of this research is on infant social experience in an evolutionary context, and that children up to 15-months of age, and non-humans, are unable to express gender identity explicitly, I will refer to infant participants in this study only with respect to their sex assigned at birth (hereafter referred to as sex). It is also important to note that there is considerable individual variation in social experience and social behaviours, and considerable overlap between the sexes, thus an average group difference between the sexes does not necessarily reflect the behaviour or experience of all male or female individuals.

Returning to the main topic, sex and gender differences are seen in various areas of human social development including in infant and children's social cognition, prosocial behaviour, play styles, communication, and expression of aggression and other emotions (e.g. Adani & Cepanec, 2019; Benenson, Apostoleris, & Parnass, 1997; Blakemore et al., 2009; DiPietro, 1981; Fabes et al., 2003). From an early age there is evidence for sex differences in social attention: in new-borns, through 3-, 6- and 12-months old in the UK and America, female infants appear to show higher preferences for social stimuli than males (Connellan et al., 2000; Gluckman & Johnson, 2013; Lewis, 1969; Lutchmaya & Baron-cohen, 2002; Osofsky & O'Connell, 1977). In terms of emotion expression, female children report and show more positive emotions, especially internalising emotions (e.g., fear and sadness). This is also evident in adults, where adult females seem to express more emotion than males across cultures (Blakemore et al., 2009; Brody, 1984; Brody, Lovas, & Hay, 1995; Buntaine & Costenbader, 1997; Chaplin & Aldao, 2013; Wintre, Polivy, & Murray, 1990). However, the exact patterns of sex differences in sociality are not always so clear. For example, although female children report more fear and sadness, there is conflicting evidence regarding differences in reports of anger, frustration, and other emotions depending on children's age (Blakemore et al., 2009). For example, there is no sex difference in the amount of temper tantrums, and reports of sex differences in pre-schooler anger has been shown in both directions, as well as no difference (Blakemore et al., 2009). Female children, have also been said to show more social understanding at younger ages (Charman, Ruffman, & Clements, 2002; Christov-moore, Simpson, Grigaityte, Iacoboni, & Ferrari, 2014; McClure & McClure, 2000), and female adults and children tend to show more prosocial and cooperative behaviours (Barbu, Cabanes, & Le Maner-Idrissi, 2011; Blakemore et al., 2009). On the other hand, across mostly Western Educated Industrialised Rich and Democratic or 'WEIRD' cultures, adult male humans show more directly and physically aggressive behaviours than adult females (Archer, 2004). This pattern is reflected in children, where male children show more competitive and aggressive behaviours than female children (Blakemore et al., 2009; Maccoby & Jacklin, 1980). Male and female children also appear to show differences in their play styles, where from four years, American boys tend to play in larger groups with rougher play compared to girls (Benenson, 1993; Benenson et al., 1997; DiPietro, 1981; Fabes et al., 2003; Lever, 1978). While there is evidence to suggest human sex differences in aggression are relics of our shared evolutionary past with other non-human primates (Meredith, 2015; Sabbi et al., 2021), there is limited understanding for the drivers for other sex differences in sociality such as emotional expression or interest in others. One of the first steps towards understanding drivers for such sex differences is to understand the social context in which infants are raised. The studies discussed above are often conducted in experimental settings or observations of peer play, with little quantitative exploration into understanding the naturalistic home context. Naturalistic data that captures everyday experiences for infants is vital for accurately characterising how behaviour may differ between the sexes and how the early environment may contribute to variation between the sexes. A further important source of variation in sex differences in infancy is age. For example, Endedijk, Cillessen, Bekkering, and Hunnius (2019) only found sex differences in affiliative and antagonistic behaviours at 28-months but not at 36- and 44-months. Barbu, Cabanes, and Le Maner-Idrissi (2011) also find that sex differences in play behaviour changes with age in young children. So differences in the ages sampled across studies could underpin the conflicting results in the literature. Given people may react differently to infants as they change with age and develop new skills (Brazelton & Als, 1979; Lagerspetz et al., 1971; Lewis, 1972; Moss, 1967; Rubin et al., 1982), it is thus important to consider infant early social experience dynamically with age.

In terms of drivers of sex differences in development (such as social interest, emotion expression, and other behaviours related to sociality), it can be hard to disentangle the impact of genetics and experience (Confer et al., 2010; Meredith, 2015). It is possible that humans have intrinsic sex differences in their social characteristics due to evolved psychological mechanisms, because different social behaviours may be adaptive for males and females. For example, some apparent sex differences in humans appear to be present from birth, prior to socialisation being able to impact infant behaviour, indicating there may be some innate differences between male and female sociality. Innate sex differences in sociality may also emerge over development due to differences in physiological development between male and female children. For example, female children show more interest in infants (Maestripieri & Pelka, 2002), and in 'play mothering' (Ruble et al., 2007; Zosuls et al.,

2009) than male children. This elevation in infant interest by females may be an evolutionary adaptation related to females playing the more important role in infant care-giving in our evolutionary history. Similarly, it is thought that sex differences in aggression are a conserved feature of evolutionary pressures on male reproduction, as this pattern is also present in other primates (Meredith, 2015).

While sex differences may be innate, they may also emerge as children age through sex-specific socialisation and stereotypes, or be a combination of innate and socialisation drivers (Lytton & Romney, 1991; Meredith, 2015). An individual's experience, which can vary by culture, parenting, and interactions with peers, can affect how behaviours are expressed (e.g. Bornstein, Putnick, Park, Suwalsky, & Haynes, 2017; Bril & Sabatier, 1986; Han, Leichtman, & Wang, 1998; Hopkins & Westra, 1990; Keller, Kärtner, Borke, Yovsi, & Kleis, 2005; Keller et al., 2004; Nosek et al., 2009; Rogoff, 2003) – and people may treat children differently depending on their sex, which can explicitly or implicitly, encourage or emphasise, sex differences in behaviour (Meredith, 2015). Children may also adjust their behaviour to expectations or model their behaviour after same-sex individuals without explicit encouragement (Meredith, 2015). Similarly, since children show voluntary sex segregation in play, male and female children could act differently because sex-specific play 'sub-cultures' emerge (Maccoby, 2002). A meta-analysis conducted by Lytton and Romney (1991) found strong evidence to support the idea that parents encourage boys and girls with sex-typed behaviour. For example, the differences that boys and girls show in expressions of emotions appear to be in line with gender stereotypes (Blakemore et al., 2009), and thus may be the result of sex-specific parenting. Given that sex-specific socialisation of children can be purposeful or not (Fagot, 1978; Sidorowicz & Lunney, 1980), it may be cultural, or even an evolutionary mechanism for parents to treat sons and daughters differently. That is to say, evolution may not only have acted upon infant behavioural strategies, but also on parenting behavioural strategies.

If males and females are parented differently and corresponding sex differences in infant social behaviour and sociality are observed, this could be indicative of a causal link between sex-specific parenting and infant sex-typed behaviours. For example, the fact that mothers seem to communicate more with girls (Lewis, 1972), and encourage communication more with girls than with boys (Fagot & Hagan, 1991; Fagot, Hagan, Leinbach, & Kronsberg, 1985) may be the cause of girls appearing to be better at social understanding and communication than boys (Adani & Cepanec, 2019; Christov-moore et al., 2014; McClure & McClure, 2000; Stoet & Geary, 2013; Whitehouse et al., 2010). However, the directionality of this could also be the other way around, i.e., it is possible that mothers act differently in response to sex-differentiated behaviour in infants, rather than mothers' sex-differential treatment driving sex-differentiated infant behaviour.

Lytton and Romney's (1991) meta-analysis, did not find support for sex-differentiated parenting behaviour in other aspects of behaviour they examined (e.g., interaction levels, clarity of communication). However, in some cases the results were not clear. When analysing *effect sizes* of parental restrictiveness and encouragement of dependency, they found there was no significant overall sex difference across studies, but when looking at the *number of papers* which reported the directionality of effects, they found significantly more papers reporting more encouragement of dependence is given to female children. It is possible that the different results they find between different meta-analytic approaches is because they grouped all studies with children under age five, but sex specific interactions between parents and offspring are not necessarily consistent over development. For example, within the first year, parents have more physical contact with boys between three weeks and three months (Moss, 1967), but after six months girls seem to have more physical contact with parents compared to boys (Lewis, 1972). Additionally, Lytton and Romney (1991) grouped all studies from different data collection methods (i.e. self-reports and observation) for analyses, but self-reports often do not capture unintentional sex differentiated behaviour by parents (Fagot, 1978). Thus, grouping studies across ages and across methods may mask or dilute real effects. Additionally, the majority of the papers reviewed by Lytton and Romney (1991) were from studies of North American families, and those that were not American were all from western countries. This adds to the consistent problem of little research on non-WEIRD populations (Nielsen et al., 2017), meaning results may not reflect human-wide traits, and thus further investigation with diverse populations may be of value to understanding sex differences in human development. Taken together, although there may have been little support for some aspects of sex specific parenting looked at by Lytton and Romney (1991), there are multiple reasons why it may be worth following up on this work.

It is also important to note that much of the literature reviewed here was not conducted very recently, and sex and gender stereotypes and attitudes can change over time (Eagly, Nater, Miller, Kaufmann, & Sczesny, 2019), thus effects should also be replicated currently to establish whether sex-specific parenting in these areas has changed. Additionally, there are few quantitative descriptions of infants' opportunities for social interaction or their possible change over time with both mothers and non-mothers.

Understanding the amount of interactions with adult females, adult males, and other children, is an important starting point if we are to understand the influence of social environment on infant development, especially given that infants show preferences for imitating same-sex models (Meredith, 2015).

While sex differences in human behaviour can be heavily influenced by experience, it is difficult to disentangle the influence of genetics, experience, and culture on sex differences in sociality. Firstly, as discussed earlier, sex specific behaviours can develop across time due to both biological development and socialisation. Secondly, even if sex-specific parenting occurs, it is hard to determine whether that is based on parents own socialisation and intentions, or mechanisms which have been selected upon in human evolution for parents to treat male and female offspring differently. One approach to try and distinguish these possibilities is to conduct cross cultural and cross species work simultaneously. If a feature is present across human cultures, it is more likely to be a human-wide trait, and thus more likely to have an evolutionary basis. Since we share a recent evolutionary history with other extant non-human primates, these primates are likely to share many behavioural and psychological traits with humans, and comparisons of humans to other primates can help determine whether certain human behaviours are likely the result of homologous or divergent traits (Confer et al., 2010).

By comparing humans to other primates we can make inferences about how selection pressures may have acted on our shared ancestors to make certain behaviours adaptive. For example, as in humans, females in other primates show more interest in infants than males do – a potential evolutionary strategy to ‘practice’ mothering skills and thus improve the chance of survival of their own offspring (*rhesus macaques:* Chamove, Harlow, & Mitchell, 1967; Ehardt & Bernstein, 1987; Lovejoy & Wallen, 1988; Wallen, Maestripieri, & Mann, 1995; *baboons:* Cheney, 1978; *howler monkeys:* Clarke, Glander, & Zucker, 1998; *blue monkeys:* Cords, Sheehan, & Ekernas, 2010; Förster & Cords, 2005). Although it may not be the case for all modern human families, mothers have had a more important role in raising children than fathers throughout human history and more broadly in other primates (humans: Wood & Eagly, 2002; Non-human primates: Schuiling, 2003), thus allocating energy to allo-parenting for males would not be as beneficial compared to females in terms of the fitness of our ancestors. This means that some sex differences in behaviour which are evident in humans today, such as higher interest by females in infants, sex-specific play styles, and heightened aggression in males (e.g. Alexander & Hines, 2002; Hassett, Siebert, & Wallen, 2008; Kahlenberg & Wrangham, 2010; Sabbi et al., 2021) may be relics of evolution, even if they are no-longer relevant to modern humans. In other words, sex differentiated traits which appear in humans and other primates are likely either a shared evolved trait from before these species diverged from one another, or could have occurred due to convergent evolution due to similar selection pressures since we diverged – but given that over the recent centuries human's environment and ways of living have changed dramatically, evolution may not have had time to 'catch up' (Confer et al., 2010).

In addition to key sex-differentiated behaviour described above that seems to be shared across human and non-human primates, observation of some of our closest living relatives—chimpanzees—has raised the possibility that mothers may parent differently for male and female infants to afford them different social opportunities. Young male chimpanzees may engage in more social interactions with more individuals than female infants (Lonsdorf, Markham, et al., 2014; Lonsdorf, Anderson, et al., 2014), and it is possible that chimpanzee mothers facilitate this pattern of sex specific behaviour. Maternal control over the number and type of individuals she associates with is facilitated by the fission-fusion social structure that chimpanzees live in. Whilst each community consists of a set number of individuals, within a community individuals form sub-groups called parties, whose composition dynamically changes throughout the day. Thus a mother who spends more time in parties with more individuals, gives her infant more opportunity for diverse social interactions, yet more time in parties with fewer individuals brings benefits such as reducing the chances of infanticide, competition, and disease transmission (Murray et al., 2014). Maternal gregariousness may therefore vary with the differential benefits socialising with unrelated individuals has for male and female offspring.

In chimpanzees, more opportunities for social interactions with others, especially with adult males may be particularly beneficial to young males, who stay in their natal communities their whole life, where forming lifelong bonds with other males can improve chances of high rank and siring more offspring later in life (Muller & Mitani, 2005; Kaburu & Newton-fisher, 2015; Wroblewski et al., 2009). In contrast, early formation of bonds with unrelated individuals in their natal community would be less beneficial to females, who migrate to a different community when they reach sexual maturity. In line with this theoretical reasoning, Murray et al., (2014) found that in the Gombe community, mothers with male infants up to 3.5-years old spent more time in proximity to non-kin compared to mothers with female infants, and mothers with male infants up to 6-months-old had more adult males in proximity than those with female infants. However, as infants aged there did not appear to be a sex difference in amount of time in proximity to adult males – in the

Kanyawara community of chimpanzees: Sabbi et al. (2021) found no difference in exposure to adult males between male and female infants up to 9-years. Other community differences may affect the cost-benefit ratio for female gregarious behaviour, such as the likelihood and severity of male aggression towards females and male hierarchy stability (Lowe, Hobaiter, & Newton-Fisher, 2018). Although further exploration is needed to understand an overall species pattern in maternal gregariousness and infant opportunities for social interaction with non-kin partners in chimpanzees, these findings illustrate the importance of considering parental behaviour.

Even in non-human primate species which do not have a fission-fusion social structure, and thus spend their days as a cohesive group, there is evidence that mothers can control infant behaviour, and are therefore able to restrict or promote certain social interactions in a sex specific manner. For example, when Barbary macaques have sons, mothers socialise more with other matrilines, but with daughters constrain their socialisation to individuals from their own matriline (Timme, 1995). In Japanese macaques, mothers retrieve sons more often when they are out of contact, and continue retrieving them until a later age than mothers with female infants (Eaton, Johnson, Glick, & Worlein, 1985). In contrast, Olive baboons are in contact more with daughters compared to sons in the first two weeks of life (Bentley-Condit, 2003). These studies show that infant primates may experience different relations with others due to sex-specific mothering behaviour, even in species without fission-fusion social structures.

Although there is research into sex-specific variation in mother infant proximity in non-human primates, there is limited research into how this may influence sex-specific social interactions. For example, Tyrrell et al. (2020) showed that adult male and female crested macaques have different interaction styles, as males show a more avoidant style than females. If this adult pattern is reflected in infant males (as seen in the case of prosocial behaviours and aggression in humans and chimpanzees), we may see that infant males engage less in social interactions than females. However there is no exploration into whether these patterns are present from infancy or if they are driven by sex-specific retrieval of males over females as in Japanese macaques (e.g. Eaton et al., 1985). Additionally, Kerhoas, Kulik, and Perwitasari-Farajallah (2016), found crested macaque adult males were more likely to initiate interactions with infants if they are in proximity to mothers. This suggests if there are differences in mother-infant proximity between male and female infants, then differential retrieval of male verses female infants may have knock on effects on infants' social partners. Taken together it is clear that non-human primate maternal behaviour can vary systematically with the sex of the infant, but the downstream effects of this sex-differentiated parenting behaviour is largely unexplored.

In summary, although humans exhibit sex differences in sociality, it is difficult to disentangle drivers for these differences. It has been suggested that sex differences in infant sociality may be driven by: (a) sex-specific socialisation, e.g., by cultural or parenting values or evolutionary adaptations to treat male and female infants differently, (b) intrinsic attributes of the infant, or (c) a combination of sex specific socialisation and attributes innate to the infant (Confer et al., 2010; Meredith, 2015). As covered above, one approach to understanding whether socio-cultural factors or innate factors are driving sex differences in infant sociality is to do comparative research to: a) examine if sex differences are consistent across different cultural groups where parenting and cultural values may also differ and b) examine if sex differences are consistent across some of our closest living relatives. However, studies which investigate human early social experience often are limited in the cultural diversity of their sample, rarely to try to understand infants' naturalistic home context, and/or do not consider infant social experience dynamically with age. Additionally, while theory posits that similarities in sex-patterned behaviour between human and non-human primates may represent homologous evolution, there is a dearth of work directly comparing human infant social experience to that of our closest living relatives.

3.2.1 Current study

To address the above issues, in this study I investigated the social experience and opportunities experienced by infants in their natural environment, in two human cultural groups and two non-human primate species: chimpanzees (*Pan troglodytes)* and crested macaques (*Macaca Nigra*). A cross cultural approach enabled me examine whether similar sex differences were found across cultures. This would suggest sex differences in human sociality may be consistent across human societies. Next, if similar sex differences are found across species then it would suggest sex differences in modern human sociality may be relics of evolution. Additionally, given that infants gain new skills as they develop, and that individuals react differently to infants of different ages, I used multiple time-points to examine how age impacts infant social experience. There are many ways to assess sociality and differences in early experience, however, given the lack of recent literature describing the naturalistic social environment of infants, I aimed to characterise some basic but important aspects of infants' social behaviour and environment. Specifically, I examined the interactions infants experience: who do infants interact with and who is in proximity to them?

3.2.2 Cross cultural aims and hypotheses

For the first part of my study I aimed to investigate whether the social environment was similar for male and female infants up to 15-months old in two human cultures. One group of participants were sampled from within or close to a WEIRD UK city and the other was sampled from a rural area in Uganda. Using observational methods, I explored infants' social experience and social opportunities in order to assess whether there were sex-specific differences across cultures and age. I also aimed to establish if participants from these two populations were sufficiently similar in behaviour to be considered as a single group for comparison with non-human primates or whether comparisons as two separate human samples was more appropriate. First, to assess whether male and female human infants experienced similar amounts of interaction with others, the chance they were engaged in a social activity was assessed. Second, the chances that infant social partners would be their mother, other children, non-mother adult females, or adult males was assessed. If female infants were encouraged to be more dependent, as suggested by studies on Western children (Lytton & Romney, 1991), I would expect female infants' social partner to be their mother more often than for male infants. I did not have specific predictions for the chances male and female infants' social partner would be one of the non-mother categories. I also explored the chances that infants would be involved in an interaction with multiple partners. Given that at older ages, male children show more play in larger groups (Benenson, 1993; Benenson et al., 1997; Lever, 1978), I expected that male infants may be more likely to be engaged in an interaction with multiple individuals.

Given that mothers were the primary caregivers in the two human groups sampled (see *Chapter 2*), I explored mother-infant proximity. Overall I expected infants to spend less time in close proximity to their mother as they age and become more independent. If results from Moss (1967) and Lewis (1972) were to be replicated, I would have expected an interaction between age and sex, where young male infants would be more likely than female infants to be within close proximity of their mothers, but with that pattern reversing as the infants age, so that older female infants would be in more close proximity with mothers than males. This is in line with the idea that if female infants are encouraged to be more dependent (Lytton & Romney, 1991) then one would expect less of a reduction in mother-infant close proximity for females as they age since they would experience more socialisation with their mother.

Next, to explore whether male and female infants in the two human samples had similar or different opportunities for interaction, I examined the social environment in terms of how many non-mother individuals were present within five metres of infants, as well as their age and sex identity (children, adult females, or adult males). If any sex or culture differences aligned between interaction partner identity and identity of people in proximity, it might indicate that the opportunity for interactions was driven by differences in social interactions. If there were sex differences in social interactions which did not align with opportunity, especially at the older ages, then it would indicate that male and female infants are exploiting similar social opportunities to different extents.

3.2.3 Cross species aims and hypotheses

After investigating sex differences in infant social environment in two cultural groups, for the second part of the study, I compared sex differences in social environment across humans, wild chimpanzees, and wild crested macaques. A weakness of previous studies is that they do not always use directly comparable methods across species, so I aimed to overcome this limitation by using data collection methods which were similar across groups. Using observational data, I explored whether the infant social environment was similar in male and female infant humans, chimpanzees, and macaques in the first 12-months. Given the lack of complex culture, active teaching, and gender stereotypes in non-human primates, if social environment is similar across species, this would suggest this feature of infant experience is conserved across primates, and any sex differences are more likely to reflect evolved psychological mechanisms. Given the lack of comparable data on human, chimpanzee, and crested macaque early life environment, I was unable to make global directional predictions about whether sex differences would be consistent or vary across the three study species, however relevant studies support some more specific predictions below. Firstly, to assess whether male and female infants experience similar amounts of interactions, the chance that they were engaged in a social activity was explored. Given that humans develop at a similar rate to chimpanzees (Bründl et al., 2021; Charvet, 2021), I expected age effects to be similar in these two species. However I also expected that any changes with age in the macaques may be steeper than in humans and chimpanzees, given their faster life-history trajectory (Kerhoas, Perwitasari-Farajallah, Agil, Widdig, & Engelhardt, 2014). I predicted that if male infant macaques reflect avoidant patterns seen in adults (Tyrrell et al., 2020), then they may show less social interaction than female infant macaques. As social environment can be controlled by mothers in chimpanzees and humans (given their fission-fusion social structure), for these species I investigated whether there were sex differences in the number, age and sex group (adult male or female or child/juvenile) of individuals in proximity to the infant. I expected male infant chimpanzees are more likely to have more individuals in proximity given that male chimpanzees benefit from lifelong social bonds, whereas female infants may benefit more from the advantages of spending less time around more individuals (e.g. less disease transmission; Murray et al., 2014). In all three species, I investigated mother-infant proximity to examine whether there was a difference in how dependent male and female infants were on their mothers. I expected that male infant chimpanzees might be more independent (e.g. maintain a greater spatial distance) from their mother given that they may get more benefits from interactions with non-mothers, and thus venturing further from their mother to make these interactions may be more beneficial for males than female infants. Given that crested macaques have a different dispersal pattern to chimpanzees, if we see the same pattern in macaques, then it indicates that a sex difference in mother-infant dependence in chimpanzees or humans may not actually be driven by dispersal pattern, but is in fact an evolutionarily older feature of primate behaviour. To explore the rates at which infants interact with different partners, I examined the chances infants' social partners would be their mother, other juveniles or children, non-mother adult females, or adult males. I expected that male chimpanzee infants would interact more with non-mothers as research on similar aged chimpanzees indicate that male chimpanzees interact more with non-mothers even when accounting for individuals in proximity (Lonsdorf, Anderson, et al., 2014).

3.3 Methods

3.3.1 Subjects

This comparative study investigated whether early social life varied according to sex and age in humans, chimpanzees, and crested macaques.

3.3.1.1 Humans

Human participants were the same UK and Ugandan infants described in *Chapter 2.* There were 25 female and 28 male UK infants, and 20 male and 24 female Ugandan infants. Data were collected approximately every three months from 3- to 15-months. For the cross-cultural human analyses, infants aged 2.5- to 16.2-months were included. For cross-species comparisons, infants were only included up to 12.9-months of age.

3.3.1.2 Chimpanzees

Data were collected on 34 wild infant chimpanzees (13 female, 21 male), aged 0.6- to 12.9-months old, from the two Ngogo chimpanzee communities located in the Kibale National Park, Western Uganda between February 2018 and March 2020. The Ngogo chimpanzees are considered habituated to human presence, as they have been studied by the Ngogo Chimpanzee Project since 1995, with systematic follows of adult females since

2004. The Ngogo chimpanzees were once considered the largest known cohesive chimpanzee community (Langergraber, Watts, Vigilant, & Mitani, 2017; B. M. Wood, Watts, Mitani, & Langergraber, 2017), with a home range of approximately 35km^2 (Mitani & Watts, 2010). However since the end of 2017 have fissioned into a Central and Western community (Sandel & Watts, 2021). Given aging, deaths, and female migrations during the study period, the Central community ranged from 63-65 adult individuals (39-40 female, 24-25 male), and the Western community ranged 26-19 adult individuals (19-22 female, 7 male). Twelve study infants (5 female, 7 male) were from the Western Ngogo community and 19 (6 female, 13 male) were from the Central Ngogo community.

3.3.1.3 Crested Macaques

Data were collected on 24 wild infant crested macaques (9 female, 15 male), aged 0- to 12.4-months from the PB1b and R1 communities situated in the Tangkoko Reserve, North Sulawesi, Indonesia, between March 2018 to August 2019. The Macaca Nigra Project started following these macaques in 2006 and the animals are considered habituated to human presence. While the PB1b community rarely encounters tourists, the R1 community does regularly encounter tourists.

Given aging and male migrations during the study period, the R1 community ranged from 31-36 adult individuals (25-29 female, 6-7 male), and the PB1b community ranged from 22-28 adult individuals (15-19 female, 7-9 male). Six study infants (2 female, 4 male) were from R1 and 18 (7 female, 11 male) were from PB1b.

3.3.2 Materials & Procedure

Data were used from the human full-day follow procedure described in *Chapter 2.* Full-day follow information was also collected on the chimpanzees and macaques. Once a group of chimpanzee or macaques was located, researchers identified a mother-infant focal dyad. The focal dyad was chosen based on which individuals were present in the group, and how much data had been collected for the individuals present and their proximity to their target time-points. The focal dyad was followed for as long as possible once identified until lost, or at the end of the day (1800 or when the dyad climbed the sleeping tree (macaques) or nested (chimpanzees)). If a focal dyad were lost by the researchers, data collection started on a new focal dyad. Non-human primate full-day follows were conducted in a comparable manner to human full-day follows in that information about infant and caregiver activities and social environment was regularly recorded. For both macaque and chimpanzee data collection, scan sample information was recorded every 15 minutes with the *CyberTracker* application (Cape Town, South Africa) installed on android mobile phones (a full list of data collected in these scan samples can be found in *Appendix A3.1*).

The variables used for all species in this study were:

- Infant Activity
- If activity social: Infant social partner (age and sex category)
- Mother-infant distance
- How many conspecifics were in five metres of the infant (chimpanzees and humans only)
- Number, age and sex of conspecifics in five metres of the infant (chimpanzees and humans only)

3.3.3 Analyses

All analyses were run in *R* version 4.0.1 (R Core Team, 2020).

3.3.3.1 Male and female human infants' early social environment

Generalised Linear Mixed Models (GLMMs) using *lme4* (Bates, Maechler, Bolker, & Walker, 2015) assessed effects of infant sex on infant early life social environment in humans up to 15-months old. Given that culture (UK or Uganda) and age impact infant early life environment (see *Chapter 2*), infant age, culture, and their interactions with infant sex were also included. To avoid over-fitting, where the three-way interaction did not contribute to explaining variance in the model (assessed using a likelihood-ratio test, using *lmtest;* Horthorn & Zeileis, 2002), this component was dropped from the final model. GLMMs were run at the level of scan sample, with participant ID entered as a random factor to control for multiple sampling at the level of individual. All GLMMs initially had the following structure:

*Dependent variable ~ Infant Age + Culture + Infant Sex + Infant Age*Culture + Infant Age*Infant Sex + Infant Age*Culture*Infant Sex + (1|Participant ID)*

Details of the dependent variables, model structure, and sample size included in GLMMs can be found in *Table 3.1*. Cookes distance (calculated using *Influence.ME;* Nieuwenhuis, te Grotenhuis, & Pelzer, 2012), assessed whether any participants were overly influential in the model. To understand the effects of these overly influential cases, GLMMs were run without those cases. If significance of factors changed when overly influential participants were removed, this indicated either the original full model was unstable or the results of the full model were an artefact of the sample used in this study, and not representative of the population. Where exclusion of cases changed the interpretation of the model then both the full and reduced models are reported. Results from both models are presented to give transparency to the reader regarding the confidence and robustness of patterns seen in the data when inclusion or exclusion of specific participants changes the interpretation of the model. In these cases I cautiously interpreted results in the most conservative manner (i.e.

that there was a null result), however further investigation is needed in these cases to get a fuller picture. If factors showed consistent patterns across both full and reduced model, then these were considered robust results that could be interpreted more confidently. Appendix A3.2 details model statistics for all models run without overly influential cases.

Table 3.1: Dependent variables, model structure, sample size, and whether a three-way interaction was included in the final GLMM investigating the effects of infant sex, age, and culture on infant human early life social experience. *Models where the dependent variable was a count were first run with a Poisson distribution. If this model was under-fitting zeros, then a negative binomial model was used. The number of scan samples vary depending on the model for two potential reasons either a) infant partner models only considers scans where the infant's activity was social, or b) for some scan samples information was missing for some variables. *A model of Number of non-mother adult females in five metres was attempted as with both a Poisson and a Negative-Binomial error structure, but both models were very unstable. Thus the number of non-mother adult females in five metres was converted into a binary variable of whether there were any non-mothers in five metres or not, and a Binomial model was run. Only the model marked with ** included the three-way interaction in final model.*

Research question	Dependent variable	Dependent variables description (structure)	Number of scan samples	Model error structure
Across cultures, do male and female human infants differ in how likely they are to be engaged in social activities?	Social activity	Was the infant's activity social? (Binary)	9577	Binomial
Across cultures, do male and female human infants differ in how likely they are to be engaged in social activities with partners of particular identities?	Mother partner	When infant engaged in a social activity, was the mother one of the infant's social partners? (Binary)	2270	Binomial
	Child partner	When infant engaged in a social activity, was a child one of the infant's social partners? (Binary)	2213	Binomial
	Non-mother adult female partner	When infant engaged in a social activity, was a non-mother adult female one of the infant's social partners? (Binary)	2206	Binomial
	Adult male partner	When infant engaged in a social activity, was an adult male one of the infant's social partners? (Binary)	2207	Binomial
	Multiple partners	When infant engaged in a social activity, was the infant's social interaction with more than one individual? (Binary)	2213	Binomial

Research question	Dependent variable	Dependent variables description (structure)	Number of scan samples	Model error structure
Across cultures, do the social environments of male and female human infants differ	Mother in Contact	Was the mother in physical contact with the infant? (Binary)	9537	Binomial
	Mother in 5 metres	Was the mother within 5 metres of the infant? (Binary)	9537	Binomial
	Number of non-mother individuals in 5 metres	How many non-mother individuals were in 5 metres of the infant? (Count)	9611	Negative-Binomial
	Number of children in 5 metres	How many children were in 5 metres of the infant? (count)	9604	Negative-Binomial
	Non-mother adult female in 5 metres*	Were there any non-mother adult females in 5 metres of the infant? (binary)	9605	Binomial
	Number of adult males in 5 metres**	How many adult males were in 5 metres of the infant? (count)	9605	Poisson

3.3.3.2 Male and female human, chimpanzee, and macaque infants' early social environment

In the second part of this study, I examined whether male and female infants experienced similar social environment in humans, chimpanzees, and crested macaques. Given the available data for the two non-human primates, I compared early life experience in these three species up to 12-months. I ran Generalised Linear Mixed Models (GLMMs) using *lme4* (Bates et al., 2015) to assess male and female early life social environment. Since infant social environment can change as they age, I included infant age, and its interactions with infant sex and infant species. GLMMs were run at the level of scan sample, with participant ID entered as a random factor to control for multiple sampling at the level of individual. All GLMMs initially had the following structure:

*Dependent variable ~ Infant Age + Species + Infant Sex + Infant Age*Species + Infant Age*Infant Sex + Infant Age*Species*Infant Sex + (1|Participant ID)*

The dependent variables, model structure, and sample size for GLMMs are detailed in *Table 3.2*. Individuals were only included if they contributed five or more data points. As in the human-only GLMMs, to avoid over-fitting, when the three-way interaction did not contribute to explaining variance in the model, this component was not included. Cooke's distance (using *Influence.ME;* Nieuwenhuis et al., 2012) was used to assess whether any participants were overly influential in the model. To understand the effects of these overly influential cases, the GLMMs were run without these cases. Where exclusion of these cases changed the interpretation of the model then results of both models are reported in the main results section. Results from both models are presented to give transparency to the reader regarding the confidence and robustness of patterns seen in the data when inclusion or exclusion of specific participants changes the interpretation of the model. Appendix A3.3 details model statistics for all models run without overly influential cases.

3.3.4 Ethical note

Ethical approval was obtained for human data collection from the University of York Psychology Department Ethics Committee. Additional ethical approval was obtained from the Regional Ethics Committee at the Ugandan Virus Research Institute for data collection with Ugandan humans. Ethical approval for chimpanzee and macaque data collection with was obtained from the University of York Animal Welfare and Ethical Review Body. For research on chimpanzees, permission was obtained from the Ugandan Wildlife Association. Permits were obtained for all data collection in Uganda (Ugandan humans and chimpanzees) from the Ugandan National Council for Science and Technology. For research on crested macaques, research permits were granted by the Indonesian Ministry of Research, Technology and Higher Education (RISTEKDIKTI) and from Balai Konservasi Sumberdaya Alam Sulawesi Utara (BKSDA Sulut).

Table 3.2: Dependent variables, model structure, sample size, and whether a three-way interaction was included in the final GLMM investigating the effects of infant sex, age, and culture on human, chimpanzee and macaque infant early life social experience. *Models where the dependent variable was a count were first run with a Poisson distribution. If this model was under-fitting zeros, then a negative binomial model was used. The number of scan samples vary depending on the model for three potential reasons either a) infant partner models only considers scans where the infant's activity was social, b) models looking at individuals within five metres of the infant only include humans and chimpanzees, or c) for some scan samples information was missing for some variables.*

Research question	Dependent variable	Dependent variables description (structure)	Number of scan samples	Model error structure	Model notes
Across species, do male and female infants differ in how likely they are to be engaged in social activities?	Social activity	Was the infant's activity social? (Binary)	13634	Binomial	Final model did not include three-way interaction

Research question	Dependent variable	Dependent variables description (structure)	Number of scan samples	Model error structure	Model notes
Across species, do male and female infants differ in how likely they are to be engaged in social activities with partners of particular identities?	Mother partner	When infant engaged in a social activity, was the mother one of the infant's social partners? (Binary)	3421	Binomial	Final model did not include three-way interaction
	Child /juvenile Partner	When infant engaged in a social activity, was a child or juvenile one of the infant's social partners? (Binary)	3366	Binomial	Final model did not include three-way interaction
	Non-mother adult female partner	When infant engaged in a social activity, was a non-mother adult female one of the infant's social partners? (Binary)	3362	Binomial	Final model did not include three-way interaction
	Adult male partner	When infant engaged in a social activity, was an adult male one of the infant's social partners? (Binary)	3363	Binomial	Model was not stable
	Multiple partners	When infant engaged in a social activity, was the infant's social interaction with more than one individual? (Binary)	3362	Binomial	Model was not stable
Across species, do the social environments of male and female infants differ?	Mother in contact	Was the mother in physical contact with the infant? (Binary)	12966	Binomial	Final model included three-way interaction
	Mother in 5 metres	Was the mother within 5 metres of the infant? (Binary)	10880	Binomial	Model only included humans and macaques
	Number of non-mother individuals in 5 metres	How many non-mother conspecifics were in 5 metres of the infant? (Count)	9407	Negative-Binomial	Final model did not include three-way interaction

Research question	Dependent variable	Dependent variables description (structure)	Number of scan samples	Model error structure	Model notes
	Number of children/ juveniles in 5 metres	How many children/juvenile conspecifics were in 5 metres of the infant? (count)	9398	Negative-Binomial	Final model did not include three-way interaction
	Number of non-mother adult females in 5 metres	How many non-mother adult female conspecifics were in 5 metres of the infant? (count)	9401	Poisson	Final model did not include three-way interaction
	Number of adult males in 5 metres	How many adult male conspecifics were in 5 metres of the infant? (count)	9401	Poisson	Final model did not include three-way interaction

3.4 Results

For all GLMMs unless stated otherwise, the full model explained significantly more variance than the null model (a model only containing the random factors, without fixed factors, Likelihood Ratio Test results in *Tables 3.3 to 3.23*). In all human GLMMs, the reference level for culture was Uganda, and the reference level for sex was male.

3.4.1 Are sex differences and similarities in human infant social experience consistent across two cultures from 0-15months?

3.4.1.1 Do male and female human infants differ in how likely they are to be engaged in social activities?

There was no effect of sex or any interactions for how likely infants were to be engaged in a social activity (see *Table 3.3*). As found in *Chapter 2,* infants were significantly less likely to be engaged in a social interaction as they aged, and there was no effect of culture.

3.4.1.2 Do male and female human infants differ in how likely they are to be engaged in social activities with partners of particular identities?

Human infant social interactions with their mother

There was an interaction between infant age and infant sex as to how likely mothers were to be infants' social partners (see *Table 3.4, Figure 3.1*): as male infants aged, their mother was less likely to be their interaction partner than for female infants. There was also an interaction between infant age and culture – there was a steeper decrease in the chances that infants would be engaged in a social interaction with their mother for UK infants than Ugandan infants.

***Table 3.3: Model parameters for human infant social activity GLMM**. The reference level for social activity was 'infant not engaged in social activity'. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at p<.001 level; ** indicates significance at p<.01 level.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Social activity GLMM ($\chi^2_{(6)}$=45.5, *p*<.001***)	(Intercept)	-.999	.117	-8.55	-1.23 to -.771	<.001***
	Infant age	-.026	.010	-2.61	-.046 to -.007	.009**
	Infant Sex	.098	.145	.678	-.186 to .383	.498
	Culture	.121	.142	.852	-.157 to .401	.394
	Infant age* Sex	-.015	.012	-1.28	-.038 to .008	.201
	Infant sex* Culture	.088	.128	.682	-.166 to .342	.495
	Infant age* Culture	.010	.012	.853	-.013 to .033	.394

***Table 3.4: Model parameters for human infant mother partner GLMM**. The reference level for Mother Partner was 'mother was not infants social partner'. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at p<.001 level; *indicates significance at p<.05 level*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Mother Partner GLMM ($\chi^2_{(6)}$=32.3, *p*<.001***)	(Intercept)	1.87	.280	6.70	1.33 to 2.44	<.001***
	Infant age	-.057	.023	-2.52	-.102 to -.013	.012*
	Infant Sex	-.634	.348	-1.82	-1.33 to .049	.069
	Culture	.902	.357	2.53	.120 to 1.61	.012*
	Infant age* Sex	.060	.027	2.21	.007 to .114	.027*
	Infant sex* Culture	.068	.326	.208	-.577 to .725	.835
	Infant age* Culture	-.065	.028	-2.36	-.120 to -.011	.018*

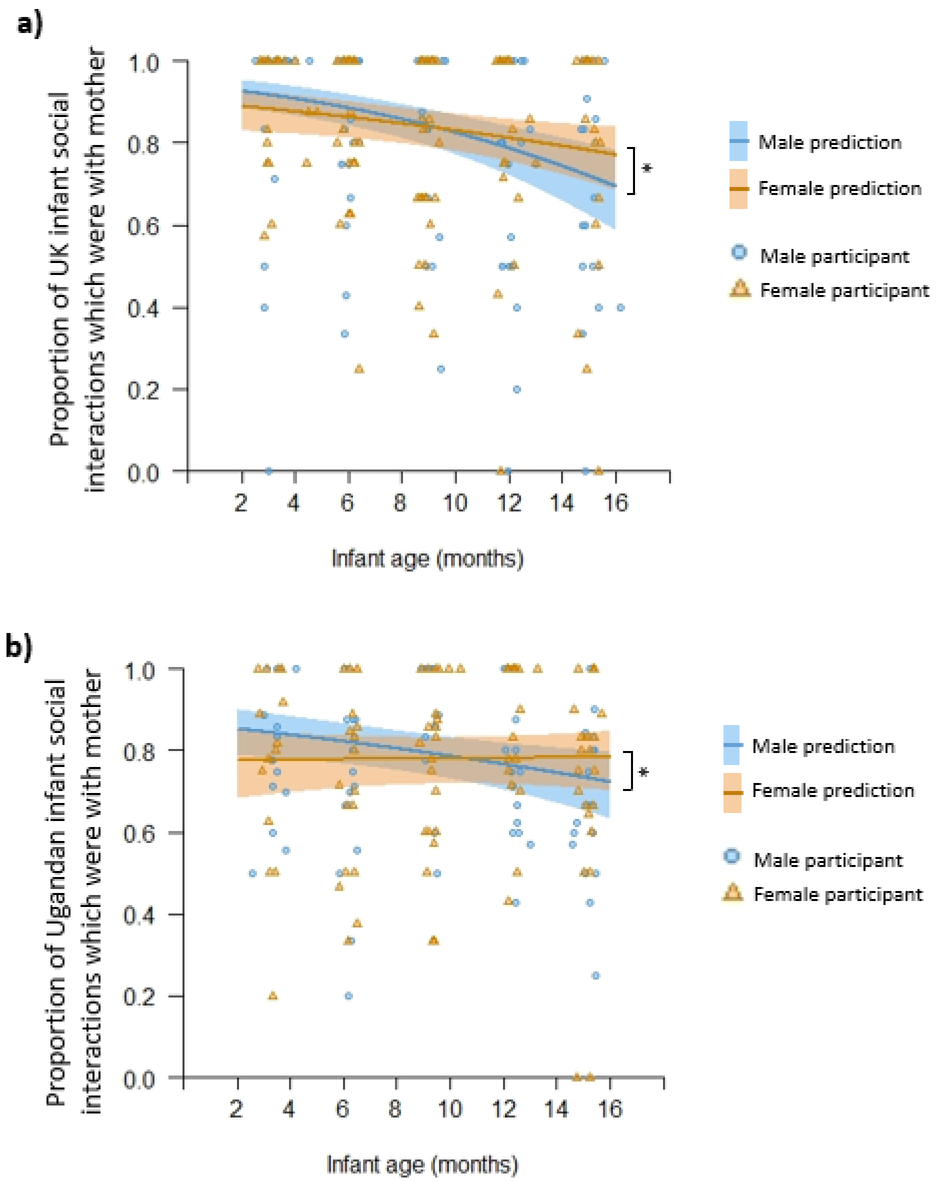


Figure 3.1: Proportion of social interaction scan samples where male and female infants were engaged with their mother (circles/triangles), and the expected probabilities of this given GLMM results (lines) as they age. a) UK infants, b) Ugandan infants. *Shading around the lines show 95% confidence intervals. * indicates significant interaction effect at p<.05 level*

Table 3.5: Model parameters for human infant child partner GLMM*. The reference level for Child Partner was 'infant's social partner did not include a child'. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; **indicates significance at <.01 level; *indicates significance at <.05 level.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Child Partner GLMM ($\chi^2_{(6)}$=62.5, *p*<.001***)	(Intercept)	-2.62	.352	-7.46	-3.34 to -1.94	<.001***
	Infant age	.076	.027	2.81	.023 to .131	.005**
	Infant Sex	.173	.447	.387	-.718 to 1.07	.699
	Culture	-1.13	.456	-2.48	-2.03 to -.233	.013*
	Infant age* Sex	-.026	.033	-.803	-.092 to .039	.422
	Infant sex* Culture	-.230	.425	-.542	-1.09 to .613	.588
	Infant age* Culture	.109	.033	3.27	.043 to .176	.001**

Human infant social interactions with other children

There were no sex effects on how likely infants were to have a child social partner (see *Table 3.5*). As in *Chapter 2,* as infants aged, their social partner was more likely to be a child, and this effect was stronger for UK than Ugandan infants.

Human infant social interactions with non-mother adult females

There was an interaction between infant age and infant sex as to how likely infants' partners were a non-mother adult female (see *Table 3.6)*: as female infants aged, their partners were less likely to be a non-mother adult female, but as infant males aged, their partners were more likely to be a non-mother adult female. There was also an interaction between culture and age: as Ugandan infants aged their social partners were less likely to be a non-mother adult female, but as UK infants aged, their social partners were more likely to be a non-mother adult female. However, when overly influential participants (female: 2 Ugandan, 5 UK; male: 1 Ugandan, 2 UK) were removed from this model, there was no interaction between infant sex and age (*Est*= -.104, *SE*= .069, *Z*=-1.51, *p*=.132), indicating instability in the model, and that this effect may be a feature of the specific participants sampled in this study. Other effects in this reduced model retained the same patterns as the original model (including critically, that there were no sex effects interacting with culture).

Table 3.6: Model parameters for human infant adult female partner GLMM. *The reference level for Adult Female Partner was 'infant's social partner did not include a non-mother adult female'. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; ++indicates significance at <.01 level in main model, but this effect is driven by overly influential participants.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	***SE***	***Z***	***95% confidence interval***	***P***
Adult Female Partner GLMM ($\chi^2_{(6)}$=34.0, *p*<.001***)	(Intercept)	-3.23	.540	-5.97	-4.34 to -2.21	<.001***
	Infant age	-.023	.044	-.527	-.111 to .063	.598
	Infant Sex	.183	.682	.269	-1.19 to 1.51	.788
	Culture	-1.35	.699	-1.93	-2.75 to .012	.053
	Infant age* Sex	-.140	.053	-2.66	-.245 to -.038	.008^{++}
	Infant sex* Culture	1.11	.707	1.56	-.266 to 2.56	.118
	Infant age* Culture	.195	.054	3.61	.091 to .303	<.001***

Human infant social interactions with adult males

There were no effects of sex, age, or culture on how likely it was for an infant's partner to be an adult male (see *Table 3.7*). However, when overly influential participants (male: 2 Ugandan, 2 UK; female: 2 Ugandan, 2 UK) were removed, female infants were more likely than male infants to have an adult male social partner (*Est*= 2.46, *SE*= 1.09, *Z*=2.26, *p*=.024), and Ugandan infants were less likely than UK infants to have an adult male social partner *(Est*= 1.97, *SE*= 1.22, *Z*=2.44, *p*=.015), indicating instability in the original model. Null effects in the other variables, including no interaction between infant sex and culture, remained stable across models. A conservative interpretation of these results is that male and female infants in the UK and Uganda may interact with adult males at a similar rate as throughout 3- to 15- months.

Human infant social interactions with multiple partners

There were no effects of sex, or any interactions with sex and age or culture on how likely infants' social interactions were to be with multiple individuals (see *Table 3.8*). Ugandan infants were less likely than UK infants to be engaged in a social interaction with multiple individuals overall.

Table 3.7: Model parameters for human infant adult male partner GLMM. *The reference level for Adult Male Partner was 'infant's social partner did not include an adult male'. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; ' indicates non-significance in main model, but that when overly influential participants were removed this was significant at the .05 level.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Adult Male Partner GLMM ($\chi^2_{(6)}$=29.7, *p*<.001***)	(Intercept)	-4.52	.807	-5.61	-6.25 to -3.06	<.001***
	Infant age	-.074	.073	-1.01	-.221 to .067	.311
	Infant Sex	.663	.796	.834	-.867 to 2.29	.405 '
	Culture	1.56	.826	1.88	-.006 to 3.27	.060 '
	Infant age* Sex	.029	.053	.533	-.076 to .134	.594
	Infant sex* Culture	-.332	.764	-.435	-1.90 to 1.17	.664
	Infant age* Culture	.064	.070	.918	-.071 to .204	.358

Table 3.8: Model parameters for human infant multiple partners GLMM. *The reference level for Multiple Partners 'infant's had one social partner'. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; * indicates significance at <.05 level.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Multiple Partners GLMM ($\chi^2_{(6)}$=88.9, *p*<.001***)	(Intercept)	-5.97	.983	-6.07	-8.12 to -4.23	<.001***
	Infant age	.112	.077	1.44	-.035 to .270	.149
	Infant Sex	-.092	.861	-.107	-1.80 to 1.61	.915
	Culture	2.05	1.01	2.03	.210 to 4.22	.042*
	Infant age* Sex	-.015	.048	-.303	-.110 to .080	.762
	Infant sex* Culture	.424	.766	.554	-1.10 to 1.96	.580
	Infant age* Culture	.049	.078	.635	-.112 to .197	.526

3.4.1.3 Do the social environments of male and female human infants differ?

Human infant in physical contact with their mother

As infants aged, they were less likely to be in contact with their mother, however this effect was stronger for males than for females (*See Figure 3.2, Table 3.9*). There was no effect of culture, or any interactions with culture on how likely mothers and infants were to be in physical contact.

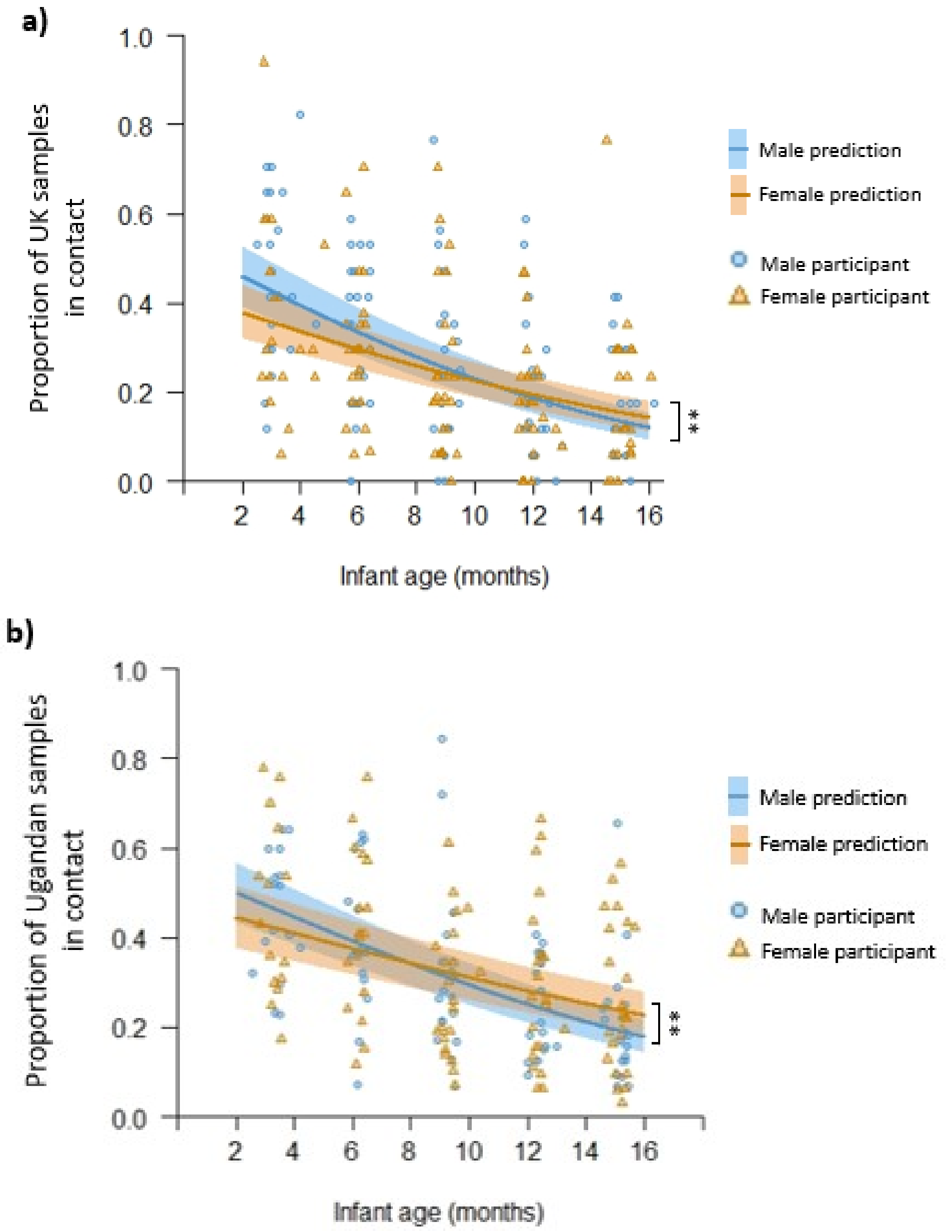


Figure 3.2: Proportion of scan samples where male and female infants were in contact with their mother (circles/triangles), and the expected probabilities of this given GLMM results (lines) as they age*. a) UK infants, b) Ugandan infants. Shading around the lines show 95% confidence intervals. ** indicates significant interaction effect at p<.01 level.*

Table 3.9: Model parameters for human mother-infant contact GLMM. *The reference level for Mother-infant Contact was 'mother and infant not in contact'. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; ** indicates significance at <.01 level*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Mother-Infant contact GLMM ($\chi^2_{(6)}$=311, *p*<.001***)	(Intercept)	.220	.155	1.42	-.086 to .526	.157
	Infant age	-.110	.010	-11.1	-.129 to -.091	<.001***
	Infant Sex	-.300	.205	-1.46	-.704 to .103	.143
	Culture	-.126	.198	-.637	-.517 to .265	.524
	Infant age* Sex	.038	.012	3.19	.015 to .061	.001**
	Infant sex* Culture	-.105	.237	-.444	-.573 to .365	.657
	Infant age* Culture	-.021	.012	-1.74	-.045 to .003	.083

Human mother in five metre proximity of their infant

As in *Chapter 2,* infants were less likely to be within five metres of their mothers as they aged, and infants in the UK were more likely to be within five metres of their mothers than infants in Uganda (See *Table 3.10*). There were no significant interactions in the main model, however when influential participants were removed (female: 3 Ugandan, 3 UK; male: 3 Ugandan, 3 UK) there was an interaction between infant age and sex (*Est*=.048, *SE*=.013, *Z*=3.79, *p*<.001): as male infants aged, there was a steeper decrease in the amount of time spent in five metres of their mother than for female infants. This indicates instability in the original model regarding sex effects. A conservative interpretation is that any potential sex effects of infants being within five metres of their mothers are driven by the subset of cases where infants were in five metres but also in physical contact with their mothers.

Table 3.10: Model parameters for human mother-infant in five metres GLMM. *The reference level for Mother-infant in five metres was 'mother and infant not in five metres'. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level;* ***'''****indicates non-significance in main model, but that when overly influential participants were removed this was significant at the <.001 level.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	***SE***	***Z***	***95% confidence interval***	***P***
Mother-Infant in 5 metres (all participants) GLMM ($\chi^2_{(6)}$=123, *p*<.001***)	(Intercept)	1.02	.183	5.56	.658 to 1.38	<.001***
	Infant age	-.062	.009	-6.57	-.081 to -.044	<.001***
	Infant Sex	-.060	.244	-.248	-.543 to .422	.804
	Culture	1.06	.243	4.36	.584 to 1.54	<.001***
	Infant age* Sex	.019	.012	1.59	-.004 to .042	.113 '''
	Infant sex* Culture	-.248	.295	-.842	-.834 to .336	.400
	Infant age* Culture	.001	.012	.062	-.024 to .025	.951

Human number of individuals in five metre proximity to the infant

When all types of individuals excluding the mother were considered together, there was an interaction between infant age and infant sex on how many non-mothers were within five metres of an infant (see *Table 3.11*). As female infants aged they were less likely to have non-mother individuals in five metres of them, but as male infants aged they were more likely to have more individuals within five metres of them. When overly influential participants were removed (female: 1 Ugandan, 7 UK; male: 4 Ugandan, 3 UK) the age by sex interaction remained stable, but the reduced model also showed a significant interaction between infant sex and culture (*Est*=.439, *SE*=.192, *Z*=2.29, *p*=.022), where, in the UK, female infants were more likely to have more non-mother people in five metres than males, whereas there was no effect of sex on number of individuals in five metres in the Ugandan sample. A conservative interpretation of this is that the age by sex interaction is robust, but the sex by culture interaction is less likely to be robust, and warrants further investigation.

Human children in five metre proximity to the infant

There were no effects of infant sex or age on the number of children in five metre proximity to the infant (*Table 3.12*). Ugandan infants had significantly more children within five metre proximity than UK infants.

Table 3.11: Model parameters for human number of non-mothers within five metres GLMM. *LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; ** indicates significance at <.01 level; * indicates significance at <.05 level; ʻ indicates non-significance in main model, but that when overly influential participants were removed this was significant at the .05 level.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Number non-mothers in 5 metres GLMM ($\chi^2_{(6)}$=16.7, *p*=.010*)	(Intercept)	.199	.129	1.54	-.056 to .453	.124
	Infant age	.003	.006	.477	-.009 to .015	.633
	Infant Sex	.217	.170	1.28	-.118 to .554	.201
	Culture	-.121	.165	-.732	-.448 to .205	.464
	Infant age* Sex	-.023	.007	-3.09	-.037 to -.008	.002**
	Infant sex* Culture	.246	.209	1.18	-.161 to .657	.240ʻ
	Infant age* Culture	.009	.007	1.27	-.005 to .024	.203

Table 3.12: Model parameters for human number of children within five metres negative-binomial GLMM. *LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; ** indicates significance at <.01 level*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Number Children in 5 metres GLMM ($\chi^2_{(6)}$=22.1, *p*=.002**)	(Intercept)	-.040	.167	-.239	-.367 to .287	.811
	Infant age	-.009	.006	-1.37	-.022 to .004	.169
	Infant Sex	-.109	.241	-.452	-.582 to .364	.651
	Culture	-.788	.233	-3.38	-1.25 to -.331	<.001***
	Infant age* Sex	.011	.008	1.41	-.004 to .027	.158
	Infant sex* Culture	.001	.313	.005	-.611 to .614	.996
	Infant age* Culture	.015	.008	1.86	-.001 to .032	.063

Human non-mother adult female in five metre proximity to the infant

There was an interaction between infant age and infant sex (see *Table 3.13*) – as female infants aged they were less likely to have a non-mother adult female in five metres, and as male infants aged they were more likely to have a non-mother in five metres. However, when overly influential participants were removed (female: 3 Ugandan, 5 UK; male: 5 Ugandan, 3 UK), this interaction was not significant (*Est*=-.014, *SE*=.015, *Z*=-.912, *p*=.362), and there were no other significant factors in the model.

Table 3.13: Model parameters for whether there was a non-mother adult female in five metres binomial GLMM. *The reference level for non-mother in five metres was 'no non-mother adult female in five metres'. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; ++indicates significance in main model at the .01 level, but that when overly influential participants were removed this was non-significant.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Non-mother female adults in 5 metres GLMM ($\chi^2_{(6)}$=17.0, *p*=.009**)	(Intercept)	-1.70	.206	-8.24	-2.11 to -1.29	<.001***
	Infant age	.010	.011	.874	-.012 to .032	.382
	Infant Sex	.358	.268	1.34	-.169 to .886	.181
	Culture	.082	.260	.316	-.430 to .596	.752
	Infant age* Sex	-.043	.013	-3.28	-.068 to -.017	.001++
	Infant sex* Culture	.200	.319	.626	-.433 to .831	.532
	Infant age* Culture	.013	.013	.990	-.013 to .039	.322

Human adult male in five metre proximity to the infant

There was a three way interaction between infant age, infant sex, and culture (see *Table 3.14)* in terms of the number of adult males in five metre proximity to infants. In Uganda, as female infants aged they had fewer adult males in five metres, but the number of adult males within five metres of an infant was relatively stable in the other sex and culture categories.

When overly influential participants were removed (female: 7 Ugandan, 6 UK; male: 4 Ugandan, 10 UK) this three-way interaction was no longer significant (*Est*=.-.009, *SE*=.032, *Z*=-.288, *p*=.774), indicating instability in the model. In the model without influential participants, there was an interaction between infant age and sex (*Est*=-.053, *SE*=.026, *Z*=-

2.07, *p*=.039), where female infants had fewer adult males in five metres of them as they aged, but not for male infants. In the model without influential participants, there was also an effect of culture (*Est*=.1.34, *SE*=.424, *Z*=3.17, *p*=.002), in that UK infants had more adult males in five metres of them than Ugandan infants.

Table 3.14: Model parameters for human number of adult males within five metres GLMM. *LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; * indicates significance at <.05 level; +++indicates significance in main model at the .001 level, but that when overly influential participants were removed this was non-significant; ++indicates significance in main model at the .01 level, but that when overly influential participants were removed this was non-significant.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Number male adults in 5 metres GLMM ($\chi^2_{(7)}$=67.0, *p*<.001***)	(Intercept)	-2.70	.264	-1.25	-3.24 to -2.20	<.001***
	Infant age	.025	.012	2.08	.001 to .049	.038*
	Infant Sex	1.13	.355	3.18	.457 to 1.84	.001++
	Culture	.853	.339	2.51	.266 to 1.53	.012*
	Infant age* Infant Sex	-.108	.018	-6.12	-.143 to -.073	<.001***
	Infant sex* Culture	-.548	.468	-1.17	-1.47 to .369	.242
	Infant age* Culture	-.006	.016	-.397	-.038 to .025	.692
	Infant age* Infant Sex* Culture	.081	.022	3.61	.037 to .125	<.001+++

3.4.1.4 Summary

In summary, sex effects in infant early life social experiences were broadly comparable in the two cultures examined. Mothers were more likely to be an infants' social partner and to be more often in contact with male infants at 3-months; but as they aged, mothers and female infants were more likely to be in contact, and female infants' social interaction partners were more likely to be their mother. Infant males seemed to have fewer individuals within five metres of them when young, especially in the UK; but as infants aged the males had more individuals in proximity, whilst females had fewer individuals in proximity. There were some hints in the data that male and female infants may differ in their tendency to be in close proximity to or to interact with non-mother adults as they age, however, these effects were not reliable and they seemed to be driven by a few individuals where they did appear. Overall, then, these two cultures show the same broad pattern that suggests there may be human sex differences in early socialisation. In order to explore how they compare to non-human primates, I next collapsed across cultures and compared human early social environment to that of chimpanzees and macaques.

3.4.2 Are sex differences and similarities in social experience consistent across human, chimpanzee, and macaque infants from 0- to 12-months?

In all human-NHP GLMMs, the reference level for species was human, and the reference level for sex was male.

3.4.2.1 Across species, do male and female infants differ in how likely they are to be engaged in social activities?

There was no significant effect of sex on how likely infants were to be engaged in a social activity. There was, however, an interaction between infant age and species (see *Table 3.15*), in that infant macaques and humans were engaged in more social activities than chimpanzees when they were younger. However, as they aged, the chances that an infant chimp would be engaged in a social activity increased, and the chances that infant humans and macaques decreased, so that by 12-months, infants in all species were exhibiting a similar amount of social interaction.

Table 3.15: Model parameters for all species social activity GLMM. *The reference level for Social activity was 'infant was not engaged in a social activity'. The reference level for Species was Human. The reference level for Sex was male. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; ** indicates significance at <.01 level.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
All species Social activity GLMM ($\chi^2_{(9)}$=216, *p<.001****)	(Intercept)	-.857	.097	-8.80	-1.05 to -.667	<.001***
	Infant age	-.031	.011	-2.97	-.052 to -.011	.003**
	Infant Sex	.046	.127	.359	-.204 to .296	.719
	Species (Chimp)	-1.73	.236	-7.36	-2.20 to -1.28	<.001***
	Species (Macaque)	.550	.127	4.33	.301 to .800	<.001***
	Infant age* Sex	-.005	.013	-.346	-.031 to .021	.729
	Infant sex* Species (Chimp)	.087	.205	.425	-.317 to .489	.671
	Infant sex* Species (Macaque)	-.083	.159	-.521	-.399 to .231	.602
	Infant age* Species (Chimp)	.092	.024	3.85	.046 to .139	<.001***
	Infant age* Species (Macaque)	-.072	.015	-4.91	-.100 to -.043	<.001***

3.4.2.2 Across species, do male and female infants differ in how likely they are to be engaged in social activities with partners of particular identities?

Cross species infant social interactions with their mother

There was no significant effect of sex on how likely infants' social partners were to be their mothers (*Table 3.16*). There was, however, an interaction between infant age and species on how likely infants' social partners were to be their mother (see *Table 3.16*). In all species, the chances that an infant's social partner would be their mother decreased, but this effect was strongest in macaques, and weakest in humans – so that by 12-months, infant macaques and chimpanzees had a similarly low chance that their social partner would be their mother, but human infants at 12-months had a higher chance that their social partner would be their mother than both macaques or chimps.

Table 3.16: Model parameters for all species mother partner GLMM. *The reference level for Mother Partner was 'mother was not infants partner'. The reference level for Species was Human. The reference level for Sex was male. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; * indicates significance at <.05 level.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
All species Mother partner GLMM ($\chi^2_{(9)}$=305, *p<.001)*	(Intercept)	1.98	.227	8.70	1.54 to 2.44	<.001***
	Infant age	-.044	.024	-1.81	-.092 to .004	.071
	Infant Sex	-.312	.282	-1.11	-.870 to .785	.268
	Species (Chimp)	-2.03	.535	-3.79	-3.10 to -.981	<.001***
	Species (Macaque)	.303	.278	1.09	-.253 to .848	.276
	Infant age* Sex	.026	.029	.886	-.032 to .083	.376
	Infant sex* Species (Chimp)	.454	.474	.957	-.487 to 1.39	.339
	Infant sex* Species (Macaque)	.110	.329	.333	-.539 to .783	.739
	Infant age* Species (Chimp)	-.119	.056	-2.12	-.231 to -.006	.034*
	Infant age* Species (Macaque)	-.259	.031	-8.46	-.320 to -.200	<.001***

Cross species infant social interactions with other non-adults

There was no significant effect of sex on how likely infants' social partners were to be non-adults (i.e. a child or juvenile) (*Table 3.17*). There was, however, an interaction between infant age and species on how likely infants partner was to be another child or juvenile (see *Table 3.17*). In all species infants' partners were similarly likely to be another child or juvenile at the youngest age tested. For all species, the chances their social partner was a child or juvenile increased with age, but this increase was strongest in the macaques, then chimpanzees, and weakest in the humans.

Table 3.17: Model parameters for all species child or juvenile partner GLMM. *The reference level for child or juvenile Partner was 'a child or juvenile was not infants partner'. The reference level for Species was human. The reference level for Sex was male. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; * indicates significance at <.05 level*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
All species juvenile/child partner GLMM ($\chi^2_{(9)}$=214, *p<.001****)	(Intercept)	-2.65	.278	-9.52	-3.19 to -2.10	<.001***
	Infant age	.062	.029	2.15	.005 to .119	.032 *
	Infant Sex	-.216	.343	-.628	-.888 to .457	.530
	Species (Chimp)	-.590	.675	-.874	-1.91 to .733	.382
	Species (Macaque)	.278	.342	.814	-.392 to .948	.416
	Infant age* Sex	.000	.033	.002	-.065 to .065	.999
	Infant sex* Species (Chimp)	.079	.551	.143	-1.00 to 1.16	.886
	Infant sex* Species (Macaque)	.252	.417	.605	-.564 to 1.07	.545
	Infant age* Species (Chimp)	.206	.062	3.30	.084 to .327	<.001***
	Infant age* Species (Macaque)	.211	.034	6.15	.143 to .278	<.001***

Cross species infant social interactions with non-mother adult females

There was an interaction between infant age and sex on how likely infants' partners were to be a non-mother adult female (see *Figure 3.3, Table 3.18*). Male infants were more likely to have a non-mother adult female partner as they aged, but this was not the case for female infants. There was also an interaction between infant age and species on how likely an infants' partner was to be a non-mother adult female. Humans and macaques showed a similar pattern, in that they had low levels of social partners who were non-mother adult females which slightly increased with age. Chimpanzees had a higher chance of having a non-mother adult female social partner than humans and macaques, and the chances that an adult female was a chimpanzee infants' partner decreased with age. Taking these interactions together, it means that, for all species, when young, male infants had a lower or similar chance of interacting with an adult female, but as they aged they had a higher chance of interacting with non-mother adult females than female infants. In the case of the chimpanzees, who were less likely to interact with adult females as they aged, the age-sex effect is seen in the form of female infants' chances of interacting with non-mother adult females decreasing at a faster rate than for male infants.

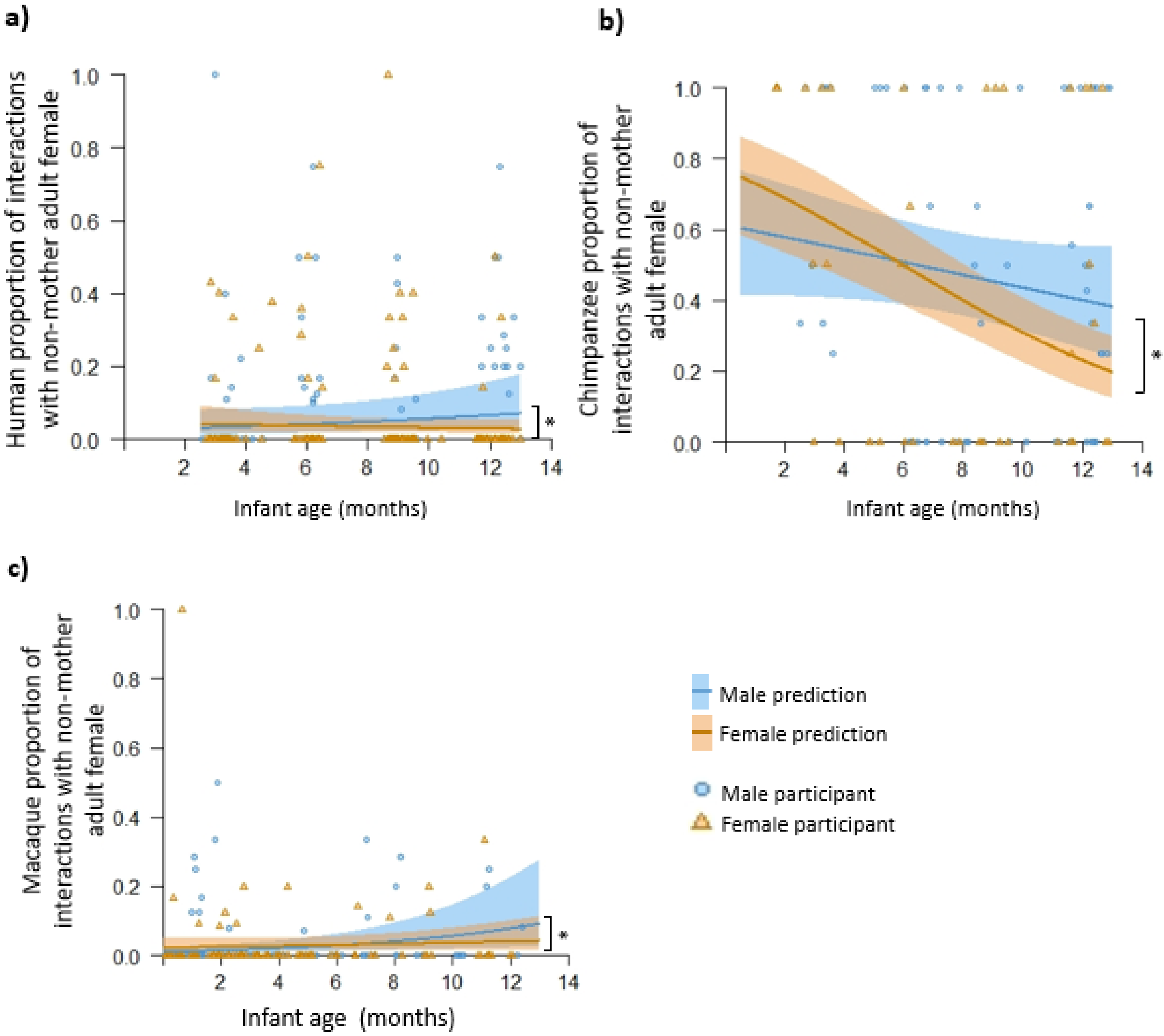


Figure 3.3: Mean proportion of social interactions where infant partner was a non-mother adult female for male and female infants (circles/triangles), and the expected values of this given GLMM results (lines) as they age. *Graph A: Humans, Graph B: Chimpanzees, Graph C: Macaques. Shading around the lines show 95% confidence intervals. * indicates significant interaction effect at p<.05 level. Predicted probabilities based of range of infant ages for that species that were entered into the model.*

Table 3.18: Model parameters for all species non-mother adult female partner GLMM. *The reference level for non-mother adult female Partner was 'a non-mother adult female was not infants partner'. The reference level for Species was human. The reference level for Sex was male. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; ** indicates significance at <.01 level; * indicates significance at <.05 level.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
All species adult female partner GLMM ($\chi^2_{(9)}$=106, *p<.001****)	(Intercept)	-3.70	.398	-9.30	-4.51 to -2.95	<.001***
	Infant age	.086	.040	2.13	.007 to .165	.033*
	Infant Sex	.648	.486	1.33	-.307 to 1.61	.182
	Species (Chimp)	4.16	.624	6.66	2.95 to 5.41	<.001***
	Species (Macaque)	-.912	.540	-1.69	-1.98 to .156	.092
	Infant age* Sex	-.128	.050	-2.54	-.228 to -.030	.011*
	Infant sex* Species (Chimp)	.084	.610	.137	-1.13 to 1.31	.891
	Infant sex* Species (Macaque)	.172	.619	.277	-1.05 to 1.41	.781
	Infant age* Species (Chimp)	-.158	.058	-2.71	-.273 to -.044	.007**
	Infant age* Species (Macaque)	.092	.063	1.47	-.033 to .213	.142

Cross species infant social interactions with adult males and multiple partners

Random effect intercepts for the GLMMs to explore adult male partners and multiple partners had high variance and were not normally distributed, thus these models violated GLMM assumptions and were not run. This is likely due to the low number of infants interacting with adult males especially in chimpanzees and macaques (see *Figure 3.4)*. There was also a low occurrence of infants interacting with multiple individuals at once, especially in chimpanzees (see *Figure 3.5)*.

Descriptively, human infants seemed to interact more with adult males than chimpanzees (who only show this at 12-months) or macaques (who rarely show it). Infant humans seemed to interact with a similar number of adult males over time, and macaque infants rarely interacted with adult males even as they aged. There doesn't seem to be an effect of sex on how much infants of any species interacted with adult males.

Descriptively, human infants also seemed to be engaged more with multiple individuals as they aged. There appears not to be any sex difference in the likelihood of engaging in a social activity with multiple individuals except potentially for macaques at 12-months, where females may be more likely to be engaged with multiple individuals at this age than males.

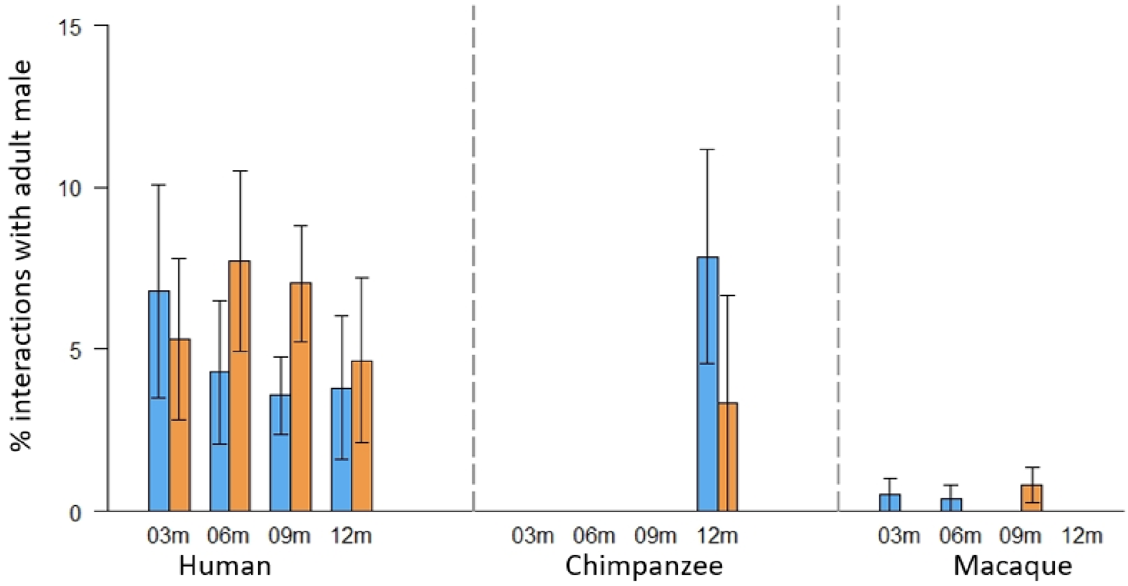


***Figure 3.4: Mean percentage of infants' social interactions which were with adult male conspecifics**. Ages binned into three-month time-points. m = months. Error bars show +/- standard error*

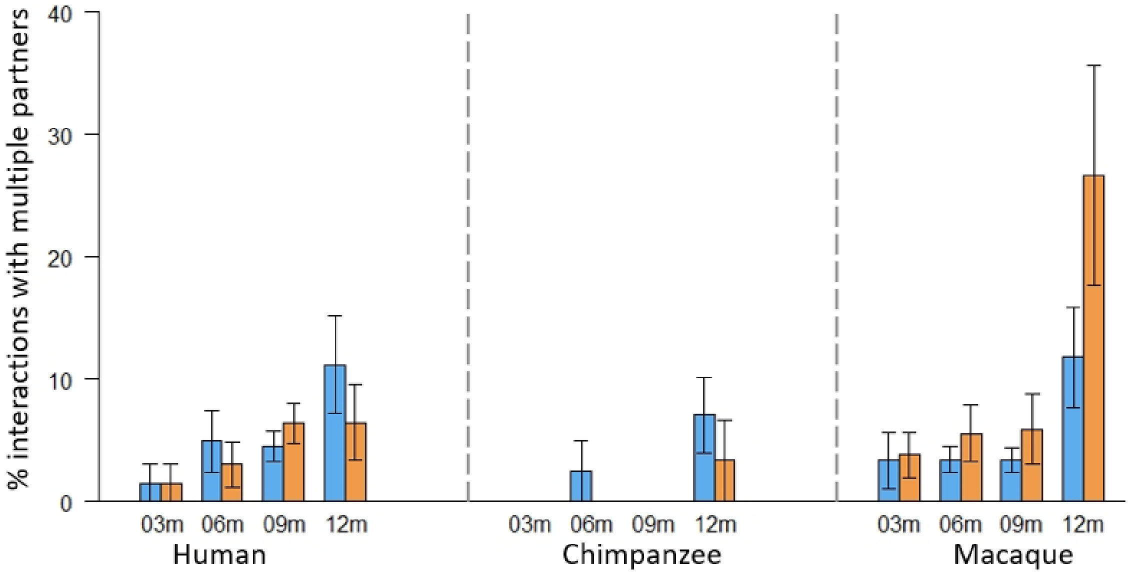


***Figure 3.5: Mean percentage of infants' social interactions which were with multiple partners.** Ages binned into three-month time-points. m = months. Error bars show +/- standard error.*

3.4.2.3 Across species, do the social environments of male and female infants differ?

Cross species infant in physical contact with their mother

There was a three-way interaction between infant sex, age, and species on how likely infants of all species were to be in physical contact with their mothers (See *Table 3.19*). Infant chimpanzees were in most contact with their mothers, followed by macaques, then humans. Infants in all species were less likely to be in contact with their mothers as they aged. This effect was strongest for female chimpanzees, and then male chimpanzees. Male human infants' contact with mothers decreased at a faster rate than for female human infants with age. Male and female macaques contact with mother decreased with age at a similar rate to one another.

However, when overly influential participants were removed (3 humans, 6 chimpanzees, 11 macaques), this three-way interaction was no longer significant, leaving only a significant interaction between infant age and species – where chimpanzees likelihood of being in contact with their mother as they aged decreased the steepest, followed by macaques, and then humans. In this reduced model there was a trend for an interaction between infant age and sex (*Est*=.029, *SE*=.017, *Z*=1.73, *p*=.084), where contact with the mother decreased with age at a faster rate for males than females.

Table 3.19: Model parameters for all species mother-infant contact GLMM*. The reference level for mother-infant contact was 'mother and infant not in physical contact'. The reference level for Species was human. The reference level for Sex was male. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; +indicates significance in main model at the .05 level, but that when overly influential participants were removed this was non-significant.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
All species mother-infant contact GLMM ($\chi^2_{(11)}$=1027, *p<.001****)	(Intercept)	.197	.122	1.61	-.043 to .438	.108
	Infant age	-.129	.012	-11.1	-.152 to -.107	<.001***
	Infant Sex	-.301	.176	-1.71	-.646 to .044	.087
	Species (Chimp)	4.56	.354	12.9	3.88 to 5.27	<.001***
	Species (Macaque)	1.62	.209	7.76	1.21 to 2.03	<.001***
	Infant age* Sex	.035	.016	2.10	.002 to .067	.036+
	Infant sex* Species (Chimp)	1.52	.726	2.10	.143 to 3.02	.036+
	Infant sex* Species (Macaque)	.349	.325	1.08	-.289 to .991	.283
	Infant age* Species (Chimp)	-.201	.032	-6.31	-.264 to -.139	<.001***
	Infant age* Species (Macaque)	-.150	.024	-6.27	-.197 to -.103	<.001***
	Infant age* Infant sex* Species (Chimp)	-.144	.065	-2.20	-.279 to -.020	.028+
	Infant age* Infant sex* Species (Macaque)	-.035	.035	-.986	-.105 to .034	.324

Cross species mothers in five metre proximity of their infants

For chimpanzees, infants and mothers were observed being within five metres of one another for all except 6 scan samples (of 2058). These instances were observed across 2 female, and 1 male chimpanzee infants, when aged 11.6-months to 12.8-months old. Due to the low number of mother-infant chimpanzee observations outside five metres, chimpanzees were excluded from further analysis here. There was a three-way interaction between infant age, sex, and species in the GLMM run to explore how likely infants were to be within five metres of their mother in humans and macaques (*Table 3.20)*. For infants in both species, as they aged, they were less likely to be within five metres of their mothers. In macaques this effect was earlier for male infants. In humans the decrease of time in five metres from their mothers decreased at a similar rate in males and females. However, when overly influential participants were removed from the model, there were no effects of sex, or any interactions with sex.

Table 3.20: Model parameters for human and macaque mothers and infants within five metres GLMM. *The reference level for Species was human. The reference level for Sex was male. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; +indicates significance in main model at the .05 level, but that when overly influential participants were removed this was non-significant.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Infant and mother in 5 metres GLMM ($\chi^2_{(7)}$= 524, *p<.001***)*	(Intercept)	1.62	.164	9.88	1.30 to 1.94	<.001 ***
	Infant age	-.060	.012	-5.02	-.084 to -.037	<.001 ***
	Infant Sex	-.125	.232	-.539	-.581 to .330	.590
	Species	2.77	.336	8.24	2.11 to 3.43	<.001 ***
	Infant age* Sex	.003	.017	.170	-.031 to .037	.865
	Infant sex* Species	.202	.534	.378	-.844 to 1.25	.705
	Infant age* Species	-.410	.033	-12.54	-.474 to -.346	<.001 ***
	Infant age* Species* Sex	.101	.048	2.085	.006 to .196	.037 +

Cross species non-mother individuals in five metre proximity of the infant

When all non-mother individuals were considered together, there was an interaction between infant age and sex on how many non-mother individuals were likely to be within five metres in chimpanzees and humans (see *Table 3.21*). Females had fewer individuals in proximity as they aged, but the number of individuals in proximity to male infants was stable over time. There was also an interaction between infant age and species on how many non-mother individuals were within five metres – chimpanzees had more individuals within five metres as they aged, while humans had fewer and this decreased with infant age.

However, when overly influential participants were removed (11 humans, 5 chimpanzees), the interaction between infant age and sex was non-significant (*Est*=-.008, *SE*=.009, *Z*=-.877, *p*=.380), but a stable main effect of sex was found in both models with the females having more individuals within five metres compared to male infants (*Table 3.21* for original model: reduced model *Est*=.296, *SE*=.122, *Z*=2.42, *p*=.015). There was still a significant interaction between infant age and species in the reduced model (*Est*=.026, *SE*=.011, *Z*=2.41, *p*=.016). In both the full and reduced model, at the younger ages female infants seemed to have more individuals in proximity to them, however instability occurred as infants got older as to whether there remained a difference (reduced model results) or if this gap closes (full model results).

***Table 3.21: Model parameters for human and chimpanzee number of non-mothers within five metres GLMM**. The reference level for Species was human. The reference level for Sex was male. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. ** indicates significance at <.01 level; * indicates significance at <.05 level; +indicates significance in main model at the .05 level, but that when overly influential participants were removed this was non-significant.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Number non-mothers in 5 metres GLMM ($\chi^2_{(6)}$=33.4, *p<.001****)	(Intercept)	.184	.089	2.08	.009 to .358	.038*
	Infant age	-.006	.006	-1.01	-.018 to .006	.313
	Infant Sex	.313	.123	2.55	.071 to .555	.011*
	Species	.362	.161	2.25	.046 to .679	.024*
	Infant age* Sex	-.017	.008	-2.05	-.033 to -.001	.041+
	Infant sex* Species	-.363	.236	-1.54	-.832 to .099	.123
	Infant age* Species	.026	.010	2.67	.007 to .046	.008**

Cross species non-adults in five metre proximity of the infant

The GLMM to explore the effects of infant age, sex, and species on how many children or juveniles were within five metres of infants did not explain significantly more variance than the null model (with only an intercept and the random factor; LRT: $\chi^2_{(6)}$=9.41, *p=.152).* Thus the number of non-adults in proximity to infants did not differ between male and female infants or as infants aged.

Cross species non-mother adult females in five metre proximity of the infant

There was an interaction between infant age and sex on how many non-mother adult females are likely to be in five metres (see *Table 3.22*): As female infants aged, they were likely to have a decreasing number of non-mother adult females in five metre proximity, but the number of non-mother adult females was stable across age for male infants. There was also an interaction between infant age and species on how many non-mother adult females were likely to be in five metre proximity: as human infants aged, they were likely to have decreasing number of non-mother adult females individuals in proximity to them, but as chimpanzee infants aged they were likely to have an increasing number of non-mother adult females in proximity to them.

However, when overly influential participants were removed (16 humans, 5 chimps), the age-sex interaction on the number of non-mother adult females in five metre proximity was no longer significant (*Est*=-.020, *SE*=.012, *Z*=-.505, *p*=.065). In this reduced model there was no effect of infant sex (*Est*=.278, *SE*=.177, *Z*=1.57, *p*=.117), but there was an overall effect of age (*Est*=-.028, *SE*=.008, *Z*=-.328, *p*=.001), in that infants were likely to have less non-mother adult females in five metre proximity to them as they aged. Across both the full model and the model without overly influential participants, there was no interaction between infant sex and species.

Cross species adult males in five metre proximity of the infant

There was an interaction between infant age and sex on the number of adult males within five metres of an infant (see *Table 3.23*). As females aged, there were fewer adult males in proximity to them, but as males aged, there were more adult males in proximity to them. There was also a main effect of species, where chimpanzee infants had more adult males in five metre proximity than human infants. There were no interactions between infant sex and species.

Table 3.22: Model parameters for human and chimpanzee number of non-mother adult females within five metres GLMM. *The reference level for Species was human. The reference level for Sex was male. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; ++indicates significance in the full model at p<.01 level, but that when overly influential participants were removed this was non-significant. +indicates significance in full model at p<.05 level, but that when overly influential participants were removed this was non-significant.* ***"*** *indicates non-significance in the full model, but that when overly influential participants were removed, this was significant at p<.01 level.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	***SE***	***Z***	***95% confidence interval***	***P***
Non-mother adult females in 5 metres GLMM ($\chi^2_{(6)}$=103, *p<.001****)	(Intercept)	-1.22	.130	-9.40	-1.48 to -.967	<.001***
	Infant age	-.009	.008	-1.21	-.024 to .006	.227 ''
	Infant Sex	.442	.177	2.50	.093 to .791	.013+
	Species	.904	.226	4.00	.460 to 1.35	<.001***
	Infant age* Sex	-.028	.009	-3.11	-.046 to -.010	.002++
	Infant sex* Species	-.343	.352	-.975	-1.04 to .350	.320
	Infant age* Species	.060	.009	6.49	.042 to .079	<.001***

Table 3.23: Model parameters for human and chimpanzee number of adult males within five metres GLMM. *The reference level for Species was human. The reference level for Sex was male. LRT = Likelihood Ratio Test for final model compared to model with only intercept and random factor. *** indicates significance at <.001 level; ** indicates significance at <.01 level; * indicates significance at <.05 level.*

	Model parameters					
Model (Null model LRT Chi-Square)	**Factor**	**Estimate**	**SE**	***Z***	***95% confidence interval***	***P***
Adult males in 5 metres GLMM ($\chi^2_{(6)}$=16.3, *p=.01**)	(Intercept)	-2.27	.183	-12.4	-2.65 to -1.92	<.001***
	Infant age	.019	.011	1.80	-.002 to .040	.072
	Infant Sex	.670	.249	2.69	.180 to 1.17	.007**
	Species	.701	.326	2.15	.070 to 1.34	.031*
	Infant age* Sex	-.044	.014	-3.21	-.071 to -.017	.001**
	Infant sex* Species	-.545	.493	-1.11	-1.54 to .419	.269
	Infant age* Species	-.002	.017	-.115	-.035 to .031	.908

3.5 Discussion

In the first part of this study I aimed to investigate whether male and female human infants from two cultures experienced similar or different social environments in their first 15-months. In part two, I aimed to investigate whether male and female human, chimpanzee, and macaque infants experience similar social environments in their first 12-months. In terms of the cross-cultural comparison, overall sex effects (or the absence of sex effects) in infant early life social experiences were broadly comparable across the two cultural groups. Despite previous research indicating infant females show more social interest than males from a young age (Connellan et al., 2000; Gluckman & Johnson, 2013; Lewis, 1969; Lutchmaya & Baron-cohen, 2002; Osofsky & O'Connell, 1977), this did not seem to impact engagement with others in this study. The overall amount of engagement with others was similar for male or female infants and from both cultures from 3- to 15-months, thus supporting findings from other earlier research (Lytton & Romney, 1991). This suggests female infants' early social interest does not appear to impact how much others react to them, or how much female infants initiate interactions as they get older. However, it has also been as suggested that as female infants age they may be more encouraged to be dependent on mothers than male infants (Lytton & Romney, 1991). This was held up in the current data. I found that in both cultures as infants aged, their mother was less likely to be their interaction partner. This effect was stronger for males than females, so that at older ages female infants were engaged more with their mothers than male infants.

This age-sex interaction in the likelihood of infants to be engaged with their mothers in social activities was also reflected in the results of mother-infant physical contact in both cultural groups: as infants aged, they were less likely to be in physical contact with their mother, but again, this effect was stronger for males than females. So, the youngest male infants were more likely than female infants to be in contact with their mothers, but with that pattern reversing as infants age, so that older female infants were more likely to be in physical contact with mothers than males. This provides further support to the idea that female infants are encouraged to be more dependent than males on mothers as they age (Lytton & Romney, 1991). This suggests the apparently conflicting results that female infants up to 3-months spend less time in contact with mothers than males, but female infants at 12-months spend more time in contact with mothers than males (Lewis, 1972; Moss, 1967) were due to sampling different aged infants. Perhaps surprisingly, when considering the likelihood of infants being within five metres of their mother, no clear sex effects were observed. However model instability may have contributed to this null result and further work is needed to ascertain if infant proximity to the mother is stable from 3- to 15-months across sex.

Given that parents may restrict or encourage social partners of particular identities differently for male or female infants, and that infants may use the opportunities they are given in different capacities, I next examined whether there were sex or sex-culture interaction effects on infant opportunities for interacting with or observing others, or in the number or type of infant interaction partners. When young, infant males had fewer non-mother individuals within five metres of them compared to females. However, as males aged they had more individuals within five metres, whereas females had fewer individuals in proximity as they aged. These differential opportunities did not, however, seem to translate into differences in direct social interactions. Male and female infants were equally likely to be engaged in interactions with others and to be engaged in social interactions with multiple individuals. Thus, the higher number of people in proximity when female infants were young did not give them an advantage over male infants in terms of active interactions. These data also indicate that that previous findings of boys showing stronger tendencies than girls to play in groups with multiple partners at older ages (Benenson, 1993; Benenson et al., 1997; Lever, 1978), are not evident in infants up to 15-months and likely emerge later. However given that infants can learn through observing others in proximity (Akhtar, 2005; Gaskins & Paradise, 2010; Lancy, 2013), these extra opportunities that girls seem to have when young may influence other aspects of human infants' developing cognition, such as social norms or cooperative behaviour (Blakemore et al., 2009; Endedijk et al., 2019; Lytton & Romney, 1991).

Focussing on the identity of the non-mother individuals in five metre proximity to and interacting with infants, males and females seemed to have similar numbers of children in proximity and similar likelihoods of interacting with other children. However, at least in the Ugandan sample, female infants had fewer adult males in proximity as they aged compared to male infants, indicating the chances of observing adult male specific behaviour, or third-party interactions which involve adult males was higher for male infants than female infants at older ages. This sex-differentiated opportunity to engage with adult males did not however translate into a clear sex difference in social interaction with adult males – although future work should confirm this as model instability could have contributed to this null result. There were also some hints in the data that male and female infants may differ in their tendency to be in close proximity to or interact with non-mother female adults as they age. However, these effects were not reliable as they seemed to be driven by a few individuals where they did appear, again suggesting further work is required to clarify if there may be genuine differences here.

Overall, the cross-cultural investigation revealed sex effects (mother-infant contact, mother as infant social partner, number of non-mother individuals in five metres, number of adult males in five metres) all varied as a function of infant age. This further highlights the importance of considering age when characterising and comparing infant early environment (see *Chapter 2*). Although potentially important dynamic sex differences in social opportunities have been identified, the data were not suitable for examining whether further sex differences may reside in the nature of the interactions undertaken. For instance the type of play or the type of toy offered to an infant may be different for male or female infants, and different interaction partners may differentiate their style of interaction with male and female infants to differing degrees. Video data of free play interactions with different partners may be a suitable way to examine these questions in future.

I expected that if infant male and female early social environment was a human universal, that I would see limited cross-cultural differences in the nature of sex-typed patterns of infant social environment between the two cultural groups examined and this notion was broadly supported. This is consistent with the proposal that sex differences in socialisation may be a human-wide trait, although to confirm this future studies would have to test a wider range of communities.

For the second part of this study, I investigated sex differences in humans, chimpanzees, and crested macaques in their first 12-months. Differential sex effects in infant environment across the three study species would indicate species-specific mechanisms (e.g. social norms and culture in humans; dispersal patterns in non-humans). However, in most cases I found no interactions between sex and species, and in the cases where there were hints in the data towards a sex-species interaction (mother and infant in five metres and mother-infant contact), the models were unstable and effects were driven by a few individuals. Further investigation to understand the sex related patterns in these species regarding mother-infant contact and proximity in the first year is necessary to confirm whether there are any consistent or species specific sex effects in infant-mother proximity during this period of infant development.

In contrast, conserved sex effects in infant environment across the three study species, despite different sex specific dispersal patterns, would indicate sex differences likely arose from evolved psychological mechanisms in either the infants or parents. In line with this, I found consistent cross-species sex differences in the likelihood for infants' social partners to be non-mother adult females. In human, chimpanzee, and macaque infants, when young, male infants had a lower or similar chance of interacting with an adult female, but as they aged they were more likely to be interacting with non-mother adult females than female infants. It is unlikely that this sex-age interaction in the amount of social interactions with non-mother adult females is driven by differential opportunities for interaction, as the conservative interpretation of results from this study is that there were no sex-differences in humans and chimpanzees in terms of whether there would be a non-mother adult female in five metres of infants. This however requires further investigation because the patterns relating to infant age and sex in terms of number of non-mother adult females in proximity may not be robust.

Another consistent effect across humans and chimpanzees was the sex-effect of the number of non-mother individuals in five metre proximity of infants at the youngest ages (~2-3 months), in that female humans and chimpanzees had more non-mother individuals in proximity to them compared to males. However due to model instability, it is unclear if this was an interaction with infant age or not. While at the older ages, the pattern was unclear, the clear pattern at the younger ages seen in this study contrast with the results of Murray et al. (2014), who found in another eastern chimpanzee community (Gombe), especially in the first six months of life, mother chimpanzees with sons were more gregarious than mothers of daughters. These authors argue that male fitness benefits more from socialising, and so mothers with daughters spend less time around more conspecifics. A possible reason for the conflicting results in my study is that the risk of infanticide may differ across communities of chimpanzees (for example, infanticide risk increases with instability in male chimpanzee hierarchy; Lowe et al., 2018), and thus the cost-benefit for socialising males versus females when young may vary depending on chimpanzee community. Further, although female infant chimpanzees and humans had more individuals in proximity at younger ages, no sex effects were found at young ages in any species for the likelihood of engaging in social interaction with any specific partner or multiple partners. This indicates the sex difference in opportunities for interaction does not directly influence infants' actual interaction experience.

A third sex effect I found to be consistent across humans and chimpanzees was regarding the number of adult male conspecifics in proximity to human and chimpanzee infants. For female infants, the number of adult males in five metres proximity decreased with age, and for male infants the number of adult males in proximity increased with age. Again, these results conflict with Murray et al. (2014), who found that particularly in the first 6-months, male infants were more likely to be in proximity of, and more likely to interact with adult male chimpanzees – whereas I only found there was a difference beginning to emerge between male and female infants as they approached 12-months. This also contrasts to Sabbi et al. (2021), as they found no sex differences in infant proximity to adult males, however this may be due to not having investigated infant age dynamically, and having looked at a much broader age range (infants to juveniles up to 9-years).

Taken together, my data suggests that although there may be sex differences in the number of individuals in proximity to the infant, interaction opportunities created by physical proximity are not driving actual interaction levels with certain non-mother individuals. Future research needs to look at if the number of individuals of particular age-sex classes in proximity predicts the amount of interactions at an individual level – as while these factors do not seem to align at a group level, individual level variation in the number of opportunities may predict interaction levels. Additionally, to start to unpack whether the infant, mother, or other individuals drive sex differences observed in this data set, future research could examine whether the infant or partner initiates the social interactions and whether other individuals approach the infant or the infant approaches them. This would, for example, allow investigation into whether it is a change in infant males' interest in adult females as they age, or whether adult females change their interest in infant males as they age which drives the higher likelihood of male infants interacting with adult females at older ages.

As mentioned above, no clear sex differences were found across species in the likelihood for infants to engage in social interactions, engage in interactions with adult males, or the number of non-mother adult females in five metre proximity. There were also no sex differences seen in the likelihood of infant interactions with mothers, interactions with other juveniles, or the number of juveniles in five metre proximity. This indicates there is consistency across species, suggesting females and males experience highly similar early environments. In some cases these null results were unexpected and contrasted with the human-only results considering infants up to 15-months or with previous research. Firstly, I found no sex differences in how likely the interaction partner would be their mother in infant humans, chimpanzees, and macaques up to 12-months-old. Given that there appeared to be an interaction of sex with age in human infants up to 15-months, but not up to 12-months, it appears the decrease in the likelihood of males and increase in likelihood of females interacting with their mother is not clearly established until after 12-months of age. Secondly, contrary to expectations, there was no sex difference in the amount of social interactions in macaques and chimpanzees. This indicates that the avoidant behaviour seen in adult males (Tyrrell et al., 2020) emerges after the first year of life in crested macaques. My data also fails to support the idea that male chimpanzee infants socialise more than female chimpanzee infants within their early months (Lonsdorf, Anderson, et al., 2014). It is possible that again the differences in male and female chimpanzee infant socialisation levels differs from those seen in Gombe, due to mothers altering their associations with other chimpanzees according to costs and benefits of socialising male and female infants given infanticide risk in specific chimpanzee communities during the time of study (Lowe et al., 2018). Further investigation into sex differences in chimpanzee infant early social environment may thus be needed to confirm overall chimpanzee species patterns.

In conclusion, this research used a comparative approach with analogous methods across groups, thus allowing direct comparison of naturalistic behaviour across cultures and species. This approach identified some important sex differences in early infant social behaviour and environment that were relatively stable both across cultural contexts in humans and across three primate species. The consistency of sex differences or lack of sex differences across two different cultural contexts indicates that these effects may be human-wide traits, rather than being culturally driven – this could be confirmed by examining early life experience in additional cultural groups. Similarly, in the cross species investigations, the clear sex differences which were found were consistent across species. Given the lack of complex culture, active teaching, and stereotypes in non-human primates, these sex differences in infant social behaviour and environment may be driven by conserved, evolved psychological mechanisms, shared with other primate species. Future work with a broader range of non-human primate species is required to confirm this. The majority of sex differences changed dynamically with infant age, even within the first 12- or 15-months of life. This study therefore demonstrates how important it is to consider male and female infants across multiples ages to fully understand the context in which they develop.

Chapter 4: Early life predictors of joint attention

4.1 Abstract

Joint attention, which is the ability to *coordinate* and *share* attention about objects or events, is an important social capacity which emerges during infants' first year of life. Joint attention as a broad concept includes joint attention *skills* (such as following in on others' attention, or directing others' attention), and joint attention *events* – in which two or more individuals use their joint attention and communication skills to share attention about an object or event with each other. Previous research has identified infant characteristics (such as emotional expression) and factors related to infant experience (such as maternal interaction style) which have been linked to the development of an individual's joint attention *skills.* However, less is known about the factors which predict infants being motivated to engage in joint attention *events*. Previous research has not implemented rigorous operational definitions of joint attention events, has neglected investigation into some basic social experience variables, and has focused on western, industrialised, educated, rich, and democratic (WEIRD) populations. In this chapter I explored whether factors which have been related to joint attentionin the past, as well as those which have not been studied before, are linked to whether mother-infant dyads will engage in joint attention events when presented with a novel stimulus. This included infant characteristic variables (e.g., expression of emotion, general cognitive development, communication development, and age of reaching physical milestones) and aspects of early social experience (e.g., mother interaction style, amount of social interactions). I looked at whether factors 3-, 6-, 9- and 11-months predicted joint attention engagement at 11- and 15-months in infants from the UK and Uganda. Joint attention events were measured during a naturalistic experiment where an erratically-moving laser light was presented on the ground close to the mother-infant dyad. I found that neither infant age, sex, nor cultural group predicted joint attention engagement. Other factors investigated, measuring infant characteristics and experience, were also not associated with the likelihood of infants engaging in joint attention events.. Methodological issues may have contributed to these null results, however replication with alternative contexts or measures of joint attention events may allow further investigation of whether the development of joint attention events is supported by the same factors which facilitate infants' individual joint attention skill development.

4.2 Introduction

Joint attention, which is the ability to *coordinate* and *share* attention about objects or events, starts to develop in human infants' first year of life (Bakeman & Adamson, 1984). Joint attention is an important social ability that is linked to other complex social skills, for example more advanced play (Bigelow et al., 2004), language learning (Adamson et al., 2019; Carpenter et al., 1998; Mundy & Gomes, 1998; Tomasello, 1988; Tomasello et al., 1986), cooperation (Tomasello et al., 2005; Wu et al., 2013), and theory of mind (Charman et al., 2000). Given that joint attention has important downstream links to other aspects of social development, understanding how joint attention emerges can provide the ground work on which to build interventions or advice for parents on how best to support the development of this important ability. Current research indicates that there may be links between infant experience and infant characteristics and skills, with aspects of joint attention development (Campos et al., 2000; Frank, Simmons, Yurovsky, & Pusiol, 2013; Gaffan et al., 2010; Hobson et al., 2004; Markus, Mundy, Morales, Delgado, & Yale, 2000; Osório et al., 2011; Salley & Dixon, 2007; Todd & Dixon, 2010; Vaughan et al., 2003). However, the literature is limited in its understanding of how these factors are relevant across cultures. Moreover, there are limitations in the precise definitions of joint attention. Thus, this chapter uses a longitudinal, cross-cultural approach to examine how factors within infants' early life may impact their engagement in joint attention events in a naturalistic context.

4.2.1 Joint attention development and its components

Before we examine potential predictors of joint attention development, we first need to clarify what we mean by joint attention and how it can be identified. Across the literature, joint attention is treated as a broad concept which can include joint attention *skills*, and joint attention episodes, bouts, or '*events'*. Here I will refer to joint attention skills as individual abilities that a child develops that enable them to coordinate attention with another individual – for example, attention checking, being able to follow other peoples' gaze or points (responding to joint attention skills), or to direct someone's attention to an object of interest (initiating joint attention skills; Mundy & Newell, 2007). Joint attention skills can be used competitively or selfishly and do not necessarily result in a shared experience with another individual. For instance, an infant could follow anothers' gaze to an object of interest, then go and take the object and interact with it individually. On the other hand, joint attention episodes or bouts, hereon referred to as '*events*' refer to the 'sharing' aspect of joint attention, when two individuals are engaged together. Engaging in joint attention *events* often uses joint attention skills (i.e., to share attention, individuals must first coordinate attention), but critically also requires infants to be motivated to engage jointly with their partner about an object or event, using communication to make the jointness of their experience manifest. For instance, after directing another individual's attention towards an object, the infant must then communicate something about that object to their partner.

Infants start developing different abilities necessary for engagement in joint attention events form a young age. The most basic traits that infants must have prior to engagement in joint attention are a social interest (which is present from birth in typically developing children; Cassia, Simion, & Umilta, 2001; Striano & Reid, 2006; Valenza, Simion, Cassia, & Umilta, 1996; Vouloumanos & Werker, 2007), and an interest in objects (which increases between 5- and 6-months; Deák & Triesch, 2006). Skills which allow children to respond to joint attention cues are important for engagement in joint attention events because they facilitate infants' coordination of attention. Theses responding to joint attention skills start to develop between 6- and 9-months, as infants start to follow gaze and point directions (Deák & Triesch, 2006; Gredeback et al., 2010). Infants begin reliably showing responding to joint attention skills by 11- to 13-months (Carpenter et al., 1998). These skills come together, and joint attention *events* start to be seen around 9- to 12-months (Carpenter & Call, 2013; Liszkowski, Carpenter, & Tomasello, 2007), and continue developing and becoming more sophisticated from 9-months and through the second year (Carpenter et al., 1998; Liebal, Behne, Carpenter, & Tomasello, 2009; Liebal, Carpenter, & Tomasello, 2010; Liszkowski et al., 2007; Moll, Richter, Carpenter, & Tomasello, 2008) as infants start to point more often, speak their first words, and widen their vocabulary (Fenson et al., 1994). In a visual joint attention event, partners typically alternate their gaze between the object of interest and each other (coordinating attention) and then share some kind of communication about the object or event (sharing attention), making it manifest that they know they are attending to the object together (Carpenter & Liebal, 2011).

One problem in the current literature which looks at early life environment predictors of joint attention, is that studies either focus exclusively on joint attention skills (e.g. Hobson et al., 2004; Leavens & Bard, 2011; Salley & Dixon, 2007; Todd & Dixon, 2010; Vaughan et al., 2003), or studies which do include joint attention events vary in their operational definition (Graham, Buryn-weitzel, Lahiff, Wilke, & Slocombe, 2021). Whilst understanding the factors that support the development of joint attention skills is important, joint attention skills alone are not sufficient for joint attention events to emerge. Joint attention events may be more relevant when trying to understand the context of joint attention as a social skill which can predict other social abilities. For example, gaze following can be performed with a selfish or competitive motivation, and does not necessarily mean you will also be good at communicating with reference to an object, which may be more relevant for cooperative action (e.g., you need to communicate your intentions regarding an object to cooperatively move it). Additionally, studies which look at joint attention events use a range of operational definitions for what constitutes a joint attention event (Graham et al., 2021). Some studies operationalise joint attention events in ways which do not encompass all aspects of sharing and knowing together – for example operationalising joint attention events as when two individuals towards the same location at the same time (see, Graham et al., 2021). However this *parallel attention* does not necessarily have an aspect of *sharedness* about it – as both individuals may be looking at the same thing by chance (e.g., if the focus is something salient in the environment).

Knowing together is an important part of the definition of a joint attention event (Carpenter & Liebal, 2011; Siposova & Carpenter, 2019) because it means an individual knows they are having a *shared experience* regarding an object or event – this could assist word-object matching in language acquisition, or shared intentionality in cooperation. Given this, in this study I will be using a definition based on that set out by Carpenter and Liebal (2011), who present a rigorous operationalisation which captures all important parts of a joint attention event: both individuals must look to a stimulus, then both must look to each other, and the pair must communicate during or just after mutual gaze. By including both individuals looking to the object, we can infer what the following behaviours are in reference to; and by having the individuals engage in mutual gaze, we can infer any following communication is directed at that individual (without relying on directionality cues from language which are lacking in pre-linguistic children). This gaze alternating (looking between the object and partner) constitutes the *coordinating* of attention. Including communication during the mutual gaze completes the event and allows an observer to infer whether the individuals within a dyad *know together* that each other are attending to the same object. Using this definition allows us to observe a dyad and deduce whether pre-verbal individuals are engaging in a joint attention event together when studying the development of joint attention.

4.2.2 Theoretical models of joint attention

In terms of developmental theories of joint attention, there are two main competing theoretical perspectives. The first, the *shared intentionality model* explains joint attention as a biological adaptation which arises from specific socio-cognitive abilities, including understanding others as intentional agents and the uniquely human motivation to share emotions and experience with others (Tomasello et al., 2005; Tomasello & Moll, 2010). Given that the shared intentionality model predicts that joint attention and related skills developed from a unique origin, we would thus expect a tight association between different joint attention skills. In contrast to this, *multiple processes models* argue that joint attention and related skills arise from domain general processes, leading to the expectation that different joint attention skills may have different developmental trajectories and joint attention development may be sensitive to early life experiences (Bard, Bakeman, Boysen, & Leavens, 2014; Deak, Triesch, Krasno, de Barbaro, & Robledo, 2013; Mundy, Card, & Fox, 2000). For example, the 'lived experience' multiple processes model, put forth by Bard et al. (2014), posits that the amount of social engagement experience promotes the development of joint attention skills and that differences between human and other hominoids in our expression of joint attention is due to differences in the environment in which we are raised. Multiple processes models support the idea that routines and early life experiences may support behaviours which are relevant to joint attention development in different ways, and thus different aspects of joint attention may develop independently as they may be underpinned by different domain general processes. Given that the shared intentionality model argues that joint attention will develop in children irrespective of their early environment, and multiple processes models argue that early socio-ecological environment will predict the development of joint attention, investigating early life predictors of joint attention could help disentangle these two perspectives.

4.2.3 Infant characteristics as predictors of joint attention

4.2.3.1 Joint attention and infant sex and age

Infant age and sex may have important influences on the early development of joint attention. Infant joint attention skills increase with age in the first two years of life, with one study finding responding to joint attention skills increasing in a linear manner from 9- to 18-months of age and initiating joint attention skills demonstrating a cubic developmental pattern (Mundy et al., 2007). Engagement in joint attention events is thought to start to emerge as part of the 'nine-month revolution' (Liszkowski, Carpenter, & Tomasello, 2007) and continues developing and becoming more sophisticated from 9-months and through the second year (Carpenter et al., 1998; Liebal, Behne, Carpenter, & Tomasello, 2009; Liebal, Carpenter, & Tomasello, 2010; Liszkowski et al., 2007; Moll, Richter, Carpenter, & Tomasello, 2008)

There is mixed evidence for whether infant sex influences joint attention behaviour. Sex differences have been found in areas related to joint attention such as social orienting (Romer, Ravitch, Tom, Merrell, & Wesley, 2011), and emotional expression (Blakemore et al., 2009; Chaplin & Aldao, 2013). Perhaps unsurprisingly, sex differences have also been found in direct measures of joint attention, albeit not consistently. For instance, Olafsen et al. (2006) measured joint attention in 12-month old infants with the Early Social Communication Scales (which measures infants' initiating and responding to communication skills) and found that girls outperformed boys on all communication related elements of the scales. In contrast, Heymann et al. (2018) failed to find any sex differences in any measure of the Early Social Communication Scales they conducted with infants at 14-,18- and 24-months old. Mundy et al. (2007) also failed to find any main effects of infant sex on responding to joint attention or initiating joint attention skills when considering longitudinal measures taken at 9-, 15- and 18- months together. However, post-hoc analyses showed girls outperformed boys at initiating joint attention measures at 9-months. Taken together, it seems important to consider effects of infant age and sex in any investigation into joint attention.

4.2.3.2 Joint attention and emotion

In terms of early life predictors of joint attention, there is evidence that some infant characteristics or skills (hereon referred to just as 'infant characteristics') are linked to the development of joint attention. Both the shared intentionality model and the multiple processes models would expect that individual variation in engagement of joint attention may be at least partially explained by variation of infant characteristics, such as emotional expressiveness, communication, and general cognition. It is important to acknowledge here, that while these factors may seem separate to infant experience, it is possible that infant prior experience has interacted with how they express these traits, and thus experience may impact joint attention development indirectly. An example of how such traits may be linked with joint attention is that joint attention events in infants are most likely to occur when they communicate their emotions about an object or event (Kasari, Sigman, Mundy, & Yirmiya, 1990; Mundy, Kasari, & Sigman, 1992), and thus more emotionally expressive individuals may be more likely to engage in joint attention events. Vaughan and colleagues (2003) examined whether early infant emotional reactivity could predict joint attention skills at concurrent or later ages. They conducted a longitudinal study with Spanish and English speaking families from Miami, USA. Parent reports of temperament were used as a measure infant emotional reactivity at 9- and 12-months. At 9-months, researchers measured infant initiating joint attention skills, and at 12-months they measured both initiating joint attention and responding to joint attention skills. They found no associations between infant emotional reactivity and responding to joint attention skills, but found that concurrent infant positive reactivity was associated with initiating joint attention skills at 9-months, and that infant negative reactivity at 9-months predicted 12-month initiating joint attention skills. These results suggest it is not necessarily how 'happy' or 'unhappy' individuals are which predict initiating joint attention skills, but that it may be *how much* they express emotions (rather than the directionality of the emotions) which may be linked to their chances of initiating joint attention.

However, the results from Vaughan et al. (2003) have been partially challenged by subsequent research that found negative relationships between infant initiating joint attention skills and negative emotion (Osório et al., 2011; Salley & Dixon, 2007). Salley and Dixon (2007) examined the relationship of temperament to initiating joint attention and responding to joint attention at the later age of 21-months. They tested 51 European Americans and found no link between positive emotionality and initiating joint attention or responding to joint attention. Instead, they found a negative relationship between initiating joint attention and negative emotion (fear and discomfort), in contrast to Vaughan et al. (2003). Osório et al. (2011), found in their sample of 52 10-month old Portuguese infants, negative emotionality was negatively associated with initiating joint attention skills, as well as a negative association with parallel attention. Although most studies have found no relationship between *responding* to joint attention skills and emotionality (Osório et al., 2011; Salley & Dixon, 2007; Vaughan et al., 2003), Todd and Dixon (2010) tested 25 infants from mid-west America, and found infant temperament moderated responding to joint attention skills at 11-months – with infants who scored highly on negative temperament being less likely to respond to joint attention bids. Taken together, these studies indicate there is a relationship, (albeit complicated, and possibly moderated by infant age) between infant temperament and joint attention *skills*. There is however no research looking at how temperament is associated with joint attention *events,* and given that joint attention skills may not reflect infant propensity to engage in joint attention *events,* more research is necessary to see if these associations between emotional expression and joint attention skills follow through to infant engagement in joint attention events.

4.2.3.3 Joint attention and communicative and cognitive abilities

In addition to expressing emotion, a range of other communicative abilities can support and enhance engagement in joint attention. Markus et al. (2000) investigated the link between communication skills and infant expression of joint attention (defined as simultaneous focus on an object while the child indicates awareness of the joint focus). They found that receptive communication skills at 12- and 18-months predicted duration of joint attention episodes at 18-months. They also found an association between expressive communication at 12-months and infant initiating joint attention skills at 18-months. However they found no concurrent or predictive relationships between expressive or receptive communication and responding to joint attention skills.

In line with the idea that a certain level of communication development is necessary to express joint attention, there may also be other parts of general infant cognitive development which support joint attention. Currently, however, there is limited empirical support to link general cognitive development and joint attention behaviours. Osório et al. (2011) did find a trend for general cognitive ability being positively associated with infant engagement in parallel attention, but no association between responding to joint attention or initiating joint attention skills. Additionally, Markus et al. (2000) found that 12-month cognitive scores were associated with concurrent responding to joint attention skills, but not with initiating joint attention or joint attention episodes (as defined as the dyad being focused on the same object and the infant indicating some awareness of their joint focus). Finally, if joint attention develops due to infants' innate motivation to share, then one could argue that they are more likely to share attention regarding something that is of interest to them: if an infant finds objects more exciting, then this may be linked to how likely they are to engage with others in a triadic way with these objects, yet this has not been investigated in the current literature.

4.2.3.4 Joint attention and motor development

Infant mobility is another aspect of infant development which may be linked to joint attention expression (Campos et al., 2000; Frank et al., 2013; Karasik, Tamis-lemonda, & Adolph, 2011; Walle, 2016). As discussed in *Chapter 2*, reaching new physical milestones can be impacted by parenting behaviours and also afford infants new learning opportunities (Adolph & Hoch, 2019; Campos et al., 2000; Iverson, 2010; Kretch et al., 2014). Once infants develop motor skills such as being able to sit, crawl, and walk, this impacts their viewpoint and how they experience the world (Adolph & Hoch, 2019; Daniel & Lee, 1990; Fausey, Jayaraman, & Smith, 2016; Frank et al., 2013; Gibson, 1988; Iverson, 2010; Jayaraman, Fausey, & Smith, 2015; Kretch et al., 2014). An infant who can sit has more stable posture for interacting with others and objects, and has more opportunity to engage in mutual gaze as parents are less likely to sit behind a stable infant to support their posture (Adolph &

Franchak, 2017; Frank et al., 2013). These are key skills for the development of joint attention.

Reaching mobility milestones (e.g. crawling and walking) may support joint attention in other ways too. As infants move around, and are able to pick up objects and bring them to show others they do not need to rely on others to place objects, or be in a certain location to have a triadic interaction about them (Karasik et al., 2011). Additionally, infants who can walk have more visual access to faces than crawlers due to the posture change which enables infants to view faces without having to crane their necks (Frank et al., 2013; Kretch et al., 2014). Infants who begin sitting stably, crawling, or walking earlier will have different learning opportunities than infants who develop these skills later (Adolph & Franchak, 2017; Karasik, Tamis-lemonda, & Adolph, 2011; Schwarzer, Freitag, & Schum, 2013), and thus the age at which infants reach these physical milestones may impact their joint attention development. It is important to also note, that while aspects of infant physical development may be genetically driven, there is also evidence that parental behaviour can influence the age at which infants develop such skills (Cole et al., 2012; Lagerspetz et al., 1971; Majnemer & Barr, 2005). So parenting practices may influence joint attention indirectly through impacting the age at which infants reach physical milestones.

While there is empirical evidence that reaching motor milestones is linked to cognitive development (e.g., spatial memory and more sophisticated social interactions, Adolph & Robinson, 2015; Clearfield, 2004, 2011; the amount of visual access to faces and amount of social looking, Frank et al., 2013; Kretch et al., 2014), there is limited work examining if there is a direct link between reaching physical milestones and joint attention development. Walle (2016) approached this by investigating whether walking ability was associated with responding to joint attention and initiating joint attention skills in 43 10- to 13.5-month old infants from the USA. Walle found that the amount of walking experience infants had, predicted parental reports of both infant initiating joint attention (defined as infant pointing, or bringing an object to parent) and responding to joint attention (defined as infant point or gaze following) skills. This study supports the theory posited by other researchers that locomotor development may be linked to joint attention development. However, relying on parental reporting of infant communicative skills has limitations: for example, parents' interpretation of 'successful' gaze or point following may vary across participants and so there is a need for a more precise exploration into these links. Experimental investigation of joint attention skills may provide more reliable measures of infant skill levels. Additionally, while theory supports the idea that milestones such as sitting may impact joint attention development, there is a lack of studies investigating if these milestones facilitate development of joint attention.

4.2.3.5 Summary of infant predictors of joint attention

So far I have discussed infant characteristics which may be linked to joint attention development. Emotional expression, communication development, cognition, and infant motor development are some factors that seem to be linked to joint attention development. Understanding how these factors are linked to infant joint attention can further our knowledge of joint attention development in general, and potentially help identify things to pay attention to when monitoring infant development. Understanding how infant experience may be more directly linked to joint attention development (as opposed to impacting infant characteristics which are linked to joint attention development) may help to distinguish between the *shared intentionality* model and *multiple processes* models. I will now discuss how infant social experience may be linked to joint attention development.

4.2.4 Infant social experience as predictors of joint attention

4.2.4.1 Maternal interaction style and joint attention

There is some evidence that parenting practices, which shape early life experiences, predict joint attention in infants. For example, maternal interaction style seems to be linked to joint attention development (Gaffan et al., 2010; Hobson et al., 2004; Osório et al., 2011). However the exact patterns of associations varied depending on variety of factors, such as the aspect of joint attention which was looked at, whether joint attention skills were tested between infants and mothers, or infants and researchers, and the age-points which were tested. Hobson and colleagues (2004), found that 28 British mothers (mixed ethnic backgrounds) who were more sensitive and reactive to their 12-month old infant's cues, and less interruptive of their infant's actions or attention, had infants who showed higher levels of orienting to an adult's (mother and experimenter) engagement with objects and events in the world. In addition to this, Gaffan et al. (2010), found that variation in maternal behaviour in 59 British mothers at 6- and 9-months was associated with infant joint attention skills, but the patterns were often not clear and depended on the measure of joint attention, and the age at which maternal behaviours was measured. For example, authors found that the degree to which mothers noticed and reacted appropriately to infant cues at 9-months, was positively associated with infant initiating joint attention skills with mothers at 9-months. However, the researchers did not find any significant association between how appropriately mothers reacted to their infant at 9-months, and how much infants showed initiating joint attention with a researcher as a partner – nor did they find any association when considering maternal reactiveness at 6-months to joint attention skills with mother or researcher at 9-months. They also found associations between mother interaction style and how much time infants spent in *shared attention* (defined as "*Episodes during which both partners knowingly attend to the same object or other external focus" pp375*; Gaffan et al., 2010). They found that mothers who more often noticed and reacted appropriately to their infant's cues at 6- and 9-months, had infants who spent more time in shared attention episodes with researchers (but not with mothers).

Gaffan et al. (2010) also found similarly nuanced connections between how mothers controlled interactions and infant joint attention skills. They found that how much mothers engaged in 'teaching' actions (such as demonstrating an action on a toy) during play at 9-months (but not 6-months) were positively associated with initiating joint attention skills with researchers (but not mothers) at 9-months. They also found that mothers who used more teaching actions at 9-months had infants who spend more time in shared attention with mothers (but not researchers). They also found that factors related to how the mother controlled the interaction in an 'entertaining' way, such as the amount of teasing or animating a toy, at 6- and 9-months, were negatively associated with initiating joint attention with mothers (but not researchers) at 9-months. Since associations were often not the same when predicting infant interactions with experimenters versus with mothers, these results indicate that the connections between maternal interaction style and how much infants initiate joint attention seem to vary depending on who the infant is interacting with, as well as the ages at which associations are investigated.

Although Gaffan et al. (2010) found negative associations between mother 'entertainment' behaviours and infant initiating joint attention with mothers, Osório et al. (2011) found a positive association between infant parallel attention and mother entertaining behaviours at 10-months. It is possible that the differences in these findings could be related to the relative frequency of different types of 'entertaining' behaviour. It is possible that 'teasing' behaviour may be 'intrusive' or against infants desires, and thus linked with 'insensitive' behaviour (found to negatively associate with joint attention development by Hobson, Patrick, Crandell, Garcı, et al., 2004; and Gaffan et al., 2010). Alternatively, maternal entertaining behaviour may differentially impact joint attention skills and episodes. In line with this, Osório et al. (2011), found that 'teach' behaviours were negatively associated with initiating joint attention, but Gaffan et al. (2010) found a positive association with 'shared attention'. These diverse findings highlight the importance of considering that, in line with multiple processes models of joint attention development, that joint attention skills may not predict joint attention event engagement, or that associations may be sensitive to methodological differences such as the paradigm used to test joint attention skills, the definition of the skills examined, and who infants interaction partner is. While there seems to be at least some kinds of links between maternal interaction style and joint attention development, there is currently a lack of research into how maternal style may link to how likely infants are to show joint attention events when defined rigorously, and how that may compare to the nuanced connections seen when looking at joint attention skills.

4.3.4.2 Other aspects of social experience as predictors for joint attention

Although maternal interaction style seems to impact joint attention development, there is currently a lack of research into whether the *amount* of social interactions human infants experience is linked to joint attention event development. This is a noteworthy gap in the current literature given that in one of humans closest living relatives, chimpanzees, research has found that infants with more social stimulation, and more experience in social interactions with caregivers early in life, perform better at coordinating their attention to an experimenter in a joint attention task compared to those with less social stimulation (Bard et al., 2014). Additionally, there are other areas of infant early life environment which may have important links to joint attention development which have received limited investigation. We know that infants can learn from observing others (Akhtar, 2005; Gaskins & Paradise, 2010; Lancy, 2013; Thiele, Hepach, Michel, & Haun, 2021), but whether infant opportunities for observing others supports the development of joint attention has not been investigated. Additionally, research has linked joint attention to exhibiting more advanced behaviour in play in normally developing infants (Bigelow et al., 2004), and play therapy is used in neurodivergent children, such as children with autism spectrum disorder (Hillman, 2018), to encourage joint attention, but there is a lack of research focusing on how engagement in social object play may be linked to joint attention development in low risk infant populations. Thus whether aspects of infant general social experience links to joint attention development merits investigation.

4.2.5 A cross-cultural approach to joint attention

Discontinuities and gaps in previous research motivate further investigation into how infant characteristics or infant experience link to joint attention development, particularly joint attention events, when defined rigorously. However, one overarching issue that stands out across current research is that there is also limited work looking at whether these predictors of joint attention stand up cross culturally. Firstly, there is limited investigation into whether infants across different cultures show similar levels of joint attention at comparable ages. While Callaghan et al. (2011) found no cross-cultural differences in joint attention engagement (defined as responding to bids for attention and then gaze alternating between stimulus and partner) across Canadian, Peruvian, and Indian infants; there is evidence for a cross-cultural difference in early responding to joint attention skills in the sample used in this study (British and Ugandan infants: Buryn-Weitzel et al., 2021). Research also shows that parental initiating joint attention and responding to joint attention behaviours differ cross-culturally (Chinese immigrant and British participants: Vigil, 2002) which may impact infant engagement in joint attention events. Additionally, there is ample suggestions that differences in the society which a developing child belongs to may impact their joint attention development – for example, parents in different cultures show different interaction routines with their children, such as different amounts of triadic object play, amounts of mutual gaze, or amount of infant directed communication from the mother (British, Euro-American, Gusii, Kaluli, Samoan, Ugandan, and Yucatec Maya infants; Gaskins, 2006; Haensel, Smith, & Senju, 2021; Slocombe et al., 2020). Further, in some cultures, different contexts may be more or less appropriate in which to exhibit joint attention due to different cultural values (Gavrilov, Rotem, Ofek, & Geva, 2012) – for example Vigil (2002) suggests that joint attention skills are expressed differently across different cultures due to differences in cultural beliefs about children's needs. Furthermore, research into specific environmental influences on joint attention development is also limited to Western, Educated, Industrial, Rich and Democratic (WEIRD; Henrich et al., 2010) samples.

4.2.6 The current study

Overall, the current literature indicates that joint attention development is linked to infant characteristics (such as emotional expressivity) and experience variables (such as maternal interaction style). However, the influence of different variables likely changes dynamically with infant age and different aspects of joint attention (initiating joint attention skills, responding to joint attention skills; engagement in joint attention events). Indeed, whether engagement in joint attention events (where attention is both coordinated and shared) is predicted by variation in environmental factors remains unclear, as there is limited research available, especially from non-WEIRD populations to test this crucial question. In this study I aimed to address these issues by using a longitudinal, cross-cultural approach to identify early life predictors of infant engagement in joint attention events. I examined whether infant characteristics, or their early life experience predicted how likely they were to engage in a joint attention event with their mother. Joint attention was tested in infants' home environments using a naturalistic laser experiment with mother-infant dyads living in the UK and Uganda. During the laser experiment, a novel moving laser stimulus was presented to mother and infant when infants were 11- and 15-months old. Joint attention events (following definition of Liebal et al., 2010) were coded from the videos. This experimental paradigm was chosen over alternatives because it was thought the stimuli would be equally novel to infants in both cultural groups tested. The study aimed to investigate the potential contributions that infant characteristics, and infant experience have on joint attention development.

Firstly, before focussing on the main analyses of interest that investigated infant characteristics or infant experience as predictors of infant likelihood to engage in joint attention events, I tested whether variance in joint attention engagement could be explained by infants' culture, age, or sex. As outlined previously, infant age and sex have been found to effect joint attention behaviours and skills and it is important to consider these factors. Equally, given different cultures may encourage joint attention engagement in different contexts (Vigil, 2002), it was also important to test for cross cultural variation in engagement in joint attention events. Next, I investigated whether infant characteristics, such as infant emotional expression, and infant physical, cognitive, and communicative development, and early life environment measures predicted infant engagement in joint attention events. In terms of early life environment I included measures of maternal interaction style that have been previously linked to aspects of joint attention development as well as novel exploratory measures including the amount of social interaction and social object play infants experience and the opportunity for infants to observe others. I obtained predictive measures of early life environment and development from instantaneous scan samples of infant behaviour during 'typical' day observations, questionnaires, and video analysis of mother-infant play. I related these predictive measures to performance in the joint attention laser experiment.

In terms of infant characteristics, I examined whether general infant development was linked to joint attention expression by looking cognitive and communicative scores. Following Markus et al. (2000) and Osório et al. (2011), I expected that those with higher communicative and cognitive scores would be more likely to engage in joint attention events. Joint attention is most likely to occur when infants are communicating emotion (Kasari et al., 1990; Mundy et al., 1992), and the literature suggests that infant emotional expression is linked to joint attention skills and parallel attention episodes (Osório et al., 2011; Salley & Dixon, 2007; Todd & Dixon, 2010; Vaughan et al., 2003). Extrapolating to joint attention events from these findings, I expected that in line with Vaughan et al. (2003) infants who show more positive emotion would be more likely to engage in joint attention events and in line with Osório et al. (2011), Salley and Dixon (2007), Todd and Dixon (2010), infants who showed more negative emotion would be less likely to engage in joint attention events. I expected that those who engaged in more solo object play at early ages would be more likely to engage in joint attention events, as those with higher interest in objects may be more likely to be motivated to share attention about them, supporting the shared intentionality model.

Infants who can sit independently have a more stable base for mutual gaze (Frank et al., 2013). I therefore expected those who reached sitting milestones at an earlier age would be more likely to engage in joint attention events. Infants who can crawl and walk are able to bring objects to other people and have more access to faces (Frank et al., 2013; Karasik et al., 2011; Kretch et al., 2014). I therefore expected infants who were able to crawl and walk at younger ages may have more opportunities to develop joint attention skills, and therefore may be more likely to engage in joint attention events.

To test the key prediction of the multiple processes models, that infant experience and environment will influence development of joint attention, I examined a number of environmental factors. In line with previous findings regarding joint attention skills and parental engagement style (e.g. Gaffan et al., 2010; Hobson et al., 2004; Osório et al., 2011), I expected that mother interaction style would influence how likely infants are to engage in joint attention events. More specifically, following Gaffan et al. (2010), I expected that infants with mothers who were sensitive to their cues and reacted appropriately would be more likely to engage in joint attention events. Related to this, following Hobson et al., (2004), I expected that infants with mothers who intruded on infant space or interrupted their actions or attention would be less likely to engage in joint attention events. Given that an important part of a joint attention event is for individuals to communicate with one another about the object or event of interest, I expected that mothers who are more communicative to their infant during play to have infants who were more likely to show joint attention events. Additionally, given that mutual gaze is also an important part of *sharing* joint attention, and that infants are less likely to share mutual gaze if there is a larger motor cost to achieving mutual gaze (Franchak et al., 2018), mothers and infants who play more in a face-to-face set up may be more likely to engage in joint attention events.

In terms of the novel, exploratory environmental factors, I expected infants who engaged in more social interactions, and who had more people in proximity to them early in life providing opportunities for gaining social understanding would be more likely to show joint attention events. I also expected that infants who took part in more social object play would have more opportunities for engaging in a triadic way and thus expected them to be more likely to engage in joint attention events.

4.3 Methods

4.3.1 Participants

Participants were the same British and Ugandan infants described in *Chapter 2*. Four additional participants were excluded due to not having a viable joint attention experimental trial (see below), this left 43 Ugandan participants (24 female, 19 male) and 50 UK participants (25 female, 25 male) for analyses.

4.3.2 Data collection overview

Data for this study were collected using multiple methods described in the following sections. Data were collected longitudinally from infants aged 3- to 15-months-old. Data for predictors of joint attention were taken from: full-day follows, a developmental questionnaire, mother-infant play videos, and the Bayley Scales of Infant and Toddler Development Third Edition (hereon refered to as Bayley-III; Bayley, 2006). Three of the Bayley-III subscales were used: the Cognitive subscale, Expressive communication subscale, and Receptive communication subscale. The ages of infants for data collection and sample sizes for the different data collection methods are detailed in *Table 4.1.* How likely infants were to engage in joint attention was measured during a *'laser experiment'* which was conducted as a naturalistic experiment at 11- and 15-months.

4.3.3 Materials

4.3.3.1 Full-day follow materials

Materials for full-day follow data collection are detailed in *Chapter 2* (and appendix *A2.2*).

4.3.3.2 Developmental questionnaire materials

Materials for the developmental questionnaire are detailed in *Chapter 2* (and appendix *A2.3*).

4.3.3.3 Mother-infant play video materials

Mother-infant play videos were recorded using either a Panasonic HC-VX870 or a Panasonic HC-V180 video camera.

Table 4.1: Sample size, mean age, and age range for data collection. *Note: given the practicalities of conducting longitudinal research, not all participants had viable data for all time-points for all data collection methods (e.g. visits were sometimes missed due to scheduling difficulties, some participants left the study before reaching 15-months, sometimes protocols were incomplete due to infant distress, or video recordings of play or laser trials did not meet the specifications for inclusion set out to ensure data quality). The number of laser experiment trials included in this table is the maximum number of participants available per time-point, but when taking the time-points together the total number of unique participants in the UK was 50 and in Uganda was 43, as described above. Numbers for data collected with methods marked with a * only consider infants with at least one viable laser experiment (hence full-day follow and developmental questionnaire values may differ compared to other chapters where this data was used).*

		Ugandan participants			**UK participants**		
Data collection method	**Time-point**	**Number of Participants**	**Mean age** (months)	**Age Range**	**Number of Participants**	**Mean age** (months)	**Age Range**
Full-day follows*	3-month	23	3.3	2.8 - 3.8	35	3.0	2.5 - 4.0
	6-month	23	6.2	5.8 - 6.5	35	6.0	5.2 - 6.4
	9-month	23	9.3	8.8 - 9.6	35	8.9	8.5 - 9.5
Developmental questionnaire*	3-month	34	3.1	2.1 - 3.9	34	2.9	2.5 - 3.8
	6-month	38	6.0	5.6 - 6.5	46	5.9	5.3 - 6.6
	9-month	37	9.1	8.6 - 9.9	43	9.0	8.5 - 9.7
	12-month	37	12.2	11.1 - 12.9	44	12.0	10.6 - 12.9
	15-month	38	15.1	14.6 - 15.5	46	15.0	14.2 - 16.7
Mother-Infant play videos*	6-month	13	6.2	5.8 - 6.5	41	6.0	5.3 - 6.6
Bayley-III Cognitive*	11-month	33	11.4	10.4 - 12.6	47	11.2	10.8 - 11.8
Bayley-III receptive Communication*	11-month	28	11.1	10.3 - 11.8	46	10.8	10.3 - 11.5
Bayley-III expressive communication*	11-month	28	11.3	10.7 - 11.7	46	11.2	10.8 - 11.8
Laser experiment	11-month	32	11.3	10.8 - 12.3	42	11.0	10.3 - 11.8
	15-month	37	15.2	14.4 - 15.6	41	15.0	14.5 - 15.8

4.3.3.4 Bayley-III materials

Relevant materials for the Bayley-III Cognitive subscale, Expressive communication subscale, and Receptive communication subscale were used from the Bayley-III administration kit, as detailed in the Bayley-III administration manual (Bayley, 2006). The Cognitive scale is composed of 91 items which cover small tasks that assess aspects of cognitive processing such as sensorimotor development, exploration and manipulation, object relatedness, and concept formation. The Receptive communication sub-scale is composed of 49 items which assess preverbal behaviours, and vocabulary understanding development. The Expressive communication sub-scale is composed of 48 items which assess preverbal communication such as babbling and gesturing, as well as word production.

The Bayley-III scale was designed and validated with Western populations, so for use in Uganda items of the scales were reviewed to assess their local applicability by Ugandan research assistants, and researchers familiar with the objects found regularly in the home environment in that area of Uganda. Nine items in the Receptive communication sub-scale, and four items in the Expressive communication subscale were deemed culturally inappropriate in the published Bayley-III scales – for example, one item in the Receptive communication sub-scale requires infants to identify which picture is named by the experimenter from a choice of five objects, however some objects were not common in the home of the Ugandan participants in this study, and so infants would be disadvantaged in this scale if these objects were to be used. For items deemed potentially culturally inappropriate the items were replaced to be more familiar to the Ugandan participants'. All edits can be found in *Appendix A4.1*. For all items which were edited, the Ugandan participants either performed higher or at the same rate as the UK participant counterparts on the same items.

Bayley III scales reliability and validity

The Bayley III methods are considered reliable measures of infant cognitive, expressive communication, and receptive communication abilities. When tested from 10- to 12-months, the correlation between two half-tests, or the 'reliability coefficients', were .87, .76, and .90 for the cognitive, expressive communication, and receptive communication subscales respectively (Bayley, 2006) – thus showing internal consistency. The scales also show test-retest reliability: when 9- to 13-month olds were tested twice in 15 days (mean interval six days) their corrected r was .77, .77, and .84 for the cognitive, expressive communication, and receptive communication subscales respectively (Bayley, 2006).

The Bayley III methods are considered valid measurements of the intended constructs. The Bayley III scales have been compared to those of other developmental scales such as the Bayley scales for infant development II (BSID-II), and the Preschool Language Scale, fourth edition (PLS-4). The PLS-4 is composed of an auditory comprehension subscale, and an expressive communication subscale. When scores from children tested on the Bayley III as well as the BSID-II and the PLS-4 and were compared, there were higher correlations between relevant Bayley III subtests than irrelevant subtests. For example, as expected the correlations between the Bayley III receptive comprehension subscale with the PLS-4 auditory comprehension subscale was .62, whereas with Bayley-III gross motor and fine motor subscales was lower (.31 and .29 respectively).

4.3.3.5 Laser experiment materials

The laser experiment was conducted using a low power coloured laser (1mW). The laser was either red, green, or blue. This experiment was filmed using a Panasonic HC-VX870 and a Panasonic HC-V180 video camera.

4.3.3.6 Video coding materials

Videos of the mother-infant play and laser experiments were coded to extract data from them. Video coding was done on laptops with *Windows 10* (Bott & Stinson, 2019) installed. Coding was done either using *The Observer XT 14* software (Noldus), or via direct observation and entering the information directly into a Microsoft Excel (2016) spreadsheet.

4.3.4 Procedures

Data were either collected during full-day follows at 3-, 6-, and 9- months (overall procedure described in *Chapter 2)* or during *home visits* (overall procedure described in *Chapter 2*) at 3-, 6-, 9-, 11-, 12-, and 15- month time-points.

4.3.4.1 Full-day follow procedure

The overall full-fay follow procedure is detailed in *Chapter* 2. In summary, data were collected from a sample day of infant life. In Uganda data were collected every 15 minutes through direct observation. In the UK, data were collected every 30 minutes by phoning the mother and asking her questions. The amount of solo object play, amount of social object play, and amount of social interactions infants engaged in were characterised using activity data collected during full-day follows at the 3-, 6- and 9-month time-points. The number of individuals in five metres was also characterised using full-day follow proximity data from the 3-, 6- and 9-month time-points. During full-day follows, information on whether the focal infant cried or not was also collected. In the UK, at each phone call, caregivers were asked if their child cried within the previous half hour. In Uganda, researchers noted down when they witnessed the infant cry, and summarised every 15 minutes whether the infant had cried or not in the previous 15 minutes. Data on how often infants cried was also used from the 3-, 6- and 9-month time-points.

4.3.4.2 Developmental questionnaire procedure

During home visits at 3-, 6-, 9-, 12-, and 15-, months a developmental questionnaire was conducted (overall procedure described in *Chapter 2*). The time-point that infants were first recorded as being able to sit, crawl, and walk, were extracted from the developmental questionnaire.

4.3.4.3 Mother-infant play video recording procedure

To categorise mother-infant play style, videos of mother-infant play were collected. In the UK, during the 6-month home visits, mothers were requested to play with their infants in any way they normally would. These play sessions were filmed. In Uganda videos of mother-infant play were recorded either during the 6-month home visit (as in the UK), or during the 6-month full-day follow. During Ugandan full-day follows, mother and infant play was opportunistically filmed. Videos taken of play in Uganda were translated and transcribed into English by a local research assistant who was fluent in English and the main language of the mother.

4.3.4.4 Bayley-III procedure

When infants were 11-months old, the Bayley-III scales (Bayley, 2006) were conducted. The Bayley-III can be used to assess infant development up to 42-months of age across five domains (Cognitive, Communication, Motor, Social-emotional, and Adaptive). In this study, the Cognitive, Receptive communication, and Expressive communication sub-scales were used as measures of infant cognitive and communicative development. The scales were presented following the procedure detailed in the Bayley-III administration manual (Bayley, 2006). In summary, infants were presented age appropriate items (e.g. small tasks to assess their cognitive or communication development), and proceeded through items with increasing difficulty until infants were unable to pass five items consecutively. Infants were awarded one point for each item they completed successfully, and these were totalled to give a score for each sub-scale. At 11-months, two home visits were made to participants so these scales were not always presented on the same day, but we aimed to complete each subscale within one session.

4.3.4.5 Laser experiment procedure

During 11- and 15-months home visits, a laser experiment was conducted to evaluate infants' propensity to engage in joint attention events. Following Kaller (2012), the light of a laser pointer was presented to a mother and infant pair in their home environment. The colour of the laser light presented was counterbalanced across age points and participants. The laser was presented to the dyad with the aim that it would be unfamiliar and provide an exciting, novel stimulus over which the mother-infant dyad may wish to share attention. The laser light was shone on the ground around the mother and infant for approximately three minutes. The laser light was moved erratically and occasionally turned off and on again to remain interesting to the infant and retain their attention. Trials were cut short if the infant lost attention or became distressed. Care was taken to avoid shining the light in the eyes of the infant or mother.

Before the trial, the mother was informed that researchers would shine the light of a laser pointer to her and her infant. We asked her to respond to it how she normally would when seeing something new and unexpected, for example as if a beautiful butterfly were to fly past. For the initial set-up we aimed to have the mother and infant sit separately, angled towards an empty space in front of them *(*See *Figure 4.1*). The experiment was filmed from two angles: one camera was aimed to focus on the infant, and the other on the mother, so that both of their faces and eye gaze, as well as the laser light could be seen in at least one camera. Experimenters were positioned behind the cameras, and would move the camera position if necessary to try to retain clear views of the participants' faces and the laser. The initial area for the experiment was a space on the floor, clear from toys which may distract the infant, and we aimed to have the infant sitting without body contact to the mother. However, the set-up sometimes had to be altered because of space restrictions within some participants' homes (e.g. by altering filming positions) or because of infant temperament or mobility (e.g. infant would not sit separately from mother without getting upset or would move so was not sitting in the ideal start-up position). Throughout a trial if the infant was mobile then the constellation could also change if they moved. The light of the laser pointer was only presented in areas where both the mother and infant could theoretically see the light, i.e., if the infant moved out of the experimental area in a way that would prevent the laser being presented in a space viewable to both mother and infant, then the laser light would not be presented.

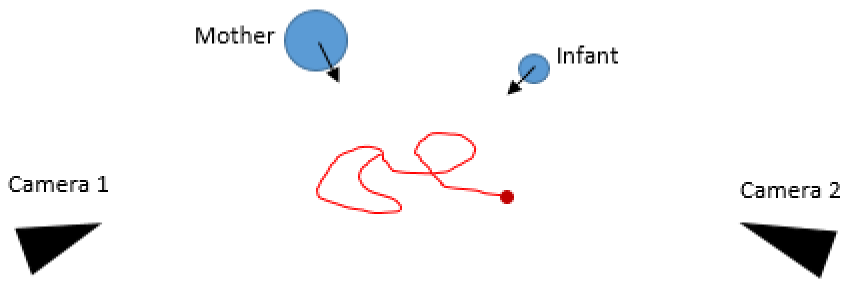


Figure 4.1: Initial constellation for laser experiment. *The body orientation of the mother and infant is indicated by arrows. Cameras were held by experimenters and the direction of the cameras is indicated by the narrow point of the triangle. The path of an example laser movement is depicted by the red line and dot. The experimental area in which the laser was presented and where the infant and mother were sat was usually up to about 2metres square, however if the infant moved outside of this area without the mother following, then the distance could be larger.*

4.3.3 Video coding

4.3.3.1 Laser experiment video coding

The coding criteria for the laser experiment can be seen in *Table 4.2*. *Stimulus presence* was coded during the *experimental period* so that we could know when the stimulus was present before coding *gaze direction*. All instances of *mutual gaze* during the experimental period were checked to see if both mother and infant gazed to stimulus in the three seconds prior to mutual gaze. Events where both mother and infant gazed towards the stimulus before mutual gaze were then examined to determine whether infants and mothers communicated during, or within 3-seconds after mutual gaze. Mutual gaze events where (i) the mother and the infant looked at the laser just before the mutual gaze event, and (ii) communication was produced by the mother and the infant during or just after mutual gaze, were considered *joint attention events*.

Table 4.2: Video coding criteria for Laser experiment videos. *Variables marked with a *were only coded during the Experimental period.*

Variables coded *(software used)*	**Definitions**
Experimental period vs Not coded *(The Observer XT)*	*Experimental period* was coded so that the video could be separated into sections of the video which were considered part of the trial, and sections which were not considered part of the trial. Thus sections which were not the experimental period were not coded for other variables. The experimental period of the video was considered from when the laser was first shown until the video ends, or when the experimenters say to the mother that the trial is over. *Not coded* period was coded before and after the experimental period and if there are any disruptions in the trial (e.g. child starts interacting with experimenters or leaves experimental area and needs bringing back).

Variables coded *(software used)*	Definitions
Stimulus presence *(The Observer XT)**	*Laser present* was coded when the light of the laser was turned on. The *laser turned off* period was coded so that we could consider the disappearance of the laser as an event which the infant may which to share attention about. This was included because infants indicate that they are able to share attention about absent referents (Liszkowski et al., 2007). *Laser turned off* was coded for the period of up to 10-seconds after the laser was turned off. *Stimulus absent* was coded to indicate the sections of the experimental period where we would not consider any laser stimulus or laser turning off event as an event for sharing attention about. Stimulus absent was coded before the laser was turned on the first time, and after the laser was turned off for 10-seconds.
Gaze direction - *coded separately for infant and mother* (*The Observer XT)**	*Gaze partners face* was coded when the infant or mother gazed at their partners face. *Gaze stimulus* was coded when the infant or mother gazed towards the stimulus. The 'stimulus' here refers to either the light of the laser, or to the surface the laser was shining on before it was turned off during the *laser turned off* period (n.b. this means that the mother and infant could gaze to the 'laser' for up to 10-seconds after the light was no longer being presented, this period was included because sometimes the absence of the laser would provoke a joint attention event). *Gaze elsewhere* was coded when infant or mother looked at neither the laser nor the partners face. Gaze elsewhere instances were only coded if they lasted for more than 1-second, but all other looks were coded no matter how brief.
Mutual gaze* *(The Observer XT*)	*Mutual gaze* was coded when infant and mother simultaneously gazed at each other's faces. These instances were identified based on the mother and infant gaze direction coding.
Communication-coded separately for infant and mother *(Microsoft Excel)*	*Communication* was coded as present or absent for the period during and 3-seconds after mutual gaze, directly into an Excel spreadsheet. Communication was coded as present when the individual showed a communicative facial expression, gesture, or if they vocalised. All vocalisations were considered potentially communicative unless they were effort noises produced by the infant when moving, or a cough or sneeze. See *Appendix A4.2* for a list of gestures and facial expressions that were considered potentially communicative in this context. Communication that was clearly directed towards only the experimenter (i.e. the individual only looks at the experimenter during the communication) was not coded.

Laser experiment video coding inter-observer reliability

After training research assistants, I and the research assistants independently coded five videos. The inter-observer reliability (IOR) function from *The Observer XT 14* (Noldus) was used to compare coding of experimental period, stimulus presence, and gaze direction between myself and each of the research assistants on both the duration and frequency of each category. Video coders achieved Cohen's kappas (Cohen, 1960) of above .70 for both frequency and duration analyses on five videos indicating high inter-observer reliability. IOR was run for whether communication was present around a mutual gaze event on 15% of mutual gaze instances using the *Psych* package in *R* (Revelle, 2020), and Cohen's kappa was above .79 each for whether the mother and infant communicated. Coding for the final dataset was split among myself and the research assistants trained on the relevant variables.

4.3.3.2 Mother-infant play video coding

Five minutes of mother-infant play was selected for video coding. Interactions which included other individuals (e.g. siblings) were not included. Ideally the five minutes of play would come from one continuous play bout. However if there was no single episode of that duration, the five minutes of play was taken from up to 3 videos, from a maximum of 6 uninterrupted bouts of mother-infant play. If the five minutes of play came from multiple play bouts, an attempt to balance the duration across bouts was made. If multiple appropriate videos were available, the five minutes of play was taken from the longest continuous play bout.

Play was not included if the mother or infant's attention was directed towards a researcher or other person for a prolonged period. If there was sufficient recordings of uninterrupted mother-infant play then the first minute of the videos were not used to allow a 'buffer' period for the dyad to settle into play. If there were multiple potential videos or sections of videos available to select for coding, then the videos which allowed coding of the most variables was selected (e.g. videos which included angles of infant and mothers face, videos without background noises).

Two types of video coding were conducted on mother-infant play videos: moment-to-moment coding, and Global ratings coding. Moment-to-moment coding was done using *The Observer XT 14* (Noldus). Global ratings coding was done by watching the video and entering the score into Microsoft Excel (2016). Moment-to-moment coding was used to characterise how much the mother vocalised during the play bout, and how much of the play was face-to-face play (as a proxy of how much opportunity infants had for mutual gaze with mother during play). Full moment-to-moment play video coding instructions can be found in *Table 4.3*. All video coding was done by fluent English speakers. When coding videos of Ugandan dyads, the videos were coded in conjunction with the written English translation.

*__Table 4.3: Moment-to-moment coding categories and definitions for focal play videos.__ Variables marked with a * were only coded during the 'coded period'.*

Variables coded	Definitions
Coded period vs Not coded	*A 'coded period'* was coded so that the video could be separated into sections of the video which were considered part of the trial, and sections which were not considered part of the trial. Thus sections which were not the coded period were not coded for other variables. *Coded period* was coded from when the selected section of 5-minutes of play began until there was an interruption or 5-minutes was complete. *Not coded* period was coded before and after the coded period and if there were any interruptions in the coded period (e.g. child or mother starts interacting with experimenters or anyone other than one-another for more than 3-seconds).
Mother vocalisations*	*Mother Vocalise* was coded when the mother made any vocalisation (language or non-language). Vocalisations were considered continuous unless there was a pause of more than 3-seconds between vocalisations. Laughs and audible gasps were considered vocalisations, but coughs and sneezes were not. *No vocalisation* was coded when the mother was not vocalising for at least 3-seconds. *Vocalisation unavailable* was coded if for any reason it was unclear whether the mother was vocalising (e.g. there was a vocalisation audible but it was unclear if it was the mother or somebody else, or if there is background noise which prevented the coder from hearing whether the mother vocalised)
Face-face play*	*Face-face play* was coded when infant and mothers were facing one another. Facing one another was considered if mothers face fell in to one of the following categories: - 45 degrees either side of where infants chest middle points forward - OR 45 degrees either side of their current face direction (with a limitation of up to 90 degrees of chest middle if infants head is turned away from the centre line i.e. up to the shoulders) *Not face-face play* was coded when mother and infant were not in face-face play. A 3-second rule was implemented for switching between categories of *face-face plan* and *not face-face play* i.e. the change in category had to last for at least 3-seconds to be considered a change.

Global rating coding was used to characterise infant affect and to further characterise mother interaction style. Videos were watched and rated on a scale of 1-4 to indicate how characteristic each variable was of the behaviour in the video segment. Global rating coding was used to characterise: infant positive affect; mothers reactiveness towards the infant and control of the interaction (hereafter referred to as *reactiveness*); and how intrusive to the infants space or interruptive to the infants actions or attention (hereafter referred to as *intrusiveness*) mothers behaviour was. A summary of the global ratings play video coding instructions, (adjusted from Gaffan, Martins, Healy, & Murray, 2010; Miller, Mcdonough, Rosenblum, & Sameroff, 2002; Murray, Fiori-cowley, & Hooper, 1996; and Seager et al., 2018) can be found in *Table 4.4,* full instructions are in *Appendix A4.3.*

Play video coding inter-observer reliability

After training research assistants, five videos were coded for mother vocalisation, and face-face play by myself and the research assistant independently. The inter-observer reliability (IOR) function from *The Observer* (Noldus) was used to compare coding by myself to the research assistant on both the duration and the frequency for each category. The video coders achieved Cohen's kappas (Cohen, 1960) of above .84 for both frequency and duration analyses on five videos indicating high inter-observer reliability. Fourteen videos were coded independently by myself and the research assistant for the global ratings variables (infant affect, mother responsiveness, and mother intrusiveness). Inter-observer reliability was run across these 14 videos using the *Psych* package in *R* (Revelle, 2020), and weighted Cohen's kappa achieved was above .77 for each variable. Coding for the final dataset was split among myself and the research assistants trained on the relevant variables.

4.3.5 Measures extracted from data

The number of mother-infant joint attention events in the laser experiments was totalled. Given that some trials had sections which were not codable (e.g., due to poor lighting conditions, or interruption by siblings), 3-minutes of trial was not available for all participants. Thus the period of the trial that was considered for joint attention events was constrained to the first 2.25 minutes (135 seconds) of experimental period. This limit was chosen to reduce the number of participants excluded from the study (allowing 35 extra laser trials to be included compared to a 3 minute limit), while still balancing how much the experimental period had to be shortened. Including the 2.25 limit on the experimental period of trials meant that 16 trials (four UK 11-months, three UK 15-months, six Ugandan 11-months, three Ugandan 15-months) had to be excluded. *Table 4.1* indicates the final total number of participants who had laser trials which could be used in analyses when implementing the 2.25-minute limit.

Predictor variables and the format they were used in analyses are detailed in *Table 4.5.*

Table 4.4: Summary of global ratings categories and definitions for focal play videos*. All global ratings were coded for the same period of the video as in the moment-to-moment coding (see Table 4.3). Full coding instructions for reactiveness and intrusiveness in Appendix A4.3.*

Global rating category	Global rating score definitions
Mother reactiveness	**Score 1:** Mothers will be given this rating if they are: - Preoccupied or missing infants cues - If she doesn't attempt to understand cues she picks up on, or does not respond appropriately to cues she does pick up on - Or if she does respond appropriately, it is not in a temporally contingent manner, or not persisting enough until infant is satisfied. The mother may show some sensitivity in how she interacts or responds with her infant but it is not consistent – overall she is more often insensitive than sensitive. **Score 2:** Mothers will be given this rating if they are: - Sometimes preoccupied or missing infant's cues (if they miss more than one overt cue they must be given a rating 2 or less) - Sometimes she doesn't attempt to understand cues she picks up on, or does not respond appropriately to cues she does pick up on - Or sometimes although she does respond appropriately, it is not in a temporally contingent manner, or she does not persist enough for the infant to be satisfied. The mother may show some insensitivity in how she interacts or responds with her infant but it is not consistent – overall she is more often sensitive than insensitive (or she is sensitive for half of the interaction, and insensitive for the other half). **Score 3:** Mothers will be given this rating if they: - Miss a maximum of one overt cue, and rarely miss less overt cues - Attempt to understand most cues - Respond appropriately to most cues she picks up on - Mostly respond in temporally contingent manner, and persists for long enough for infant to be satisfied

Global rating category	Global rating score definitions
Mother reactiveness (cont.)	**Score 4:** Mothers will be given this rating if they: - Do not miss any obvious infant cues, rarely misses subtle cues - Attempt to understand all infant's cues - Respond appropriately to all cues she picks up on - Respond in temporally contingent manner, and persists for long enough for infant to be satisfied
Mother intrusiveness	**Score 1:** The mother does not display any intrusive or interruptive behaviour. • If the mother touches the infant it is in an affectionate and gentle manner. Her touches never cause distress or avoidance • The mother does not put her hands, face, or objects very close into the infants face unless the infant is reacting positively to it. • She does not poke, prod, or pinch the infant • If the mother wants the infant to attend somewhere else, she first follows in on the infant's attention, and only then tries to encourage attention elsewhere. • If mother wants to make infant attend to something else, she would offer it as an option by placing it in the visual field. If she puts it so close to the infants face that they can't look at other things, or in the line of sight from something the infant is looking at then it would be considered an interruption and a higher score should be given. • The mother does not use extreme or exaggerated movements to get their attention. **Score 2:** The mother rarely displays any intrusive or interruptive behaviour, however on up to five instances she may show a mild intrusion or interruption, or one or two moderately intrusive instances. If there are more than five mild instances, or any intense instances the mother should receive a higher score. • If the mother touches the infant it is usually in an affectionate and gentle manner. Her touches rarely cause distress or avoidance • On occasion the mother may interrupt the infants attention or activity, but not in a very abrupt or rough way • On occasion the mother may sometimes put something close to the infants face, or tickle prod or poke them, without a positive reaction • The mother may have a mild physical intervention, or restrict a movement by the infant by holding their arm or leg, but never in a rough way

Global rating category	Global rating score definitions
Mother intrusiveness (cont.)	The mother usually does not use extreme or exaggerated movements to get their attention. **Score 3:** While there are periods where the mother is non-intrusive, she shows about two or more instances of moderate (rougher) intrusiveness or interruption, or more than about five instances of mildly intrusive or interruptive behaviour. If the mother shows any highly intrusive behaviours they must score at least a 3. • There are some periods where the infant is able to attend to what they want • The mother may put her hands, face, or objects very close into the infants face, or put them in the infant’s line of sight to make them pay attention to it. • The mother may manipulate the infant’s body to make them perform an action without apparent motivation from the child. • The mother may use extreme or exaggerated movements to get their infant’s attention. • The mother may interrupt the infant’s attention or activity in a physical way, or prevent them from attending to something by physically interacting with the child. • She may roughly tickle the infant, or restrict their movements. **Score 4:** Mother may receive this score if she regularly interrupts or intrudes on her infant, or if she shows more than about two instances of handling her infant in a rough way. • The mother’s predominant way of interacting may prevent the infant from attending to what they want, this may be due to physical manipulation, through taking toys away, or through interrupting the visual pathway of the infant. • She may jerk their limbs, or torso, or roughly tickle or poke her infant. • This mothers actions may cause her infant distress, discomfort, or avoidance • She may manipulate infants arms or legs in ways which do not seem to be in line with infants desires (coercion) • She may persist with a game or toy even if the infant doesn’t seem to want it. She may touch or put toys close into the infants face regularly.

Global rating category	Global rating score definitions
Infant positive affect	**Score 1:** Infant did not express any positive affect **Score 2:** Infant expressed minimal positive affect. For example, a few instances of closed mouth smiling, or one instance of open mouth smiling. **Score 3:** Infant expressed moderate or inconsistent positive affect. For example at least one instance of intense positive affect such as laughter, but this is not characteristic of the infant during the segment. Would also include two or more instances of open mouthed smiling, or closed mouth smiling throughout. **Score 4:** Infant expressed multiple intense bouts or predominantly moderate affect throughout segment. This would include, for example, open mouth smiling throughout, or two or more instance of laughter.

4.3.6 Analyses

Analyses were run in *R version 4.0.1* (R Core Team, 2020), using the *lme4* package. An alpha level of >.050 was used as the level at which the null hypothesis was accepted (Gibbs & Gibbs, 2015) for all statistical tests run.

Initially I wanted to examine whether infant's culture (UK or Uganda), sex (female or male), or age (11- or 15- months old) affected how many joint attention events mother-infant dyads were likely to show during the laser experiment. I ran a Poisson distributed Generalised Linear Mixed Model (GLMM) with log link function. I included infant cultural group, infant sex, and infant age as fixed factors, including all possible interactions. I included participant as a random factor. The random effect intercepts were non-normally distributed and had a large range, so this model did not meet the assumptions of GLMM. Thus I converted the outcome variable to binary (presence or absence of joint attention event), and ran a binomial GLMM with a logit link function. This model had suitably distributed random effect intercepts. The three-way interaction was non-significant, so the model was run without this factor to avoid overfitting. I report the results from the binary model with only two-way interactions in this study. Following null results from this model (see *Results 4.4.1*), subsequent analyses did not include infant cultural group, infant sex, or infant age.

Binomial GLMMs were also used to determine whether infant development, temperament, or early social environment predicted how likely infants were to show at least one joint attention event in the laser experiment. Participant was entered as a random factor for all models. Details of the fixed factors used in these GLMMs are seen in *Table 4.6*.

All GLMMs were compared to a null model only including an intercept and random variables using *lmtest* (Horthorn & Zeileis, 2002) likelihood ratio test. Random effect intercepts were visualised to explore whether they were normally distributed or had a large range. Cookes distance (calculated using *Influence.ME;* Nieuwenhuis et al., 2012), was used to assess whether any participants were overly influential in the model. To understand the effects of these overly influential cases, the GLMMs were run without these cases. The exclusion of these cases did not change the interpretation for any GLMMs run.

Table 4.5: Variables in study, what they were a measure of, where the data was collected from, and the format they were used in analyses. **given that scan samples were taken more regularly in the Ugandan sample, for these summary variables each alternate scan sample was labelled part 1 or part 2, and one part was randomly selected to so that summary variables for the UK and Uganda were made from data collected at the same intervals. **During data collection it was noted real-time when infants cried in Uganda, and then summarised every 15-minutes as whether they cried or not since the last scan sample. In the UK we relied on mothers remembering whether the infant cried or not in the last 30-minutes. It was the impression of the researchers that the data collection method in Uganda was more sensitive to more minor instances of infant upset than in the UK and thus separate UK and Ugandan models were these models were planned for this variable..*

Measure of		Variable	Data collection procedure	Format collected in	Format used in analyses
Infant characteristics	Interest in objects	Amount of solo object play	Full day follow at 3-, 6-, and 9-months	Infant activity per scan sample (categorical)	% of scan samples where the infants behaviour was solo play*
	General cognitive development	Cognitive score	Bayley-III cognitive score at 11-months	Integer score (range 25-48)	Integer score
	Communication development	Receptive communication	Bayley-III receptive communication score at 11-months	Integer score (range 4-15)	Integer score
		Expressive communication	Bayley-III expressive communication score at 11-months	Integer score (range 8-21)	Integer score
	Emotional expression/ temperament	Infant positive affect	Global ratings play video coding at 6-months	Integer score (range 1-4)	Integer score
		Amount of crying (Uganda)**	Full day follows at 3-, 6-, and 9-months	Binary per scan sample (did the researcher observe the infant cry in the previous 15minutes?)	% of 15-minute samples where researcher observed infant cry
		Amount of crying (UK)**	Full day follows at 3-, 6-, and 9-months	Binary per scan sample (did the mother report the infant cried in the previous 30minutes?)	% of 30-minute samples where mother reported infant cried

Measure of		Variable	Data collection procedure	Format collected in	Format used in analyses
	Infant motor development	Sit	Developmental questionnaire at 3-, 6-, 9-, 12-, and 15-months	Binary per time-point (yes/no)	Age at which first reported 'yes'
		Crawl	Developmental questionnaire at 3-, 6-, 9-, 12-, and 15-months	Binary per time-point (yes/no)	Age at which first reported 'yes'
		Walk	Developmental questionnaire at 3-, 6-, 9-, 12-, and 15- months	Binary per time-point (yes/no)	Age at which first reported 'yes'
Infant social experience	Social experience	Amount of social interactions	Full day follow at 3-, 6-, and 9-months	Infant activity per scan sample (categorical)	% of scan samples that infant's behaviour was an interaction with someone else (e.g. social play, being cared for, being fed)*
	Triadic experience	Amount of social object play	Full day follow at 3-, 6-, and 9-months	Infant activity per scan sample (categorical)	% of scan samples that infant's behaviour was social play involving an object*
	Social environment	Number of people in 5 metres of infant	Full day follow at 3-, 6-, and 9-months	Number of non-mothers in 5metres per scan sample	Median number of non-mothers in 5 metres*
	Mother-infant interaction style	Mother reactiveness	Global ratings play video coding at 6-months	Integer score (range 1-4)	Integer score
		Mother intrusiveness	Global ratings play video coding at 6-months	Integer score (range 1-4)	Integer score
		Mother vocalisation	Moment-to-moment play video coding at 6-months	% of video where vocalisations were available that the mother was vocalising	% time vocalising
		Face-face play	Moment-to-moment play video coding at 6-months	% of video where mother and infant head direction as available where mother and infant were engaged in face-face play	% time in face-face play

Due to slight differences in data collection that may have affected the sensitivity of the crying measure in UK and Uganda, separate models for UK and Uganda were constructed for this outcome variable. While the model to test whether the amount of crying was associated with joint attention event engagement for UK participants ran successfully, the model for the Ugandan participants did not. The random effect intercepts for the model containing the Ugandan data were non-normally distributed and had a large range, so this model did not meet the assumptions of GLMM.

4.3.7 Ethical note

Ethical approval was obtained for all data collection from the University of York Psychology department ethics committee. Ethical approval for data collection in Uganda was also obtained from the Regional Ethics Committee at the Ugandan Virus Research Institute, and permits for data collection in Uganda were obtained from the Ugandan National Council for Science and Technology.

Table 4.6: Details of GLMMs run to address whether infant characteristics, or infant experience predicted whether they would show at least one joint attention event in the laser experiment. *Fixed factors refer to measures described in Table 4.5*

Research question	Model	Fixed Factors
Does infant cognitive development predict joint attention engagement?	Interest in objects	Amount of solo object play
	General cognitive development	Cognitive score
Does infant communicative development predict joint attention engagement?	Communication development	Receptive communication score; Expressive communication score
Does infant emotional expression/temperament predict joint attention engagement?	Emotional expression/ temperament 1	Infant positive affect
	Emotional expression/ temperament UK 2	Amount of crying (UK)
Does infant social experience predict joint attention engagement?	Experience of environment	Sit; Crawl; Walk
	Social experience	Amount of social interactions
	Triadic experience	Amount of social object play
	Social environment	Amount of people in 5 metres of infant
	Mother-infant interaction style 1	Mother reactiveness; Mother intrusiveness
	Mother-infant interaction style 2	Mother vocalisation
	Mother-infant interaction style 3	Face-face play

4.4 Results

4.4.1 Infant performance in the joint attention experiment: effects of age, sex, and cultural group.

Across all trials, the mean infant looking time towards the stimulus was 60% (*SD*=16.4), indicating infants showed high interest in the laser stimulus. The mean percentage time looking towards the laser during the trial was similarly high in all culture, age, sex classifications (see *Appendix A4.4*).

At the 11-month time-point, 23% of infants showed at least one joint attention event with their mother during the laser experiment. At the 15-month time-point, 36% of infants showed at least one joint attention event with their mother during the laser experiment. *Figure 4.2* illustrates the percentage of infants who showed at least one joint attention event with their mothers split by culture and sex at the two time-points.

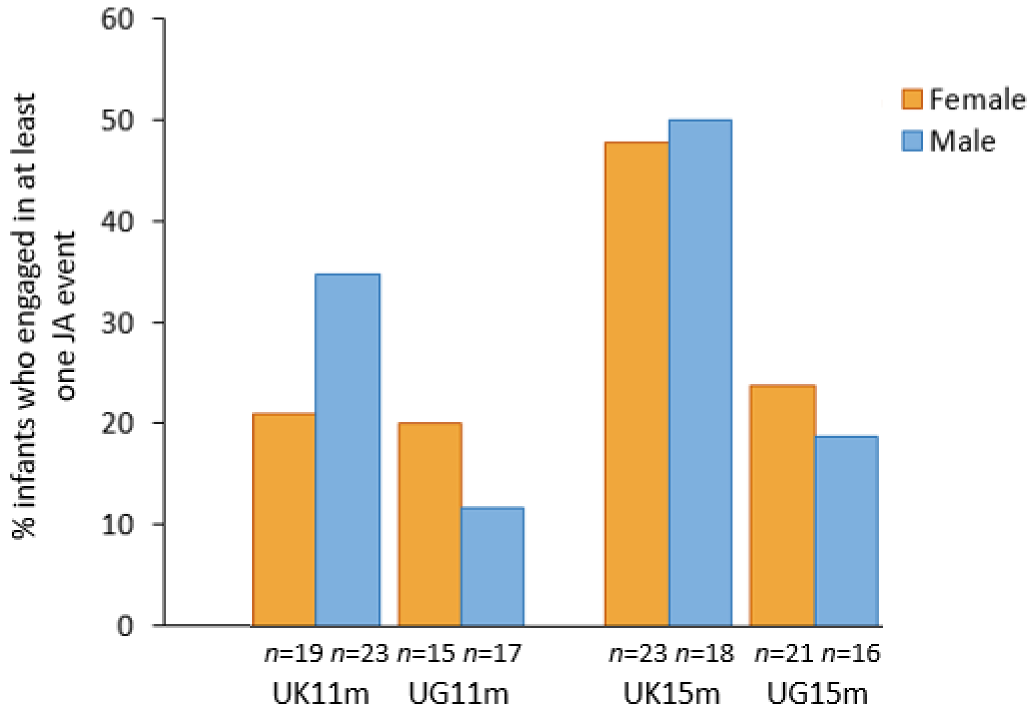


***Figure 4.2*: Percentage of UK and Ugandan infants who show at least one joint attention (JA) event in the 11- and 15-month laser experiments, split by infant sex.** 11m= 11-month time-point, 15m=15-month time-point, UG=Ugandan infants, UK=UK infants

The full GLMM examining whether infant cultural group, sex, or age predicted whether the infant would engage in any joint attention events did not explain more variance than the null model (Likelihood Ratio Test $\chi^2_{(8)}$=12.5, *p*=.051; full model parameters in *Appendix A4.5*).

4.4.2 Do other infant characteristics predict joint attention engagement?

The overall GLMMs investigating whether infant characteristics (other than age, sex, and culture) did not explain more variance than the null models (including only the intercept and random effects). The Likelihood Ratio Tests for these models are presented in *Table 4.7* (full model parameters in *Appendix A4.5*).

Table 4.7: Likelihood Ratio Tests for comparing full models to null models for models investigating infant characteristics.

Model	Fixed Factors	Likelihood Ratio Test results
Interest in objects	Amount of solo object play	$\chi^2_{(5)}$=3.10, *p*=.376
General cognitive development	Cognitive score	$\chi^2_{(3)}$=1.82, *p*=.177
Communication development	Receptive communication score; Expressive communication score	$\chi^2_{(4)}$=.938, *p*=.626
Emotional expression/ temperament 1	Infant positive affect	$\chi^2_{(3)}$=.032, *p*=.859
Emotional expression/ temperament UK 2	Amount of crying (UK)	$\chi^2_{(5)}$=.174, *p*=.982
Experience of environment	Sit; Crawl; Walk	$\chi^2_{(5)}$=4.00, *p*=.261

4.4.3 Does infant social experience predict joint attention engagement?

The overall GLMMs investigating whether infant social experience did not explain more variance than the null models (including only the intercept and random effects). The Likelihood Ratio Tests for these models are presented in *Table 4.8* (full model parameters in *Appendix A4.5*).

Table 4.8: Likelihood Ratio Tests for comparing full models to null models for models investigating factors associated with social experience.

Model	Fixed Factors	Likelihood Ratio Test results
Social experience	Amount of social interactions	$\chi^2_{(5)}$=.377, *p*=.945
Triadic experience	Amount of social object play	$\chi^2_{(5)}$=5.52, *p*=.137
Social environment	Amount of people in 5 metres of infant	$\chi^2_{(5)}$=7.63, *p*=.054
Mother-infant interaction style 1	Mother reactiveness; Mother intrusiveness	$\chi^2_{(4)}$=5.79, *p*=.055
Mother-infant interaction style 2	Mother vocalisation	$\chi^2_{(3)}$=.046, *p*=.830
Mother-infant interaction style 3	Face-face play	$\chi^2_{(3)}$=.488, *p*=.485

4.5 Discussion

In this study I examined whether infant characteristics, or infant early life experience predicted how likely they were to engage in any joint attention events with their mother. I found no clear predictors for whether infants would engage in at least one joint attention event with their mother in response to the laser stimulus at 11- or 15-months. No infant characteristic variables, or variables related to infant social experience predicted how likely infants were to engage in joint attention in the experiment. Before discussing possible implications of these null results, it is important to consider methodological issues that may have contributed to these findings.

Since this study is the first of its kind to look at predictors of joint attention implementing this robust definition of joint attention events while using a naturalistic experiment, it was not possible to do an apriori power analysis to inform sample size calculations. However, when comparing the sample size used I this study (median *n*=74, range 54-84), it is comparable or higher than studies which have investigated predictors of joint attention skills and found significant associations (median *n*=47, range 21-59; Gaffan et al., 2010; Hobson et al., 2004; Markus et al., 2000; Osório et al., 2011; Salley & Dixon, 2007; Todd & Dixon, 2010; Vaughan et al., 2003; Walle, 2016). It thus seems unlikely that sample size alone was responsible for null results, but other statistical approaches such as Bayesian statistics would be useful alternatives to provide insight into the confidence we can have in the null results obtained in this study.

In previous work, how *much* infants exhibit initiating joint attention or responding to joint attention skills or shared attention bouts was predicted by a variety of variables (e.g. Gaffan et al., 2010; Markus et al., 2000; Osório et al., 2011; Salley & Dixon, 2007; Todd & Dixon, 2010; Vaughan et al., 2003), whereas the distribution of my data forced me to examine the likelihood of engaging in at least one joint attention event (binary measure rather than a continuous one). Perhaps if I had been able to use a numeric (e.g. rate or number) outcome measure for joint attention we might have seen participants showing more joint attention events as a function of increasing age or the early life predictors investigated in this study. Lack of variation in the outcome variable makes it difficult to find predictive factors that can explain that variation. In this study limited variation in the joint attention event measure came from both having to convert the data into a binary variable, but also from the relatively low number of dyads who engaged in a joint attention event. Ultimately, in many of the trials, children did not engage in any joint attention events, perhaps reflecting my use of a more stringent operational definition for sharing of attention than most previous studies have used. Perhaps examining multiple different levels of joint-attention relevant behaviours for example, initiating joint attention skills, parallel attention, triadic attention (i.e. looking to laser and then mutual gaze), as well as joint attention events as described here, together might help to establish a more subtle and varied index of infant motivation and ability to engage in joint attention with their mothers. Such an index might in turn be better suited to revealing associations with predictor variables

In addition to the stringent operational definition I adopted to identify joint attention events, there are other factors that may have contributed to the relatively low proportion of infants who engaged in at least one joint attention event with their mother in response to the laser. The literature suggests that infants engage in joint attention from 9-months (Carpenter & Call, 2013; Liszkowski et al., 2007) and given that we did not see a significant increase in the number of infants who engaged in joint attention from 11- to 15-months old, it is unlikely that the low proportion of infants engaging in at least one joint attention event (~30% trials) was due to many of the infants having not yet developed the skills for joint attention. It seems more likely that the low level of joint attention engagements were due to infants being unmotivated to share attention about the stimulus. Future research could thus benefit from using alternative methods of measuring joint attention engagement, such as examining recordings of every-day interactions for spontaneous joint attention events, or presenting alternative or multiple stimuli such as stimuli with higher social load (thought to elicit higher motivation to share e.g. toy dolls; Gavrilov et al., 2012), to evoke infants' propensity to engage in joint attention events. It is, however, conceivable that the relatively low numbers of joint attention events identified in this study is representative of natural propensities to engage in joint attention when encountering a novel object. In comparison to methodologies such as the Early Social Communication Scales (Mundy et al., 2013), which require infants and their partner to be sat facing one another, thus reducing the motor costs of engaging in mutual gaze, the joint attention set-up in this study was more naturalistic. Allowing infants freedom to move around means that infants will adopt a naturalistic orientation and posture and thus the effort needed for engaging in mutual gaze (Franchak et al., 2018) will be more representative of real-life situations. As compared to other methodology conducted in an unfamiliar lab environment, the laser experiment used here is a more ecologically valid situation from which to extrapolate to infants daily lives (Dahl, 2017), and so may more accurately represent infants propensity to engage in joint attention. Future research should aim to examine how common joint attention events (operationalised with a strict definition) are when mother and infants encounter a range of novel objects.

Although my paradigm may have had strengths in terms of being naturalistic, ultimately the limited variation in responses it generated may have made it poorly suited to understanding the factors that predict engagement in joint attention events. Extensive pilot work to ensure joint attention measures generate variation in target participants before their inclusion in a predictive study would be a valuable step for future studies to take.

I have outlined some important methodological issues which could have contributed to the null results found in this study. However, it is also possible that these findings do represent genuine null results and that engagement in joint attention events is not predicted by the intrinsic or environmental factors I considered. I now consider the potential implications of the null results found, assuming that future analyses and research confirms them to be genuine.

Firstly I examined whether infants' culture, age, or sex predicted how likely they were to engage in at least one joint attention event. In line with Callaghan et al. (2011), I found no overall effects of how likely infants in the two cultural groups were to engage in at least one joint attention event despite considerable differences in home environment (e.g. household size, socioeconomic status; see *Chapter 2*). Infants from the UK and Uganda both showed high interest in the novel laser stimulus. The cross-cultural consistency in interest in the laser and the likelihood of engaging in joint attention supports the idea that the laser experiment paradigm used to test joint attention here was a culturally appropriate way of measuring joint attention in the UK and Ugandan samples: specifically that the situation used and modality tested (visual joint attention) was not an inappropriate situation in which to share joint attention for participants in these samples (Gavrilov et al., 2012).

The similar performance of mother-infant dyads in the UK and Uganda indicates that there is no overall combination of early life experience which comes together to support visual joint attention in a greater or lesser way in either culture in children of these ages in this context. However, while it may be that mother-infant dyads in these samples are equally likely to share attention through mutual gaze, it is possible that the overall cultural differences between these two samples may support expression of joint attention in different modalities. For example attention getting and communication via touch may be more common in the Ugandan sample than the UK sample due to the higher stress put on relational parenting (see *Chapter 2*). This could be an interesting area for future research.

I also found no effects of sex or age on whether infants would show at least one joint attention event. The lack of increase in likelihood to engage in joint attention events with age was surprising given clear evidence of age-related increases in joint attention skills from

9- to 18-months (Mundy et al., 2007). One possibility is that by 15-months, infants had already engaged with the laser at 11-months and so it was not truly novel. We tried to change the colour of the laser (red, green, or blue) to maximise novelty, however infants may have shown the expected elevated chances of engaging in joint attention events if the stimulus had been completely novel at both age points. The comparable performance of girls and boys supports previous research that has failed to find main effects of gender on joint attention skills (Heymann et al., 2018) .

Additionally, I did not find support for infant expression of emotion, being associated with infant joint attention event engagement, indicating that the associations seen between infant expression of emotion and joint attention skills (Osório et al., 2011; Salley & Dixon, 2007; Todd & Dixon, 2010; Vaughan et al., 2003) may not transfer to whether infants will show joint attention events. The inconsistent relationship between emotional expression and joint attention skills seen in the current literature (Osório et al., 2011; Salley & Dixon, 2007; Todd & Dixon, 2010; Vaughan et al., 2003), and the absence of association indicated by this study, supports the idea that different aspects of joint attention may develop along different paths. For example, the association between positive emotional expression and initiating joint attention skills (Vaughan et al., 2003) may be indicative of infants wanting another to attend to an object or event, but given that there was no association between emotional expression and joint attention events, emotionally expressive infants may be satisfied when a partner has attended to that object without needing to share the experience together. In other words, the motivations to direct another's attention to an object and to share attention about an object may be different: the motivation for a joint attention event is to have a joint experience with someone about something, and for each other to know they are both attending to the same thing.

Just as I found no evidence of associations between infant characteristics and engagement in joint attention events with their mother, I also found no support for links between variables concerning infant early life experience and learning opportunities with participation in joint attention events. While there is evidence for infant physical development giving infants different learning opportunities, and critically more opportunities for mutual gaze, (Frank et al., 2013; Kretch et al., 2014), I did not find support for infant age of reaching physical milestones predicting whether infants would show joint attention events. I also investigated whether the opportunity for mutual gaze during mother-infant play was associated with infants' likelihood to engage in joint attention events and found no connection. It seems that elevated opportunities for mutual gaze gained from precocious physical development or high levels of face-face play may not translate into higher propensities to use mutual gaze to share attention about a novel event.

One of the suggestions from the multiple processes models, namely that of Bard et al. (2014), is that infant social experience promotes the development of joint attention, however when looking at the levels of social engagement, and social-object play, I also found no associations with how likely infants were to show joint attention events. Given that infants can learn from being in proximity to others, as a measure of how many social learning opportunities infants are exposed to, I also examined whether the number of people in proximity to infants was related to how likely they were to show joint attention events. The number of people in proximity to infants at 3-, 6-, and 9- months was not related to how likely infants were to show joint attention events. I then investigated whether style of these social interactions may predict how likely infants are to engage in joint attention events. In contrast to previous research, (Gaffan et al., 2010; Hobson et al., 2004; Osório et al., 2011), I did not find that mothers' reactiveness or intrusiveness was related to the likelihood that infants would engage in joint attention events. This supports the ideas emerging from Gaffan et al.'s (2010) results that nuances in the aspects of joint attention which are investigated, and whether predictors are associated with joint attention when measured during infant interactions with mother or researcher can impact results. Given the sensitivity of these predictive relationships to nuances in the measures it may be worth considering whether future research should continue to use global ratings to quantify maternal interaction style. When scoring videos for global ratings, raters are taking different aspects of the mother's behaviour into consideration to form one rating: for example, when rating reactiveness, mother reactions to infant signals was taken into consideration; but if infants were making few signals, then there is less opportunity for mothers to react. In those cases, her reactiveness would mostly be rated based on whether she was following her own desires during the interaction, whereas in a case where the infant signalled a lot, the rating would be based on both mother's reactions to those signals, and whether she was preoccupied by her own desires. It is thus possible that perhaps different compositions, or frequencies of these specific behaviours may relate to measures of joint attention differently. One way of investigating this would be to use a more comprehensive coding scheme which codes the individual aspects of behaviour which make up the global ratings categories on a moment to moment basis. This would allow us to examine what aspects of these global ratings seem to be critical to the link between mother interaction style and joint attention development.

In conclusion, this is the first study to bring together a broad selection of factors inherent to the infant and their early life experience to see if it is linked to whether infants will show joint attention events in a naturalistic experiment, when a rigorous operational definition is applied. The naturalistic methods used measured joint attention in an ecologically valid way, which elicited joint attention at a similar level across cultures, thus showing cross cultural applicability. While the levels of joint attention were similar across cultures, they were low, and thus may have contributed to underpowered models and thus contributed to the null results found in the study. I found no support for infant cognitive, communicative, or physical development predicting whether infants would engage in joint attention in our experiment. Infant early life environment factors also showed no association with the likelihood of infants engaging in joint attention about the laser stimulus. Whilst methodological issues may have contributed to these null findings, this study also highlights the possibility that joint attention skills may be underpinned and facilitated by different factors than actual engagement in joint attention events, and builds on the idea that predictors of joint attention may be sensitive to the definitions and methodology used to address the question of how joint attention develops.

Chapter 5: General discussion

In this thesis, I used a cross-cultural comparative approach with the aim of characterising the early life environment of infants up to 15-months-old in two cultural groups (Chapter 2). More specifically, I aimed to examine how homogenous the two groups were, and how much infant experience and learning opportunities varied across these cultural groups. In my second study (Chapter 3), I used a cross-species comparative approach to investigate whether there were sex differences in infant early life experience which were consistent across humans, chimpanzees, and macaques, with the aim of establishing whether sex differences in human infant experience may be genetically inherited as either parenting strategies or innate differences in infant behaviour. In my third study (Chapter 4), I investigated whether aspects of infant experience, or infant characteristics would predict whether they would engage in joint attention events. In this final chapter I briefly discuss the principal findings from each of these chapters, and bring together themes cross-cutting them, as well as suggesting avenues for future research based upon the findings from the empirical work in this thesis.

5.1 Are there differences in parenting attitudes and infant experience across cultures?

While previous research has shown that infant early life environment may vary cross culturally, there is little research describing how it may vary in a broad or quantitative manner, thus my aim in Chapter 2, was to characterise important aspects of infant early life environment from 3- to 15-months. I studied maternal attitudes and a variety of factors in infant early life environment in two samples thought to experience different early life – one 'WEIRD' culture from the UK, and a second non-WEIRD sample from Uganda. I found infant early environment can vary in considerable ways, including mothers' attitudes towards parenting and socialisation goals, and other factors of infant early life environment. So much so that when considering all factors together, the infants could be clearly separated into two groups, which indicates that the overall experience from any one UK infant was different to any one Ugandan infant. More specifically, I found—as expected—Ugandan mothers had more relational than autonomous parenting attitudes, and UK mothers had more autonomous than relational attitudes. This is in line with previous research with similar rural communities which rely on subsistence farming where parents are more likely to show relational attitudes versus parents from WEIRD communities who are more likely to show autonomous attitudes towards parenting (Keller, 2007). It would be useful to examine in future what it is that drives attitudes such as these, for example, are they values which have been passed down from their parents? Are the attitudes sustained by the community structure (e.g. collectivistic verses individualistic)? And are the attitudes mediated by things such as access to socio-economic resources or parenting education (e.g. antenatal classes)? This could be investigated with, for example, semi-structured interviews, or follow-up questions to questionnaire answers.

In Chapter 2 I also investigated which aspects of infant early life environment were similar and different across the two cultures at the level of specific factors, and predicted that at a group level we would find results which aligned with the autonomous-relational attitudes of the UK and Ugandan samples. For most variables tested, the results aligned with autonomous-relational predictions, such as how likely infants were to reach physical milestones at an early age, how many caregivers they had in a day, the amount of mother-infant contact, and where they slept at night. However, some results on specific variables were unexpected: for example, the Ugandan infants were less likely than the UK infants to be in five meters of their mothers. These differences across cultures in terms of infant physical development and social environment indicates that infants in these two samples acquire different learning opportunities in their early life which may impact development of other skills such as understanding physical properties of the world (Mohring & Frick, 2013; Slone et al., 2018), self-soothing behaviours, and understanding of 'the self' (Keller et al., 2005). It is important to note, almost all variables of infant early life experience changed as a function of age – for example infants were more likely to have more social partners as they age, potentially due to factors such as infants developing skills such as initiating interactions or other people potentially being more interesting in engaging with infants as they age.

While overall the Ugandan group experienced a more relational parenting style, and the UK group experienced a more autonomous parenting style, when looking at specific individual attitudes they rarely predicted specific infant experience. For example, mothers attitudes regarding being in close proximity to their infant did not predict how likely they were to be in close proximity, and mothers attitudes regarding whether it was important to devote a lot of time exclusively to their infants did not predict how much time mothers spent in activities exclusively for their infant. The discontinuities between specific attitudes and specific behaviours in addition to the behaviours I found that did not vary as predicted by the relational-autonomous parenting models, together highlight the importance of measuring behaviour, rather than extrapolating expected behaviour based on attitudes alone. Many cross cultural studies simply measure parental attitudes or focus on observations of behaviour in a single context (Keller et al., 2009, 2005, 2006; Keller, Lohaus, et al., 2004;

Keller, Yovsi, et al., 2004) because measuring behaviour is time consuming and challenging. However, this study shows that attitudes and behaviours do not always align. Therefore, measuring behaviour can offer important insights and a more accurate picture of infant experience than parental attitudes in isolation, or focusing on one context can provide.

The divergence between individual attitudes which I was able to associate with individual experiences, may be due to a range of reasons. It is possible that mothers' interpretation of the questions varied, for example when being asked about independence, there are various ways in which infants can develop independence, and while some mothers may interpret this as physical independence (which is the behavioural measure I compared in this study), others may interpret it as infant independence in caring for themselves, such as being able to feed themselves. This underlines the importance of not generalising specific interpretations of attitude questions to behaviour. There may also have been other reasons which meant maternal attitudes did not match up with infant experience. For example there may have been constraints on mothers' time due to other commitments (such as work, or care for other children), or on resources available to them that prevented them acting in line with their attitudes. Additionally, it may also be that when infants are being cared for by others than the mother, they have different attitudes which influence how the child is raised, so it would be interesting to investigate in future how attitudes of other caregivers relate to the primary caregivers' opinions, and how that also links to infant experience.

Another line for future research would be to investigate the degree to which the results from this study, which focussed on relatively small samples in each cultural context are representative of the wider populations in those locations. For example, in this study, we had limited diversity in the UK sample in terms of ethnic background and socioeconomic status. It would, therefore, be interesting to examine whether similar patterns are found in a broader sample of UK participants (Medin, Ojalehto, Marin, & Bang, 2017; Rad, Martingano, & Ginges, 2018). Likewise, in Uganda, our sample of rural substance farmers may not be representative of populations from urban-Uganda. Further extensions to characterising infant development from other locations, including other WEIRD and non-WEIRD countries would also give us a better understanding of the environment typically developing children experience within this critical period of development.

Overall, the results from Chapter 2 lays groundwork for understanding the early environment of infants in diverse contexts. This work also allows us to look at later development of skills and understand if differences in early life experiences have implications for infant social or cognitive development.

5.2 Are there sex-specific patterns of infant social environment in humans, chimpanzees, and macaques?

In Chapter 3 I take the first steps towards describing male and female infants' early life social environment which sets the groundwork for understanding the context in which sex differences in social cognition, such as cooperation and prosocial behaviour, develop. Previous work suggests that there may be sex differences in the early social environments of human, chimpanzee, and other non-human primate infants (Benenson, 1993; Benenson et al., 1997; Bentley-Condit, 2003; Eaton et al., 1985; Lonsdorf, Anderson, et al., 2014; Murray et al., 2014; Timme, 1995). One way of examining the drivers for these effects is to do cross-cultural and cross-species work. Attitudes towards male and female infants may vary with culture and may drive differential sex differences in social experience across cultural contexts. In contrast, if sex differences are consistent across cultures, this indicates sex differences may be underpinned by common cultural values across samples or may hint at a biological basis for a more human universal trait. In my second study (Chapter 3), I investigated whether there were sex differences in infant human social experience up to 15-months. I found for both UK and Ugandan participants, there were clear sex-effects that were cross-culturally consistent: when male infants were young they were more likely to be in physical contact with, and interact with their mother. However as they reached 15-months, female infants were more likely to be in physical contact with, and to interact with their mother. Furthermore, when young, infant females had more non-mother individuals in proximity to them than males did, but this decreased with age. In contrast, the number of non-mothers in proximity to males increased with age. The similarities across cultures in how mothers interacted with infants indicates that sex differences were not driven by cultural differences across these two samples. This could be because there is a biological basis to these socialisation patterns (as suggested by the data below) or that both cultures have similar socialisation patterns. Future work examining whether the sex effects found in this study are consistent in other cultures would further our understanding of how universal such sex effects in early social environment are. Different cultures may have different attitudes towards male and female infants, so it would also be interesting in future to investigate whether there is a relationship between sex-specific cultural attitudes and infant social experience.

Next, I investigated whether sex differences in human experience may be evolutionarily inherited from our last common ancestor with chimpanzees, or even earlier common ancestors shared with other primates, by conducting a study using methods that were comparable across species. I investigated whether the early social environment was similar for male and female infants across humans, chimpanzees, and crested macaques up to 12-months-old. Given the similarities in sex-effects across the two human cultures, for these cross-species analyses I collapsed the human groups in to one sample. I found that sex differences were consistent across species. When comparing chimpanzees to humans, I found that young male infants had less non-mother individuals in proximity than young female infants and the number of adult males in five meters increased with age for male infants but decreased with age for female infants. When comparing all three species—humans, chimpanzees, and macaques—I found older male infants were more likely to interact with non-mother adult females than infant females. These results show that as infants age their social experience changes differently depending on their sex, and the consistency of these effects across species indicates they are more likely driven by conserved, evolved psychological mechanisms than by species specific evolutionary pressures.

Sex differences in infant experience can be driven by socio-cultural factors, or factors related to our evolution (Meredith, 2015). The similarity in sex differences across species indicates that culture is unlikely to drive these sex differences in in humans, and nor are species specific dispersal patterns driving sex differences in the non-human primates. Previous research suggests that sex differences seen in chimpanzee social behaviour, such as male infants being more likely than female infants to be in proximity of adult males in the first 6 months of life (Murray et al., 2014), are due to the greater benefit they give males who remain in their natal group for life (Lonsdorf, Anderson, et al., 2014; Murray et al., 2014). However, in the current data these findings were not replicated and other patterns did not support previous suggestions that chimpanzees' male-dispersing life-history is the main driver of sex differences (Lonsdorf, Anderson, et al., 2014; Murray et al., 2014). This suggests that there may be other factors at play across chimpanzee communities which determine sex-differences in social experience, such as instability in the male social hierarchy impacting infanticide risk (Lowe et al., 2018). Additionally, the pattern that older male infants were more likely to be interacting with non-mother adult females than female infants were found across humans and macaques as well as chimpanzees. Since crested macaques are a male-dispersing species, this suggests that this pattern may be an evolutionarily old trait in all three species. This proposal could be further explored by examining whether other species in the primate lineage exhibit the same patterns. This would allow us to test whether there are associations between species-specific life-history pressures which predict the sex differences in experience. For example by examining other primate species, such as bonobos – who are equally related to humans as chimpanzees are (Langergraber et al., 2012), and have female dispersal, but have dominant female social structures (compared to male dominance in chimpanzees), or other old world monkeys (the lineage of monkeys most closely related to apes and which includes macaques; Glazko & Nei, 2003), to test whether crested macaques show the same patterns as other closely related monkeys. On a within-species level, it would also be interesting to examine who is driving sex differences, i.e., are mothers' socialisation strategies different for male or female offspring, or are differences in experience infant-led. This could be explored by, for example, analysing who initiates interactions (infant or non-infant), and who maintains distances between individuals. There could be a few different scenarios that explain current patterns: e.g., do adult males approach infant males more as they age; do infant males approach males more as they age; or do mothers retrieve female infants more than male infants when adult males are around.

Some of the results in the cross-species analyses were unexpected. For example, human sex differences found in the cross-cultural comparison up to 15-months of age were not always replicated in the cross-species analysis which only examined up to 12-months. There was, for instance, no sex effect found for how likely infants are to interact with their mother in the cross-species comparison. This suggests that this sex-specific change in behaviour in humans may not be clearly established until infants are over 12-months old. It would be interesting in future to examine this in more detail to, for example, see whether there is a non-linear change with age, and see how consistent the rate of change is with age. It may also be interesting in future to explore whether this sex-specific pattern which is evident at 15-months in humans is present in other primate species as well, or if this is a human-specific pattern. This further highlights how age is an important factor when considering sex differences in infant social experience, indicating that it's important to not generalise sex differences or similarities at any particular point of development to other ages.

Taking the results from Chapter 3 together, this work describes male and female infants' early social environment across three species of primate and identifies important infant sex differences in sociality. The patterns of sex differences and similarities across sex were consistent across two human cultural contexts and across human, chimpanzee, and crested macaque species. This suggests that sex differences are not solely the result of culture or socialisation and hints toward a shared biological basis for these differences. This work could be built upon in future to examine whether these sex differences in social experience are related to development of sex differences in areas such as cooperation and prosocial behaviour.

5.3 Early life predictors of joint attention development

While in my second chapter I explored infant early environment cross-culturally, in my fourth and final empirical chapter I investigated whether there were any knock-on effects of infant early life environment on the development of an important social ability—joint attention. Previous research has linked factors inherent to the infant (such as emotional expression and cognitive skills), as well as experience (such as maternal interaction style) to how much infants show joint attention skills (Gaffan et al., 2010; Hobson et al., 2004; Leavens & Bard, 2011; Markus et al., 2000; Osório et al., 2011; Salley & Dixon, 2007; Todd & Dixon, 2010; Vaughan et al., 2003). Previous research has focused on whether infants will show joint attention related skills (e.g., Hobson, Patrick, Crandell, Garcia Perez, & Lee, 2004; Leavens & Bard, 2011; Salley & Dixon, 2007; Todd & Dixon, 2010; Vaughan et al., 2003), and when joint attention research does look at infants using their skills to engage in joint attention 'events', studies vary in their operational definitions (Graham et al., 2021). To address this gap, I used a rigorous definition for what constitutes a "joint attention event", which indicates that infants are *sharing* attention with their partner. I investigated whether a broad set of factors including infant characteristics (e.g. cognitive and communicative skills) and factors related to infant experience (e.g. number of people nearby, maternal interaction style) were associated with the likelihood infants would engage in joint attention events. None of the factors I investigated had clear links to whether infants would engage in joint attention events – including those where links have previously been found between predictor variables and infant joint attention skills and/or joint attention events (Gaffan et al., 2010; Hobson et al., 2004; Markus et al., 2000; Osório et al., 2011; Salley & Dixon, 2007; Todd & Dixon, 2010; Vaughan et al., 2003; Walle, 2016). It is possible that methodological factors contributed to these null results, for example, a modest sample size may have lacked statistical power and using a stringent definition for 'joint attention events' could have contributed to the low number of individuals who were considered engaging in any joint attention events, which in turn created limited variation in the outcome variable. Alternative statistical methods, such as Bayesian models, would allow us to have more insight into the confidence we could place in these null results.

While methodological issues may have contributed to the null results in this study, it is also possible that the lack of connection between predictor variables and infant engagement in joint attention events is representative of a true pattern. If this is the case, individual joint attention skills (e.g., gaze and point following, showing, directing attention) and engagement in joint attention events when faced with a novel stimulus may be sensitive to different factors and may have different developmental trajectories. If further work confirms that individual joint attention skills and engagement in joint attention events develop independently from each other and are influenced by different environmental factors this would challenge the shared intentionality model of joint attention development which posits that joint attention evolved as a uniquely human motivation to share experiences with others and predicts that all aspects of joint attention should be tightly related as they share a common origin (Tomasello et al., 2005; Tomasello & Moll, 2010). Another way to test this idea would be to explicitly test how individual variation in joint attention skills is related to individual variation in engagement in joint attention events: for example, do children who show high levels of responding to joint attention skills also engage in more joint attention events?

Overall, Chapter 4 highlights how the way in which joint attention is defined and measured can impact conclusions regarding what predicts joint attention expression. This study also indicates that the factors which facilitate infants' individual joint attention skill development may not support engagement in joint attention events in the same way.

5.4 Important themes

Experience is commonly pointed towards as a source of individual variation in infant development of milestones (Geary, 2006; Sameroff, 2010), however the literature contains few quantitative descriptions of infant early life experiences. One of the strengths of the work in this thesis was incorporating a naturalistic approach to characterise infant early experience, which is the first step towards understanding how social cognition is sensitive to experience. Using this approach I showed that during the first 15-months, when infants are rapidly developing many skills, their experience of the world is also changing, for example in terms of the amount of social activities, or number and identity of individuals nearby,. Critically these changes over time can differ depending on infant sex or cultural context (Chapter 2 and 3). Currently however there are still gaps in our knowledge regarding the drivers for how infant experience changes with age. Future exploration into the consistency of parental practices and attitudes as their infant's age would allow further understanding of the age-related cultural differences in infant experience. Additionally, results from Chapter 3 indicate that there are potentially innate sex differences in infant social experience, but it is unclear whether differences are driven by the mothers or infants over time. It is possible that as infants age they act differently depending on their sex, or that mothers react differently to an aging child depending on their sex. As outlined above, this could be further examined by analysing, for example, who maintains mother-infant distance, and who initiates interactions as infant age.

Whilst it is clear that considering behaviour and environment dynamically with infant age is critical, findings from this thesis also highlight the importance of considering the influence of individuals other than the mother on early infant experience. Findings from Chapter 2 indicate that infant interactions with non-mothers play a large role in their early life, and as mothers' attitudes rarely predicted specific experience for infants, it may be that the attitudes of other family members or the wider community are impacting infant experience. The number and type of people in proximity to the infant that form the infant's immediate social environment also seem to vary with infant sex (Chapter 3). This shows how non-mother associations are an important area of infant early life to consider, however little research is currently done on infant-non-mother interactions before preschool age. Thus, research in future should consider the impact that a wide variety of individuals have on infant life.

This thesis was able to cast a light on important aspects of infant life due to the observational methods used and focus on understanding naturalisitic, everyday behaviour. Whilst lab-based experimental studies are optimally situated to answer many scientific questions, it is important to remember the importance of naturalistic observation as a complimentary approach. The full day follow methods employed in this thesis are commonly used within primatology, but rarely within developmental psychology. In future taking an interdisciplinary approach and being open to using methods from other disciplines to capture variation in everyday life would be beneficial.

In this thesis I examined infants developing in two cultural contexts, including a non-WEIRD sample, making a valuable contribution towards tackling the persistent sampling bias in developmental Psychology towards WEIRD samples (Nielsen et al., 2017). Although seminal papers highlighting this problem were published over a decade ago, there is still comparatively little research conducted with non-WEIRD populations. My experience of establishing data collection in Uganda has given me an appreciation of the additional challenges and potential barriers research with non-WEIRD samples can generate. Adaptation of materials to be relevant and understandable to participants and the subsequent translation of those materials in to multiple local languages was time consuming and required extensive discussion with research assistants and piloting. Training of local research assistants with limited formal education and scientific experience required time and a flexible approach. Collecting data from participants who had never attended school and could not read or write presented unique challenges, particularly for questionnaire delivery. When conducting research with Ugandan humans, I was fortunate to work with an excellent partner organisation, the Budongo Conservation Field Station, who assisted with permit applications and facilitated all aspects of the research. The establishment of more partner organisations willing to facilitate research in developing countries would greatly aid the accessibility of conducting research with non-WEIRD samples. This would not only help address the sampling bias in developmental Psychology, but provide invaluable benefit sharing opportunities including high quality training provision for local research assistants and students as well as chances to work with communities to understand areas of research of most interest and benefits to potential participants.

Although my project made a valuable contribution to addressing the persistent sampling bias towards WEIRD populations, it is important to note that these data are still limited in their applicability to other cultures, and are not necessarily representative of humans as a species. Research from this thesis showed that there were many differences between cultures (Chapter 2), but there were also similarities across samples: in some areas of general experience (e.g. how many adults are in proximity), patterns of sex-specific experience, and the chances that infants would engage in joint attention events. However it is unclear how representative of humans' early life experience these aspects are. Sampling diverse cultures allows us to investigate the variation seen within humans, and can thus be used to understand what aspects of infant experience are universal (Rad et al., 2018). Future research could tackle this by examining more cultural samples, both in terms of different nationalities, but also other levels within similar societies, such as those varying in socioeconomic status or religion. In line with this idea, research on non-human primates should also consider multiple communities to make clear what aspects of experience are representative for the species. By comparing across different communities of the same species which vary in characteristics such as group size, or dominance hierarchy stability, we could control for variables which may impact infant development, and as with humans, look at the variation to establish which patterns are universal.

Early cultural or sex differences that change dynamically with age, may also impact development of later social or cognitive skills. While I did not find any associations between early life experience and how likely infants were to engage in joint attention events, research suggests that there are specific periods in development where infants brains are more sensitive to experience, and experiences during these times are thus more likely to impact development (Feldman, 2015; Knudsen, 2004). Evidence for such a sensitive period in terms of maternal sensitivity influencing infant initiating joint attention skills was found by Gaffan et al. (2010). They showed a positive association between how sensitive mothers were at 9-months and infant initiating joint attention skills, but mother sensitivity at 6-months was not associated with infant initiating joint attention skills These indications that there may be particular periods in development, , where environmental input has particularly powerful effects on development of certain behaviours, means it is really important for future work investigating early predictors of later skills to consider multiple age points.

This study lays groundwork for other kinds of research, as knowing the context in which children develop can be used to examine how early life impacts other areas of development. For example, previous research has found links between autonomous and relational parenting with self-recognition and obedience (Kärtner, Keller, & Chaudhary, 2010; Keller et al., 2005). The approach I used in Chapter 4 to explore whether experience predicted how likely infants were to show joint attention could be used to investigatethe sensitivity of other areas of social cognition to environmental factors. For example, what factors support the development of other areas of cognition, such as prosocial behaviour and attachment? With the example of attachment, how sensitively or appropriately parents respond to infants' communications predicts their 'attachment style' (Wolff & Ijzendoorn, 1997), which can influence social relationships throughout life (Waters et al., 2000). However most attachment style research is based on the premise that a child has a primary caregiver, (Keller, 2013), so how factors such as the more distributed caregiving seen in the more relational Ugandan sample in this thesis influences attachment requires exploration. Ultimately, using longitudinal approaches to understand the sensitivity of different aspects of cognition to experience could help caregivers provide learning opportunities, which are appropriate for stimulating and nurturing their child.

5.5 Summary and conclusion

During infancy, typically developing children develop important skills which are vital for later development, and in this thesis I make fundamental steps towards understanding the context in which infants are developing these skills. Conducting cross cultural research and linking attitudes with behaviour can help us understand how varied or similar infant development environment can be across human populations. I found that indeed there were many aspects of infant's early life experience which varied across cultural contexts and these mostly aligned to group-level attitudes. However on an individual level, specific maternal attitudes did not generally predict infant experience, thus highlighting the importance of measuring infants experience and not simply extrapolating from maternal attitudes. This work lays the foundations for future research in these communities to examine the downstream effects that varied early life experiences may have on later socio-cognitive development.

This thesis also used cross species comparison to understand the contributions of culture and biology in influencing human behaviour, in this case in regard to sex differences in sociality. The sex differences and similarities in social experience I identified were consistent across humans, chimpanzees, and crested macaques. For example, in the three species up to 12-months old, male and female infants experienced similar levels of social interaction, interactions with mothers and interactions with juveniles – but 12-month old male infants experienced more interactions with non-mother adult females than female infants. This cross-species consistency indicates that these sex differences may represent evolutionarily old traits, and are less likely driven by species-specific characteristics (e.g., culture in humans; dispersal patterns in non-human primates).

Finally, since longitudinal research can not only help us understand the ages at which children develop specific skills, but can also be used to help us understand what factors support the development of socio-cognitive skills – I used this approach to examine what aspects of infant experience or infant characteristics predict infant engagement in joint attention events. I found no clear predictors of whether infants would engage in at least one joint attention event. This highlights the importance of considering how different aspects of joint attention, such as responding to joint attention and initiating joint attention skills, and joint attention events may be supported and influenced by different factors and may follow different developmental trajectories.

In conclusion this thesis lays important groundwork for future developmental research by giving a wider context to understanding the environment in which infants develop in both a WEIRD and a non-WEIRD sample. It highlights the importance of examining infant behaviour over multiple age points, considering the infant's wider social environment beyond the mother as well as the influences of cultural context, parental attitudes, and infant sex on development. Taken together this thesis sheds new light on the understanding of infant early life environment and the context in which infants are developing.

Appendices

A2 Appendices for Chapter 2

A2.1 Demographic questionnaires

Background questionnaires were used to collect demographic information on our participants, as well as information on infant sleeping habits. After the first visit with the participants where they were asked all questions, they were presented with their previous answers and asked whether their answer has changed or whether it has remained the same. Questions about parenting experience in Uganda were included in the Background Questionnaire. These questions were asked in a separate *Siblings Questionnaire* in the UK. Indoor-Outdoors Questionnaires were used to understand where participants conducted every-day activities. Some indoor-outdoor questionnaires were conducted retrospectively – if this was the case then the questionnaire specified a 3-month time period (e.g. "Think about your child when they were aged 0- to 3-months, where did he/she do the following behaviours?"). These questionnaires were altered and extended from Kaller (2012), which were based on information collected in (Ainsworth, 1967).

Full background questionnaire:

General Background Questionnaire

This questionnaire should be filled out during the first visit (0-3 months), and at 6, 9, 12, 15, 18, 21, and 24months.

Date: ___________________ Participant ID: ___________________

General information about the child

Name (baby): ______________________________

Date of Birth (baby): ______________________________

Gender (baby): ______________________________

How many weeks into the pregnancy was the baby born (*only asked for UK participants*)? ____________________

General information about the parents

Is the father part of the baby's life *(only asked explicitly in Uganda)*? Yes ☐ No ☐

Does the father live with the baby *(only asked explicitly in Uganda)*? Yes ☐ No ☐

	Mother	**Father**
Birth date/ year:	____________	____________
Place of birth:	____________	____________
Were you raised in the UK/Uganda?	Yes ☐ No ☐	Yes ☐ No ☐
If no, where were you raised?	____________	____________
Age at birth of first child:	____________	____________

How many of your own children *(asked in separate questionnaire for UK participants):*	______	______
How many children raised *(asked in separate questionnaire for UK participants)*:	______	______
Ethnic Background:	______	______
Highest level of education:	______	______
Name of job/Work/ Profession	______	______

Languages

Which languages are spoken in your household?

Mother: ______

Father: ______

Other (e.g., siblings, grandparents): ______

Which languages are spoken with your child?

Mother: ______

Father: ______

Other (e.g., siblings, grandparents, carer, neighbours):

______

Can you read *(only asked in Uganda)*? Yes ☐ a small amount ☐ No ☐

If yes, in which language/s______

Can you write *(only asked in Uganda)*? Yes ☐ a small amount ☐ No ☐

If yes, in which language/s______

Household

How many people live in the same household as your baby (including the baby)? ______

Who currently lives with the baby *(only explicitly asked about mother and father in Uganda)*?

The mother? Yes ☐ No ☐

The father? Yes ☐ No ☐

Please specify their gender, age, and relationship of household members to your baby:

Name	*Gender*	*Age*	*Relationship to the child*

Are there other people who sometimes live with the baby? Please specify their gender, age and relationship to the baby. When/in which situations do they live with the baby? *(only asked explicitly in Uganda*):

Name	*Gender*	*Age*	*Relationship to the child*	*When do they live with baby?*

How long have you lived in this house? ______

Have you moved since the baby was born? Yes ☐ No ☐

If yes, how old was the baby when you moved? ______

Childcare

How are you feeding your baby?

☐ I have been breastfeeding my baby since _________________ (e.g., since birth, 4 weeks old)

☐ I have been bottle feeding my baby with cow or formula milk since _________________

☐ I have been feeding my baby solid food since _________________

When do you feed your baby?

☐ Whenever I think that the baby feels hungry

☐ At fixed times: _________ times a day

☐ Other, please specify: ____

Where does your baby sleep at night?

☐ In the same room as the mother

☐ In the same room as the father

☐ In a room with siblings

☐ In a separate room on their own

☐ In a room with somebody else, please specify: ______________________________

Does your baby share a bed with someone?

☐ No

☐ Yes, with the mother

☐ Yes, with the father

☐ Yes, with siblings

☐ Yes, with someone else, please specify: ______________________________

What did your baby play with yesterday? _______________________________________
____

What does your baby most enjoy playing with? __________________________________
____

Mother's work

Since your baby was born, what kind of work have you done (e.g. housework, cooking, gardening, agriculture, business/salary job)? How old was your baby when you started each of these?

UK Format:

Type of work	*Age of child when started*

Uganda format:

Housework?	Yes ☐	No ☐	*Age of child when started* _______________
Cooking?	Yes ☐	No ☐	*Age of child when started* _______________
Gardening/agriculture?	Yes ☐	No ☐	*Age of child when started* _______________
Business?	Yes ☐	No ☐	*Age of child when started* _______________
Salary job?	Yes ☐	No ☐	*Age of child when started* _______________

What is the salary job? ______________________________________

Other work? Yes ☐ No ☐ *Age of child when started* _______________

What is the other work? _____________________________________

How many days a week do you spend working outside the house? __________________
On days that you are working outside the house, for how long are you usually gone?
____
Who looks after the baby whilst you are working outside the house (Name, gender, age, and relationship to child)?
____
____
What was the longest time your baby has been separated from you?
____
____

Uganda format:
Do you always take your baby with you if you go somewhere for non-work purposes? (e.g., shopping, visiting a friend, doctors' appointments)? Yes ☐ No ☐

If no, please estimate how frequently are you separated from your baby for non-work purposes?
Number of hours per visit: _________________
Number of visits per week: _________________
UK format:
How often are you separated from your baby for non-work purposes (e.g., shopping, visiting a friend, doctors' appointments)?
____
____

Other caregivers
a) Other than yourself, who else spends a lot of time with your baby during the day? (e.g. father, grandparents, older sibling, childminder, nursery teacher). Please estimate how many hours a week they spend with the baby.

Person	*Number of hours per week spent with the baby*

b) Apart from you – who attends to your baby during the night? ___________________
____

Does your baby go to the nursery? Yes ☐ No ☐
If yes: From what age? ________________
How many days a week? __________
How many hours a day? __________
Previous experiences
Has your baby participated in any other study before? Yes ☐ No ☐
If yes, please specify: ____

Is your baby currently participating in any other study? Yes ☐ No ☐
If yes, please specify: ____
Has your baby ever seen the light of a laser pointer? Yes ☐ No ☐
Has your baby ever seen the light of a torch? Yes ☐ No ☐

Other comments:
____
____
____

UK siblings questionnaire

Siblings

Date: _____________ Participant ID: ______________
The experimenter asks these questions and fills out the form.
Is [the baby in our study] your first child?
If not: Have you had any other children?
If yes: Did you play a role in raising them?
If yes: Can you tell me a little bit more about that?

Indoor-outdoor questionnaire

Participant number _____________ Date __________________ Infant age __________

Think about your child in the last 3 months. Where did he/she do the following behaviours?

	Most or all of the time outdoors	**More time outdoors than indoors**	**Equally outdoors and indoors**	**More time indoors than outdoors**	**Most or all of the time indoors**
Resting during the day (relaxing or sleeping)					
Traveling (by car or bus counts as indoors)					
Play					
Feeding/Eating					

Think about your behaviour in the last 3 months. Where did *you* do the following behaviours?

	Most or all of the time outdoors	**More time outdoors than indoors**	**Equally outdoors and indoors**	**More time indoors than outdoors**	**Most or all of the time indoors**
Resting during the day (relaxing or sleeping)					

	Most or all of the time outdoors	More time outdoors than indoors	Equally outdoors and indoors	More time indoors than outdoors	Most or all of the time indoors
Traveling (by car or bus counts as indoors)					
Chores					
Play with infant					
Infant care					
Eating					
Work					

A2.2 Full-day follow data collection sheets

Full-day follows were collected at 3-month intervals in the UK and Uganda. In the UK, mothers were phoned every 30minutes, and were asked a series of questions about the current behaviour of herself and her infant, as well as information about the wider context of the situation, such as who was nearby. In Uganda, mothers and infants were directly observed and research assistants noted down information every 15minutes on the same topics as were asked about in the UK. The data collection sheets for full-day follow data collection are below. These data sheets were altered from Kaller (2012).

UK full-day follow data collection sheet

Full Day Focal Follow

Date:

Observer:

Participant ID:

Child's age:

Time :		
If speaking to mother: What are you doing?		
If speaking to other carer: What are you doing? What is the baby's mother doing?		
If social: Who are you doing it with?		
What is the baby doing?		
If social: Who are they doing it with?		
How far away from you is the baby?		
If speaking to other carer: How far away is the mother from the baby?		
Can your baby see you?		
Can your baby see your face?		
Has your infant cried in the last half hour? *If yes*: Why? What did you do? Did your reaction stop the crying?		
How many objects are within reach of your child? *(None, 1, 2, 3, 4, 5, or more than 5)*		
Which kinds of objects?		
Is there anyone else within 5m? Who? How many? Does your child know them or not?		
Is anyone interacting or in physical contact with your child? *If yes:* How?		
Is there anyone else a bit further, up to 10m? Who? How many? Does your child know them or not?		
Are you and your baby indoors or outdoors?		
Comments		

Uganda full-day follow data collection sheet

Mother-Infant Focal Scan Sampling

Observer: Participant no. Todays date: Weather:

	Infant	Mother	Carer	People nearby to infant + contact/interactions	
Time	Infant activity	Mother activity	Carer activity	Who in 0-5m?	Do they interact with inf?
Who is caring for the infant?	Infant Partner	Mother partner	Carer partner		
	Objects infant can reach	Can infant see mother?	Can infant see carer?		
				Who in 5-10m?	Do they interact with inf?
Did infant cry in last 15minutes?		Can infant see mother's face?	Can infant see carer's face?		
		Body contact/distance (mother)	Body contact/distance (carer)		
	Infant location (indoors/outdoors)	Mother location (indoors/outdoors)	Carer location (indoors/outdoors)		
Time	Infant activity	Mother activity	Carer activity	Who in 0-5m?	Do they interact with inf?
Who is caring for the infant?	Infant Partner	Mother partner	Carer partner		
	Objects infant can reach	Can infant see mother?	Can infant see carer?		
				Who in 5-10m?	Do they interact with inf?
Did infant cry in last 15minutes?		Can infant see mother's face?	Can infant see carer's face?		
		Body contact/distance (mother)	Body contact/distance (carer)		
	Infant location (indoors/outdoors)	Mother location (indoors/outdoors)	Carer location (indoors/outdoors)		

Comments:

A2.3 Full developmental questionnaire

A developmental questionnaire was presented to mothers every 3-months. In the UK mothers were given a paper sheet to fill in herself. In Uganda, research assistants verbally translated the questions and noted down the mothers answer. The developmental timetable questionnaire is below.

Developmental timetable

Date: ________________ Participant ID: ________________ Child's age: __________

Below, we have listed some behaviours. We would like to know which ones of these behaviours your baby shows at this age. Please tick the box for each of the following behaviours that your baby engages in. Thank you!

	My baby...	
1.	recognizes his/her mother	Yes ☐ No ☐
2.	recognizes his/her father	Yes ☐ No ☐
3.	recognizes his/her siblings (brothers, sisters)	Yes ☐ No ☐
4.	produces non-cry sounds	Yes ☐ No ☐
5.	demonstrates interests for objects	Yes ☐ No ☐
6.	smiles	Yes ☐ No ☐
7.	reacts to his/her name	Yes ☐ No ☐
8.	crawls	Yes ☐ No ☐
9.	sleeps through the night	Yes ☐ No ☐
10.	sits without support	Yes ☐ No ☐
11.	understands words	Yes ☐ No ☐
12.	speaks first word	Yes ☐ No ☐
13.	uses two-word sentences	Yes ☐ No ☐
14.	stands with support	Yes ☐ No ☐
15.	stands without support	Yes ☐ No ☐
16.	understands small questions	Yes ☐ No ☐
17.	understands simple orders	Yes ☐ No ☐
18.	releases objects on request	Yes ☐ No ☐
19.	shares objects with others	Yes ☐ No ☐
20.	shares food with others	Yes ☐ No ☐
21.	gives objects without request	Yes ☐ No ☐
22.	holds up objects to show them to you	Yes ☐ No ☐
23.	points to objects he/she wants	Yes ☐ No ☐
24.	points to objects to draw your attention to something, without wanting the object	Yes ☐ No ☐
25.	walks alone a few steps	Yes ☐ No ☐
26.	recognizes himself/herself in a mirror	Yes ☐ No ☐

A2.4 Parenting practices questionnaire

A parenting practices questionnaire was presented at 0-3, 11 and 24months. In the UK, mothers were given a paper copy to fill out themselves. In Uganda, participants were played an audio recording in a language of their preference from the choices Kiswahili, Lugbara, or Alur. The contents of the parenting practices questionnaire are listed below.

Parenting Practices Questionnaire

This questionnaire should be filled out during visits at 0-3, 11, and 24 months.

Date: ______________ Participant ID: ____________ Child's age: __________

UK instructions:

In this questionnaire you will find a selection of statements which address the correct handling of a mother with her baby or her small child respectively. Some statements will be familiar to you, others not. You will probably agree with some and not to others.

Please think of baby with about 3 months/ 11 months/ 24 months of age and express your agreement or disagreement by making a cross in the column that corresponds best with your agreement.

Don't think much about each statement, but react **spontaneously!**

Ugandan instructions:

Here we will read some statements to you which talk about how a mother interacts with her baby.

Some statements will be familiar to you, others not. You will probably agree with some and not to others. Please think of baby with about 3 months/ 11 months/ 24 months of age and express your agreement or disagreement.

Some mothers in Uganda agree to different statements than mothers in England. So there are no correct answers, we would like to know your opinion.

Don't think much about each statement, but react **spontaneously!**

	Strongly disagree	**Slightly disagree**	**Neutral**	**Slightly agree**	**Strongly agree**
1. It is important to rock a crying baby in your arms in order to console him/her.					
2. Sleeping through the night should be trained as early as possible.					
3. It is not necessary to react immediately to a crying baby.					
4. It is never too early to direct the baby's attention towards objects and toys.					

	Strongly disagree	Slightly disagree	Neutral	Slightly agree	Strongly agree
5. Babies should be encouraged to be as physically active as possible so that they become strong.					
6. If a baby is fussy, he/she should be picked-up immediately.					
7. It is good for a baby to sleep alone.					
8. When a baby cries, he/she should be nursed immediately.					
9. Babies should be left crying for a moment in order to see whether they console themselves.					
10. A baby should always be in close proximity with his/her mother, so that she can react immediately to his/her signals.					
11. A mother should make an effort to teach words to the baby as early as possible.					
12. A baby should be given the opportunity to explore any object he/she finds interesting.					
13. A baby should be caressed and hugged a lot.					
14. Too much body contact with the mother prevents the infant from becoming independent.					
15. If a baby smiles, the mother should smile back immediately.					
16. A mother should name the objects the baby is interacting with.					
17. It is good for babies at this age to be physically stimulated (e.g. practicing walking) by their mother.					
18. If a baby smiles, the mother should smile back immediately.					
19. A mother should name the objects the baby is interacting with.					

	Strongly disagree	Slightly disagree	Neutral	Slightly agree	Strongly agree
20. It is best for a baby to always be with the mother, without being in the centre of attention.					
21. Too much body contact with the mother prevents the infant from becoming independent.					
22. Babies are overstimulated by lots of toys (*only asked in UK)*.					
23. Talking to babies before they can speak is pointless.					
24. One should concentrate on the gaze of a baby.					
25. It is not good for a baby to practice sitting, walking, or standing too early.					
26. It is important to allow a baby to explore objects on his/her own without the mother interfering					
27. A baby should be held in the arms a lot, even when other chores are being completed.					
28. It is important to engage in play routines with the baby every day.					
29. Baby-talk is the wrong way to address a baby					
30. Mothers should share attention about exciting objects with their babies.					
31. Mother and baby should have a lot of eye-contact.					
32. If you carry a baby too much, you only spoils him/her (*only asked in UK)*.					
33. It is important to consider a baby as an individual with its own thoughts and feelings.					
34. If a baby vocalizes, one should "answer" immediately.					
35. It is important to devote a lot of time exclusively to the baby (*Only asked in UK)*					

	Strongly disagree	Slightly disagree	Neutral	Slightly agree	Strongly agree
36. It is unimportant for the development of a baby to show objects to him/her.					
37. One should react immediately to the different signals of a baby.					
38. Mothers should talk a lot to their babies.					
39. Mothers should have a lot of close body contact with the baby.					

A2.5 Full socialisation questionnaire

A socialisation goals questionnaire was presented at 0-3, 11 and 24months. In the UK, mothers were given a paper copy to fill out themselves. In Uganda, participants were played an audio recording in a language of their preference from the choices Kiswahili, Lugbara, or Alur. The contents of the socialisation goals questionnaire are listed below.

Socialization Goals Questionnaire

Date: ______________ Participant ID: ________________ Child's age: _______________

Instructions for UK:

Please read the following statements that describe different characteristics that children should acquire during the first three years of their life.

We would like you to indicate how much you agree with each of these statements by making a cross in the column that corresponds best with your agreement.

Mothers in the UK might agree to different statements than mothers in Uganda. That means that there are no right or wrong answers. We would like to know your opinion.

Please answer the questions in the order they are presented, don't skip any and please don't go back to earlier questions once you've moved on.

Instructions for Uganda:

We will read some statements that describe different characteristics that children should acquire during the first three years of life.

Some mothers in Uganda agree to different statements than mothers in England. So there are no right or wrong answers, we would like to know your opinion

		Strongly disagree	Slightly disagree	Neutral	Slightly agree	Strongly agree
During the first three years of life it is really important that children…						
1.	learn to cheer-up others.					
2.	learn to obey parents.					

3.	develop a sense of self (*only asked in UK)*.					
4.	develop self-confidence.					
5.	learn to control emotions.					
6.	learn to obey elderly people.					
7.	develop a sense of self-esteem (*only asked in UK)*.					
8.	develop competitiveness.					
9.	learn to care for the well-being of others.					
10.	develop independence.					

Instructions for UK:

Thank you for having told us how much you agree with each individual statement!

In the next part, there will always be two statements presented next to each other. I would like you to choose which one you think is the most important. You might think that both or neither of them are very important, but please decide which characteristic you consider to be *the most important* of the two. Please make a cross next to the statement you think is most important.

Instructions for Uganda:

Now we will read you two statements. I would like you to choose which one you think is the most important.

For example, some mothers in Uganda agree to different statements than mothers in England. So there are no right or wrong answers, we would like to know your opinion.

You might think that both or neither of them are important, but please decide which characteristic you consider to be *the most important* of the two.

Now we will practice this (*Practice only done in Uganda*):

.	I think matoke is very nice to eat.			I think rice is very nice to eat.
.	It is important to rest when you are tired.			It is important to drink when you are thirsty.
.	I am a man.			I am a woman.
.	Some people in my village own goats			Some people in my village own elephants.

During the first three years of life it is really important that children…				
11.	learn to control emotions.			develop competitiveness.
12.	learn to care for the well-being of others.			develop independence.
13.	develop self-confidence.			learn to obey adults.
14.	learn to care for the well-being of others.			develop self-confidence.
15.	develop competitiveness.			learn to care for the well-being of others.
16.	develop independence.			learn to obey adults.
17.	develop self-confidence.			learn to control emotions.
18.	develop competitiveness.			learn to obey adults.
19.	learn to control emotions.			develop independence.

A2.6 Warm-up questionnaires

Before presenting the Parenting practices questionnaire or the Socialisation goals questionnaires, mothers were made familiar to the administration and response format of the questionnaires using a 'warm-up' questionnaire. The contents of these questionnaires are below.

UK warm-up questionnaire

Warm-up Questionnaire

On this 'Warm-up Questionnaire', we would like to give you a chance to familiarise yourself with the answer format of our questionnaires. There are five different possible answers: You can either disagree strongly with the statement, disagree slightly with it, have a neutral opinion on the statement, agree slightly with the statement, or agree strongly with it.

In order to practice this format, I would like you to indicate how much you agree with each of the following statements by making a cross in the column that corresponds best with your agreement.

	Strongly disagree	Slightly disagree	Neutral	Slightly agree	Strongly agree
In some countries, mosquitos transmit diseases like malaria.					
People can run as fast as horses.					
Being struck by lightning can kill you.					
People can live up to 200 years.					
Music is necessary for people's wellbeing.					
Snakes are scary.					

Ugandan warm-up questionnaire

Warm-up Questionnaire

During this visit, we will ask you to answer some questions. In some of these questionnaires, we will read to you statements and would like you to tell us how much you agree with them.

In all our questionnaires, there are no right or wrong answers. We would simply like to find out your opinion on different aspects of parenting or child behaviour. On this 'Warm-up Questionnaire', we would like to give you a chance to get used to the answer format of our questionnaires. There are five different possible answers: Do you strongly disagree, slightly disagree, have no opinion, agree slightly, or agree strongly?

Please note that the answers do not necessarily correspond with how you feel about the statement. You could, for example, strongly agree with the statement "many people die of diseases because health services are not good enough" without being happy about this.

To practise using this answer format, we will now read some statements. Please indicate your agreement by telling it to us. What do you think about this sentence?

		Strongly disagree	**Slightly disagree**	**Neutral**	**Slightly agree**	**Strongly agree**
						
1.	In some countries, mosquitos transmit diseases like malaria.					
2.	People can run as fast as lions					
3.	Being licked by a cow can kill you.					
4.	People can live up to 200 years.					
5.	Music is needed for people to be happy.					
6.	Snakes are scary.					
7.	Reproducing is compulsory					
8.	Cooking is good					

A2.7 UK full-day follow training materials

Before researchers collected full-day follow data in the UK they were trained up on conducting the full-day follow phone calls. They were provided the following material to become familiar with, and use as reference when conducting the phone calls:

Full-day follow (UK Humans)

Brief Intro:

Full-day focal follows will be used to make time budgets for individuals. We will follow each mother-infant dyad for 8hrs at each time point.

Time points: 3m, 6m, 9m, 12m, 15m, 18m, 21m, 24m

Mother (and other caretakers) get data recorded via phone calls for **8 hours on 1 day every 3 months**. We will record the data every 30 minutes on the phone.

How to record (on the phone):

- Call the mother at 30 minute intervals, and read a script asking questions
- Print the script before starting the phone calls
- Write the mothers answers on the script.
    - ↳ Rather err on the side of writing too much than being too brief. That way we can always discuss tricky answers later.
    - ↳ If you are ever unsure about how we will later transfer some information the mothers give you onto the spreadsheet, explain the problem in the comment section of the question script and make a note in the excel spreadsheet
- The script can be found in: *File location*
- **If the mother misses a phone call and tells you later (when you reach her) what she was doing when you originally called, you have to write in the comment section that this was retrospective data**

How to transfer the data afterwards:

- The data on the script needs to be transcribed to the datasheet "Focal Excel Datasheet_Human UK"
- This datasheet can be found in the folder: *File location*

- Start by filling out the basic information: your initials, the date of the phone call, the infant's ID, and the time of the phone call. Use a new row for every phone call.

What is the mother/ baby doing? ⍰ Activities

- You need to transfer what the mother told you into one of our set categories (select the appropriate category from a drop down menu)
- If someone is engaging in several activities at the same times always select the more active and more social category:
    - ↳ E.g. the mother is sitting on the sofa, watching TV (which would be resting) and simultaneously breastfeeding her baby put nursing as the activity
- If there are 2 behaviours that seem equally active but in different ways record one and put the other in the notes so we can decide on them later as a group

- *Priority of behaviour* (if these are happening simultaneously)
    - ☒ Social interactions are top priority!
    - >Play > Being cared for, Nursing
    - > Feeding other/Being fed > Nursing (unlikely to happen simultaneously)
    - > Feeding self
    - >Travelling (if child is playing in the car, playing trumps travelling)
    - > Chatting
    - > Resting (if child is on the mother's back, in her arms, in push-chair, in car-seat, travelling trumps resting)

The table below gives a definition of activities, and whether a social partner should be recorded or not.

Activity name	Explanation	Social partner?
Feeding self	Eating something (i.e. putting food in your own mouth)	No
Feeding other	This will mostly be an activity for the mother and it means feeding the baby with a bottle or giving them solid food	Yes
Nursing	Breastfeeding a baby	Yes
Being fed	This will mostly be an activity for the baby: it includes being breastfed, being bottle fed and being fed solid food	Yes
Infant care	Activity for the mother: includes brushing hair, wiping face, washing hands, changing nappies, dressing the infant -> Can also apply to other children the mother might have	Yes
Being cared for	The baby receives the above mentioned care	Yes
Care for self	Somebody dressed themselves, goes to the bathroom etc.	No
Chatting	Chatting is an ongoing conversation/social interaction where chatting is the focus. If the mother is doing chores, eating etc. whilst also talking to someone, you should still code the chore or eating. However, chatting is more active than resting. So we will code "chatting" when the mother is resting but engaging in listening to or talking to another as part of a social interaction. Chatting is not coded for single vocalisations like a brief exchange, greeting someone or saying something one off. In these situations, please code the dominant context. Chatting between mother and older infants also counts	Yes
Play solo	Playing alone without an object (e.g. running around by yourself)	No
Play solo object	Playing alone with an object (e.g. playing with a toy car)	No
Play social	Playing with another person without objects (e.g. hide and seek)	Yes

Activity name	Explanation	Social partner?
Play social object	Playing with another person with objects (e.g. two children playing with a ball, mother reading book to baby)	Yes
Resting	Anytime sitting, on phone, watching tv, no interaction Sleeping is also counted as resting If the baby is simply being carried or held	No
Sleeping	Baby asleep	No
Active Travelling	Moving outside the house to achieve a goal (e.g. going to the shops, walking to the doctor's office, the hairdresser). Individual is exerting energy while travelling: e.g. walking, riding a bike … It does not mean moving around inside the house	No
Passive Travelling	Moving outside the house to achieve a goal (e.g. driving to the shops, taking the bus to the doctor's office, the hairdresser…). Individual is not exerting energy while travelling: e.g. going by bus, being pushed in a pushchair, driving in a car, being in a car seat…. It does not mean moving around inside the house	No
Exploring	Moving around within the local area (the house, the room, the waiting room at the doctor's, the park), that is NOT travel or play. The movement is not essential (no end goal like travelling to the shops), but it can be the movement towards an object (e.g. the baby is crawling towards a toy). Includes movements like crawling, bum shuffling, walking, sofa cruising. For adults it can also include running in the park to self-exercise or walking around in the garden for relaxation.	No
Distress	Baby is crying	No
Comfort other	Individual is comforting someone else, e.g. holding them in their arms plus doing something reassuring like rocking, shushing etc.	Yes
Household chores	Mother (and later maybe also the infant) is doing chores like preparing meals, sweeping, washing up…	Mother: no Infant: yes
Work	Refers to jobs for bringing in resources. Mother working with no potential for infant to be involved, e.g. digging fields, laptop, phone calls	No
Shopping	We differentiate between essential shopping (i.e., food for the family or medication) and leisure shopping (e.g. shoes) Online leisure shopping is just rest Online essential shopping is essential shopping	Mother: no Infant: yes
Other	Other rare context not included in the above list, or don't know how to categorise. Include description of activity in comments.	

IDs of interaction partners

If the mother / carer or the baby are doing something with somebody else (playing, being fed etc.), we want to know who their interaction partners are.

Even if that is the mother feeding the baby! We still need to specify that the mother is feeding the infant and the infant is being fed by the mother.

This category applies only to joint activities like playing, feeding etc.

Generally, we will write down the person's relation to the infant (e.g. grandmother, father). If the person really only has a relationship to the mother, we will specify that (e.g. mother's friend). The more detail you give the better (i.e. include familiarity, gender, if adult, or if child what their age/estimated is).

Carer

If the mother leaves the baby with somebody else (i.e., goes to work while the baby stays with grandma), then we need to fill in the carer's ID and activity. We still want to know what the mother is doing though.

This doesn't apply if the mother is cooking while an aunt plays with the baby in the same room.

We will count someone as being the carer when they are responsible for the child. So if the child is distressed who would the mother expect to respond?

If the mother doesn't know whether she should take the phone or leave it with someone else, you could explain that to the mother and ask her to give her phone to the 'carer' /or give us the carers phone number to call, whenever she felt she was no longer responsible for the child.

N/A

In some drop down menus, you have got the option "N/A".

This means that the column was introduced after data was collected -> so we will only choose it for old data in new columns. Don't choose it for data you are currently collecting!

BC/ Dist

This is where you put the answer to the question "How far away from you is your infant?"

- We are always interested in how far away the mother is even if the is in a different room
- If there is a different carer, we want to know the carer's distance to the child and also how far away the mother is

Category	Explanation
V	Ventral; means that the baby is carried on the front of the mother's body, for example when the mother is holding the baby in her arms or when the baby is carried in a sling on the mother's chest
D	Dorsal, means the baby is carried on the back of the mother's body, for example when the baby is in a sling on the mother's back
BC	Any body contact other than being carried ventrally or dorsally , for example infant on the mother's lap, sitting next to her touching
Distance in meters	If there is no body contact at all between mother and baby, select the distance between mother and baby that applies to what the mother said

Category	Explanation
	The mother-infant distance should be 10m+ if the mother is in a different room out of sight, even if through the walls its less than 10m. If the mother is in sight, then take the exact distance If a carer is responsible for the child and the mother has left the house (so she would not be able to come back quickly if the baby was on fire), choose “not around” as the distance option

Can infant see mother/ carer?

- We want to know whether the infant could potentially see their mother/ their mother’s face; i.e. if the infant would want to/ wake up, would they be able to see the mother?
- It doesn’t mean “Are they looking at the mother now?”
- So even if the baby is sleeping, you could code “Yes, she can see mother” when they are sleeping somewhere where they could potentially see the mother
- Mirrors and other reflective surfaces do not count -> if the baby can also see the mother in the mirror, you still need to score this as “No”; but explain the situation in the comment

Crying

- When we ask whether the infant had been crying, we mean proper crying. So if the baby was a little whiney or the mother managed to avert a crying-crisis before it happened, we will code that as “No”

Reasons for crying

- Always get the mother’s interpretation why the baby is crying
- All reasons are pretty much self-explanatory, for the rest:

Category	Explanation
Hungry	
Tired	
Scared	
Lonely	For example, mum left the baby whilst getting ready/packing the car and they cried
Hurt/Sick	
Woke up	The baby just woke up from a nap
Physical discomfort	Baby’s nappy needs to be changed, the baby is too hot or too cold etc (Added 14/12/2018)
Tantrum	The baby didn’t get his/her way; something happened that they didn’t like (e.g. being put in a car seat, not getting enough attention, being changed)

Reactions to crying

Category	Explanation/ Examples
Feed baby	Mother feeds the baby
Put to bed	Mother puts the baby into their cot, pram, moses basket etc.
Physical comfort	Picking up the baby, cuddling them, patting their back
Verbal comfort	Reassuring them, saying Shhh
Ignore	Not responding to the infant's crying
Avoidance	Not responding to the infant and leaving the room
Physical reprimand	Hitting the child
Verbal reprimand	Telling the baby off, shouting at them
Somebody else reacted	Code that when somebody else reacts to the crying, e.g. when the father picks the baby up
Other	Anything you can't fit into the categories above

Objects

- Objects are things that the infant can pick up and manipulate (e.g. a toy, a grape, a bottle)
- If the infant is playing with part of a larger thing, e.g. the corner of a blanket, we also count the blanket as an object -> but not if the infant is just lying on the blanket

Unidirectional interaction

- Sometimes people will interact with the baby in a unidirectional way. This means that they might hold the child or talk to the child without it being a joint activity (because the child is simply resting in their arms or can't answer them yet)
- You will find out about this by asking "Are they interacting with your child?" about the people within 5 meters of the baby [THIS WAS THE QUESTION UP UNTIL 21/10/2019]
- THE NEW QUESTION IS "Is anyone interacting or in physical contact with your child? If yes: How?" [introduced from 21/10/2019]
- Please indicate whether anybody is interacting with the child (Y/N)
- If yes, please fill out the column telling us who it is
    - ↳ If there are several people interacting with the child, separate them by commas
- If yes, please select an interaction from the drop down menu (explained below):

Category	Explanation/ Examples
Facial expression	e.g. the person is smiling at the baby
Gesture	The person is gesturing towards the baby
Talking (language)	The person is talking to the baby, using actual words and sentences
Talking (non-language)	The person is making sounds at the baby that are non-language (e.g. babab, ooooooh)

Category	Explanation/ Examples
Touching	The person is touching the child, e.g. stroking the baby, putting their hand on their head
Holding	The person is holding the baby in their arms
Carrying	The baby is strapped to the person's body

Individuals within 5m and 10m

- Let the mother tell you which and how many people are within 5 and 10 meter, write them down on your print out
    - ↳ We have to specify their gender and age, so try to get as much information out of the mother as possible!
- Only count people who are within sight of the infant
    - ↳ So if for example the father is in a separate room than the child (but within 5 meters) don't count him in
- Include <u>everybody</u> within 5 or 10 meters into these columns (except for the mother/carer), even if they had already been listed as interaction partners!
- Afterwards, indicate on the spreadsheet how many of the people in each of the following categories were within sight of the child:
    - For close relatives/ household members:
        - ↳ people in the household who sleep there at least once a week or full time in the holidays (e.g. children at boarding school)
            - F: Father
            - GM: Grandmother
            - GF: Grandfather
            - HFA: Household female adult
            - HMA: Household male adult
            - HF#: Household female child (incl. cousins and sisters and others; #= child's age, e.g. HF#7 for 7 year old sister)
            - HM#: Household male child (incl. cousins and brothers and others; #= child's age, e.g. HM#3 for 3 year old male cousin)
    - For familiar individuals (e.g. friends, relatives who don't live in the household)
        - ↳ people that the infant will recognise - sees infant at least once a month
            - FFA: Familiar Female Adult
            - FMA: Familiar Male Adult
            - FF#: Familiar Female child/adolescent (#=familiar person's age, e.g. FF1 for unrelated friend)
            - FM#: Familiar Male child/adolescent (#=familiar person's age, e.g. FM1 for unrelated friend)
    - For unfamiliar individuals
        - ↳ people the infant is unlikely to recognise - sees infant less than once a month

↳ total strangers

- UFA: Unrelated Unfamiliar Female Adult
- UMA: Unrelated Unfamiliar Male Adult
- UFB: Unrelated Unfamiliar Female baby (child looking like less than 2 years old)
- UMB: Unrelated Unfamiliar Male baby (child looking like less than 2 years old)
- UFP: Unrelated Unfamiliar Female Pre-schooler (child looking like 3 to 4 years old)
- UMP: Unrelated Unfamiliar Male Pre-schooler (child looking like 3 to 4 years old)
- UFC: Unrelated Unfamiliar Female child (child looking 5 to 16 years old)
- UMC: Unrelated Unfamiliar Male child (child looking 5 to 16 years old)

Indoors/outdoors

Are you and your baby indoors or outdoors? We want an answer for both mother and infant.

Options: Indoors/outdoors/vehicle.

Answers to past questions

Situation	How did we code it
Mother and baby driving in the car, baby asleep	Both: travelling
Mother and baby driving in the car, baby playing with a toy	Mother: travelling, Baby: solo play object
Chatting and eating at the same time.	if it's a meal time and people are talking, then eating is priority. But if it's friends chatting and there are a few biscuits or cake, then chatting is the priority.
Mother is holding the baby and interacting with him; he is smiling at her and she is smiling back.	Even though there is some interaction there, they are both simply resting; code unidirectional interaction though
Mother holding the baby, nothing else is going on	Both resting, body contact will indicate that the mother is holding the baby
Mother is comforting a baby that already stopped crying, but still rocking her	"Comforting other" as the mother activity and "resting" for the child
Does food count as objects?	Yes
Number of objects when in a jumperoo or when eating something like pasta	> 5
Number of objects when playing with tassels on rug	1 rug
Mother is just about to change the baby's nappy or on her way upstairs to brush their teeth	If they have started the process (going to the bathroom, to the nappy changing area) then it's infant care. If they are still

Situation	How did we code it
	sitting on the sofa thinking about doing it, then it's still resting.
Mother is getting back home from somewhere (is on the drive when we call or just came into the house, still standing in the hall)	We still count that as travelling, as long as she hasn't settled down somewhere and is resting already
The mother is giving the baby food but the baby is feeding herself	Mother activity: feeding other Baby activity: feeding self
Can mother and baby chat (if baby is old enough to reply)?	Yes
The mother is active travelling somewhere (e.g. walking to the supermarket) and she is carrying the baby (so the baby is not in a pushchair)	Baby is passive travelling
The mother is exploring while carrying the baby	Baby is resting
If babies pull themselves up on a piece of furniture to bounce, or bang them, is that solo object play or do we not count these big things as objects?	No, they would need to be manipulating part of the table in detail (e.g. closely looking at the pattern of the wood) for it to be considered an object. If they are just banging on it, it's not object play
The mother is in the middle of putting the baby to bed	Infant care
Do we still categorise interaction as chatting if the baby is pointing at things and the adult is responding to that, e.g. naming the objects they point at.	No, both have to be actually talking for it to be considered chatting
Do we code unidirectional interactions for the mother as well?	Yes
Do mirrors count in "Can the baby see you?"	No, on the spreadsheet, this classifies as a "No", but write it in the comments
Does drinking count as feeding?	If they are actively drinking in the moment before the phone call it can be coded as feeding self/other. Otherwise code their other activity.
What is potty training/ being on the potty?	If the child still needs the mother's help (i.e., the mother has to be in the room with them), they are being cared for & and the mother is doing infant care. If the child is doing it independently, the child is caring for self and the mother's activity is whatever she is doing. If the mum is supervising but not helping, this still counts as infant care.
If the infant is sleeping and travelling what should be coded?	Travelling is the priority (i.e., that should be the infant's activity), but add "sleeping" to the comments, so we can

Situation	How did we code it
	distinguish between travelling while asleep and while awake
What is swimming?	"Other" and explain in comments
Mum is going to get a phone charger	"Other" and explain in comments
Mum is moving through the house on her way to do something	Ask what she is on her way to do. If she is going to get the crying infant from their naptime, then that counts as "Infant care". If she is going to tidy the kitchen that counts as "household chores". The mother's activity when moving around the house should be the thing that she is moving to do.
The child is using a toy hoover while the mum is using a real hoover	The mother and child activities are both "household chores". Write in the comments that the child is using a toy hoover. This would also be similar if the child is mimicking other chores (not necessarily effectively doing them) e.g. pulling things out of the washing machine, using a toy lawnmower, pretending to mix things. AS LONG AS THE MOTHER IS ALSO DOING THESE THINGS FOR REAL AT THE SAME TIME.

A2.8 Uganda full-day follow training materials

Before researchers collected full-day follow data in Uganda they were trained up on conducting the full-day follow home visits. As part of this training, they were provided the following material to become familiar with, and use as reference when conducting the full-day follows:

LIST OF DATA TO NOTE	Description of category	What to write on the sheet
Observer		Put your name or your initials
Date		Date of data collection
Mother/Infant ID number		Each mother and infant will be given a number
Time		every 15 minutes
Weather	describe weather	e.g. windy, cloudy, sunny, rainy, stormy
Mother/carer	Is it the mother or another carer who is currently taking responsibility for the baby? If it is the carer, who are they? What is their relationship to the child, their sex, and age?	Chose from list of relationships

LIST OF DATA TO NOTE	Description of category	What to write on the sheet
Infant activity	Describe the activity of the infant	Chose from list of activities
Infant partner	If the infant is in a social behaviour, who is their partner. Specify their relationship to infant, sex and age.	Chose from list of relationships
Mother/Carer activity	Describe the activity of the mother and If there is a carer, also specify.	Chose from list of activities
Mother/carer partner	If the mother or carer is in an activity with a partner, Specify relationship to child, sex, and age. If their behaviour has no partner, write nobody.	Chose from list of relationships
Body contact/distance	Describe the body contact or distance from the infant to the mother and carer.	Chose from list of body contact/distance options
Can infant see mother/carer	Can the infant see the mother and/or the carer?	Yes, no, don't know/unknown
Can infant see mother/carer's face	Can the infant see the mother and/or the carer's face?	yes, no , don't know/unknown
Who in 0-5m? Do they interact with inf?	List individuals in 5 meters of the infant. Say their relationship, their sex and their age. If they are interacting with infant say how.	Chose from list of relationships and chose from list of interactions
Who 5-10 meters? Do they interact with inf?	List individuals between 5-10meters of the infant. Say their relationship, their sex and their age. If they are interacting with infant say how.	Chose from list of relationships and chose from list of interactions
Objects in reach	List objects which are in reach of the infant	Chose from list of objects
Did infant cry?	Did infant cry in the last 15 minutes. If the answer is yes, make sure you fill in the crying sheet	Yes, no, don't know/unknown
Comments	Comment anything that you were unsure of during the scan sheet - for example, you are not certain which category the behaviour fits into. If you put behaviour other, describe what that behaviour was. If something unusual happens also describe this	

What is a carer:	A carer is somebody who has responsibility of the child if they begin to cry. If the mother is out of earshot of the child crying then this will not be the mother. If the mother has asked someone else to look after the child while she is in earshot, this will still be the other carer. If there is a carer as well as the mother please take data for both the carer and the mother.

ACTIVITY LIST	Partner	Description
Feeding self	No	Mother or infant is feeding themselves
Feeding other	specify	Mother or infant is feeding someone else
Being fed	specify	Mother or infant is being fed by someone else (everything except breastfeeding)
Nursing	specify	Mother is breastfeeding a child, or child is suckling from mother
Care for child	specify	Mother is caring for an infant or child. For example: infant is being washed, infant is being dressed
Being cared for	specify	Infant is being cared for. For example: he is being washed, he is being dressed - dressing, brushing hair, wiping infant's face
Care for self	No	Mother or infant is caring for themselves , for example, they are cleaning themself (e.g. hands), sorting their hair
Play - alone no object	No	Infant is playing alone without an object
Play - alone object	No	Infant is playing alone with an object
Play - social no object	specify	Infant or mother is playing with another individual without an object
Play - social object	specify	Infant or mother is playing with another individual with an object
Resting	No	Infant or mother is resting, not doing anything, not talking to someone
Active travelling	No	Infant or mother are moving somewhere - for example going to their friend's house, going to the market. **Active travelling** is when they puts energy into traveling - e.g. they are traveling by foot or by cycle
Passive travelling	Yes	Infant or mother are moving somewhere - for example going to their friend's house, going to the market. **Passive traveling** is when they do not put energy into traveling - e.g. infant is being carried, or mother is riding a boda
Household duties	No	Infant or mother is doing household duties. For example: Sweeping, cooking, preparing food, grinding millet
Work	No	Mother is working - they are doing an activity that infants cannot help with For example: garden work, paid work, work on a computer
Shopping	No	Mother is shopping
Comforting	Yes	Mother or infant is trying to make someone feel better

ACTIVITY LIST	Partner	Description
Distress	No	Mother or infant is disturbed or upset/crying
Chatting	yes	Mother is talking to someone else and doing no other activity
Exploring	No	Crawling or walking around without playful behaviours.
Other	Yes/no	Mother or infant are doing a behaviour which is not listed above

List of relationships	
M	Mother
F	Father
GM	Grandmother
GF	Grandfather
HMA	Household Male Adult
HFA	Household Female Adult
HM#	Household Male Child/Adolescent (#=put age estimation)
HF#	Household Female Child/Adolescent (#=put age estimation)
FMA	Familiar Male Adult
FFA	Familiar Female Adult
FM#	Familiar Male child/Adolescent
FF#	Familiar Female child/adolescent
UMA	Unfamiliar Male Adult
UFA	Unfamiliar Female Adult
UM#	Unfamiliar Male child/adolescent (#=put age estimation)
UF#	Unfamiliar Female child/adolescent (#=put age estimation)

Interactions with infant
Language/Talking
Non-language vocal
Gesturing
Facial expression
Contact touching
Contact holding
Contact carrying

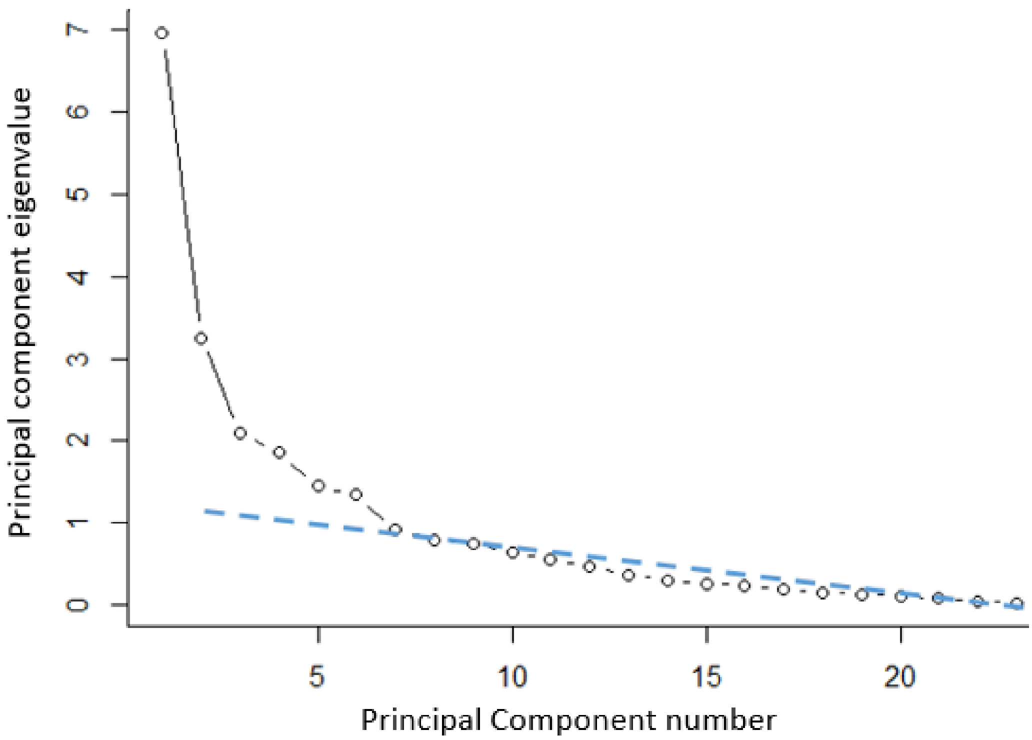
Body Contact/ Distance	
Option	**Description**
Front	Being held on the front
Back	Being held or carried on the back
Body contact	Body contact which is not being held on the front or back - for example holding hands, touching leg
1m	Carer and infant are in 1meter of each other
2-5m	Carer and infant are in 2-5meters of each other
5-10m	Carer and infant are in 5-10meters of each other
10+ m	Carer and infant are in more than 10 meters of each other, or in a different room, but mother would still know if something very bad happened to infant
Not around	Mother could not hear infant cry. She is not nearby for the carer to get her if something really bad happens to the baby. For example she has gone shopping or to get water/collect wood

Objects in reach of infant	
Ground	When the child is not sitting on a covered surface, they are on the ground outside the house. Often there are things they can reach for example, dust, stones, grass, straw, leaves
Toys	Any toys that are in reach of the child
Food - eatable	This food can be eaten as it is. If it needed to be cooked it is cooked already, if it needed to ripen it is ripe already.
food - not eatable	This food cannot be eaten as it is. Something needs to happen to this food before it can be eaten. For example it needs to be cooked before it can be eaten, or it needs to ripen before it can be eaten
plates/bowls/pots/ cups	
cutlery	spoons, forks, knives
cloth	there is a cloth in reach of the child which is not being worn by somebody
other	something else which is not listed here - for example paper, books, pens, bottle, bottletops, papyrus

A2.9 Graph of Principal Component Analysis eigenvalues

A principal component analysis (PCA) was conducted to determine if the early life environment for infants: a) fall into two distinct groups (UK dyads and Ugandan dyads), b) fall into more than two distinct groups (e.g., there is separation by ethnolinguistic group within Ugandan participants), or c) indicate universality, i.e., no separation between cultural groups. A six Principal Component (PC) solution was deemed adequate since the first six components had eigenvalues above 1 (Kaisers criterion: Kaiser, 1960), and the last 'step' in eigenvalues was between Principal Component 6 and Principal Component 7, see *Graph*

A2.1.



Graph A2.1: Principal Component (PC) eigenvalues. *As you can see PCs 1-6 six have eigenvalues greater than 1. You can also see the last 'step' in eigenvalue is between PC6 and PC7, as shown by the blue line following the trend from PCs7+ but not reaching PC6.*

A2.10 Test statistics for GLMMs done without influential cases

General linear mixed models (GLMMs) were run without participants which were deemed to be overly influential. Table A2.1 shows the number of participants deemed overly influential in each model, and Table A2.2 shows the original model parameters and the model parameters when excluding these overly influential participants.

Table A2.1: Number of overly influential participants for each GLMM per cultural group

Model	**Number overly influential participants**	
	Ugandan	**UK**
Sit GLMM	1	2
Crawl GLMM	3	2
Walk GLMM	3	3
Environment Exploration GLMM	2	2
Number of Carers GLMM	1	3
Adult Carer GLMM	10	17
Child Carer GLMM	9	n/a
Proximity with Mother GLMM	7	6

Model	Number overly influential participants	
	Ugandan	UK
Number of people in Proximity GLMM	5	9
Adults in Proximity GLMM	9	11
Children in Proximity GLMM	9	9
Shared Bedroom GLMM	n/a	1
Shared Bed GLMM	n/a	5
Contact with Mother GLMM	8	3
Mother Activities for Infant GLMM	1	2
Social Play GLMM	2	1
Contact with mother during play GLMM	2	4
Social Activities GLMM	2	2
Number of Social Partners GLMM	2	4
Adult Social Partners GLMM	3	3
Child Social Partners GLMM	2	1

Table A2.2: GLMM parameters including and excluding overly influential participants

		Parameters for full model				***Parameters for model excluding overly influential participants***			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
Sit GLMM	(Intercept)	.870	.461	1.89	.059	1.23	.607	2.03	.043*
	Group	-1.30	.458	-2.85	.004**	-1.95	.705	-2.77	.006**
Crawl GLMM	(Intercept)	1.49	.412	3.63	<.001***	2.37	.615	3.85	<.001***
	Group	-1.39	.419	-3.31	<.001***	-2.03	.545	-3.73	<.001***
Walk GLMM	(Intercept)	.139	.406	.343	.731	.248	.519	.479	.632
	Group	-1.07	.504	-2.12	.035*	-1.29	.676	-1.90	.057*
Environment Exploration GLMM	(Intercept)	-2.23	.109	-20.6	<.001***	-2.23	.109	-20.4	<.001***
	Group	-.097	.168	-.579	0.563	-.137	.170	-.805	.421
	Infant age	.095	.009	11.1	<.001***	.095	.009	10.7	<.001***
	Group *Infant Age	-.049	.014	-3.35	<.001***	-.048	.015	-3.24	.001 **
Number of Carers GLMM	(Intercept)	.418	.160	2.61	.009**	.479	.155	3.10	.002 **
	Group	-1.59	.347	-4.57	<.001***	-1.57	.375	-4.19	<.001***
	Infant age	.010	.014	.694	.488	.008	.014	.615	.538
	Group *Infant Age	-.043	.035	-1.22	.223	-.076	.041	-1.86	.063
Adult Carer GLMM	(Intercept)	-3.38	.278	-12.2	<.001***	-2.93	.259	-11.3	<.001***
	Group	-1.05	.428	-2.46	.014*	-1.50	.502	-2.98	.003 **
	Infant age	.019	.014	1.32	.186	-.027	.017	-1.58	.114
	Group *Infant Age	.002	.026	.061	.952	.006	.044	.137	.891
Child Carer GLMM	(Intercept)	-2.28	.175	-13.1	<.001***	-2.61	.194	-13.5	<.001***

		Parameters for full model				*Parameters for model excluding overly influential participants*			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
	Infant age	.027	.010	2.66	.008**	.036	.013	2.83	.005 **
Proximity with Mother GLMM	(Intercept)	.976	.130	7.49	<.001***	.864	.132	6.55	<.001***
	Group	.926	.192	4.82	<.001***	1.09	.195	5.58	<.001***
	Infant age	-.054	.007	-7.31	<.001***	-.040	.008	-5.02	<.001***
	Group *Infant Age	.004	.013	.297	.767	-.012	.014	-.881	.378
Number of people in Proximity GLMM	(Intercept)	.299	.091	3.28	<.001***	.315	.094	3.37	<.001***
	Group	-.047	.126	-.376	.707	.009	.130	.070	.944
	Infant age	-.008	.005	-1.65	.099	-.013	.005	-2.38	.018*
	Group *Infant Age	.013	.008	1.73	.084	.007	.008	.875	.382
Adults in Proximity GLMM	(Intercept)	-.757	.138	-5.47	<.001***	-.692	.155	-4.48	<.001***
	Group	.243	.191	1.27	.203	.208	.214	.972	.331
	Infant age	-.033	.008	-4.11	<.001***	-.054	.009	-5.72	<.001***
	Group *Infant Age	.000	.012	.036	.972	<.001	.014	.026	.979
Children in Proximity GLMM	(Intercept)	-.052	.213	-.244	.807	-.051	.209122	-.243	.808
	Group	-1.21	.299	-4.03	<.001***	-1.35	.295	-4.57	<.001***
	Infant age	-.002	.007	-.234	.815	-.002	.008	-.240	.81
	Group *Infant Age	.036	.013	2.88	.004**	.015	.014	1.07	.284
Shared Bedroom GLMM	(Intercept)	4.41	1.25	3.52	<.001***	52.8	6.52	8.10	<.001***
	Infant age	-.565	.123	-4.60	<.001***	-7.28	.874	-8.34	<.001***

		Parameters for full model				*Parameters for model excluding overly influential participants*			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
Shared Bed GLMM	(Intercept)	-8.54	1.86	-4.58	<.001***	-14.6	5.07	-2.89	.004**
	Infant age	-.368	.154	-2.39	.017*	-.014	.404	-.035	.972
Contact with Mother GLMM	(Intercept)	.007	.114	.060	.952	-.014	.124	-.114	.909
	Group	-.094	.162	-.577	.564	.032	.171	.186	.853
	Infant age	-.088	.008	-11.7	<.001***	-.091	.008	-10.8	<.001***
	Group *Infant Age	-.027	.012	-2.19	.029*	-.038	.013	-2.87	.004
Mother Activities for Infant GLMM	(Intercept)	-1.25	.107	-11.7	<.001***	-1.21	.104	-11.7	<.001***
	Group	.256	.151	1.70	.089	.231	.147	1.56	.118
	Infant age	-.034	.009	-3.76	<.001***	-.038	.009	-4.18	<.001***
	Group *Infant Age	-.010	.013	-.738	.460	-.008	.014	-.557	.578
Social Play GLMM	(Intercept)	-2.59	.149	-17.4	<.001***	-2.50	.152	-16.5	<.001***
	Group	.464	.192	2.41	.016*	.386	.194	1.98	.047 *
	Infant age	-.011	.013	-.826	.409	-.024	.014	-1.69	.091
	Group *Infant Age	.041	.018	2.35	.019*	.056	.018	3.09	.00199 **
Contact with mother during play GLMM	(Intercept)	2.75	.668	4.11	<.001***	3.57	.791	4.51	<.001***
	Group	-1.75	.733	-2.39	.017*	-2.45	.851	-2.88	.00393 **
	Infant age	-.116	.059	-1.98	.047*	-.182	.067	-2.72	.00652 **
	Group *Infant Age	-.008	.066	-.128	.898	.039	.074	.526	.599
Social Activities GLMM	(Intercept)	-.947	.090	-10.5	<.001***	-.896	.089	-10.1	<.001***
	Group	.124	.128	.966	.334	.056	.127	.445	.657
	Infant age	-.034	.008	-4.20	<.001***	-.041	.008	-4.96	<.001***

		Parameters for full model				***Parameters for model excluding overly influential participants***			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
	Group *Infant Age	.014	.012	1.20	.231	.023	.012	1.91	.056
Number of Social Partners GLMM	(Intercept)	-3.29	.197	-16.7	<.001***	-3.26	.202	-16.2	<.001***
	Group	-.260	.274	-.948	.343	-.334	.288	-1.16	.246
	Infant age	-.001	.018	-.079	.937	-.007	.019	-.370	.712
	Group *Infant Age	.075	.024	3.06	.002**	.078	.026	2.97	.003 **
Adult Social Partners GLMM	(Intercept)	-2.69	.374	-7.20	<.001***	-3.15	.419	-7.51	<.001***
	Group	.175	.455	.384	.701	.628	.496	1.27	.205
	Infant age	-.065	.035	-1.84	.065	-.031	.039	-.797	.425
	Group *Infant Age	.129	.042	3.06	.002**	.088	.046	1.90	.058
Child Social Partners GLMM	(Intercept)	-2.52	.268	-9.40	<.001***	-2.77	.282	-9.84	<.001***
	Group	-1.36	.411	-3.31	<.001***	-1.26	.430	-2.93	.003 **
	Infant age	.062	.022	2.86	.004**	.086	.023	3.76	<.001***
	Group *Infant Age	.119	.034	3.51	<.001***	.105	.035	2.95	.003**

A2.11 Variable loadings on principal components

A principal component analysis (PCA) was conducted to determine if the early life environment for infants: a) fall into two distinct groups (UK dyads and Ugandan dyads), b) fall into more than two distinct groups (e.g., there is separation by ethnolinguistic group within Ugandan participants), or c) indicate universality, i.e., no separation between cultural groups. The variable loadings for the six principal components are displayed in Table A2.3.

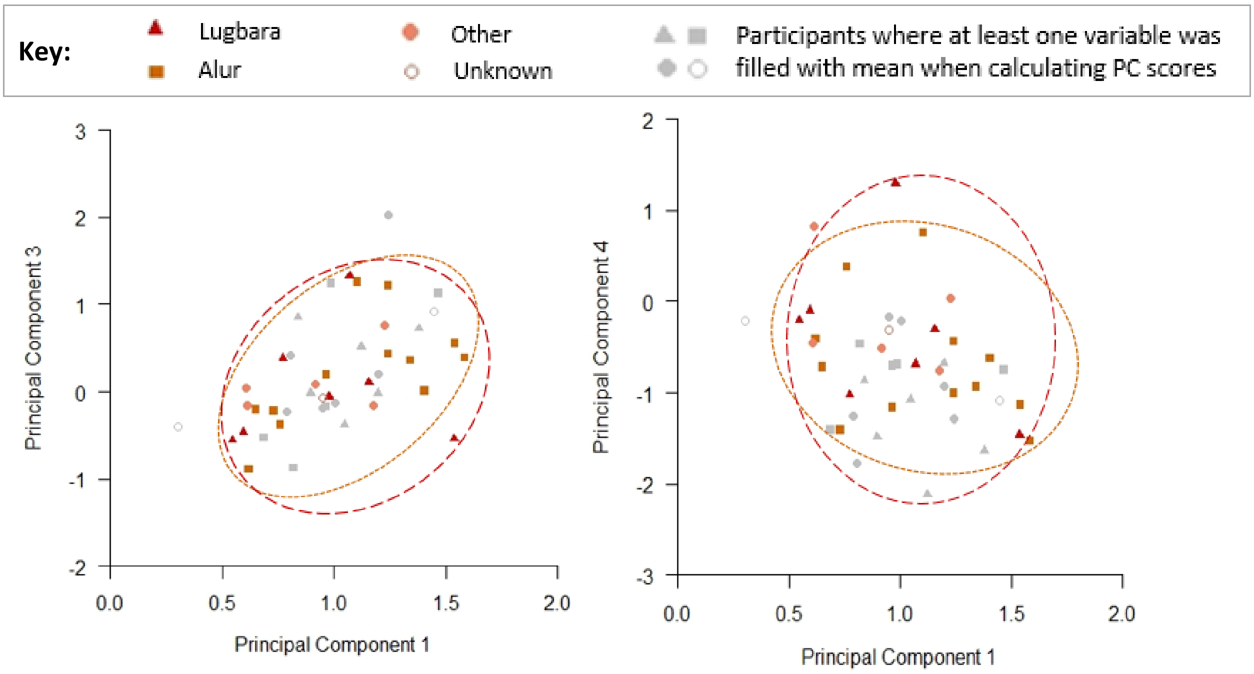
Table A2.3. Variable loadings on to Principal Components. *h2 (communality) is the proportion of common variance within a variable. Strongest loading per variable are indicated in bold. All loadings of .40 or above are indicated with * .*

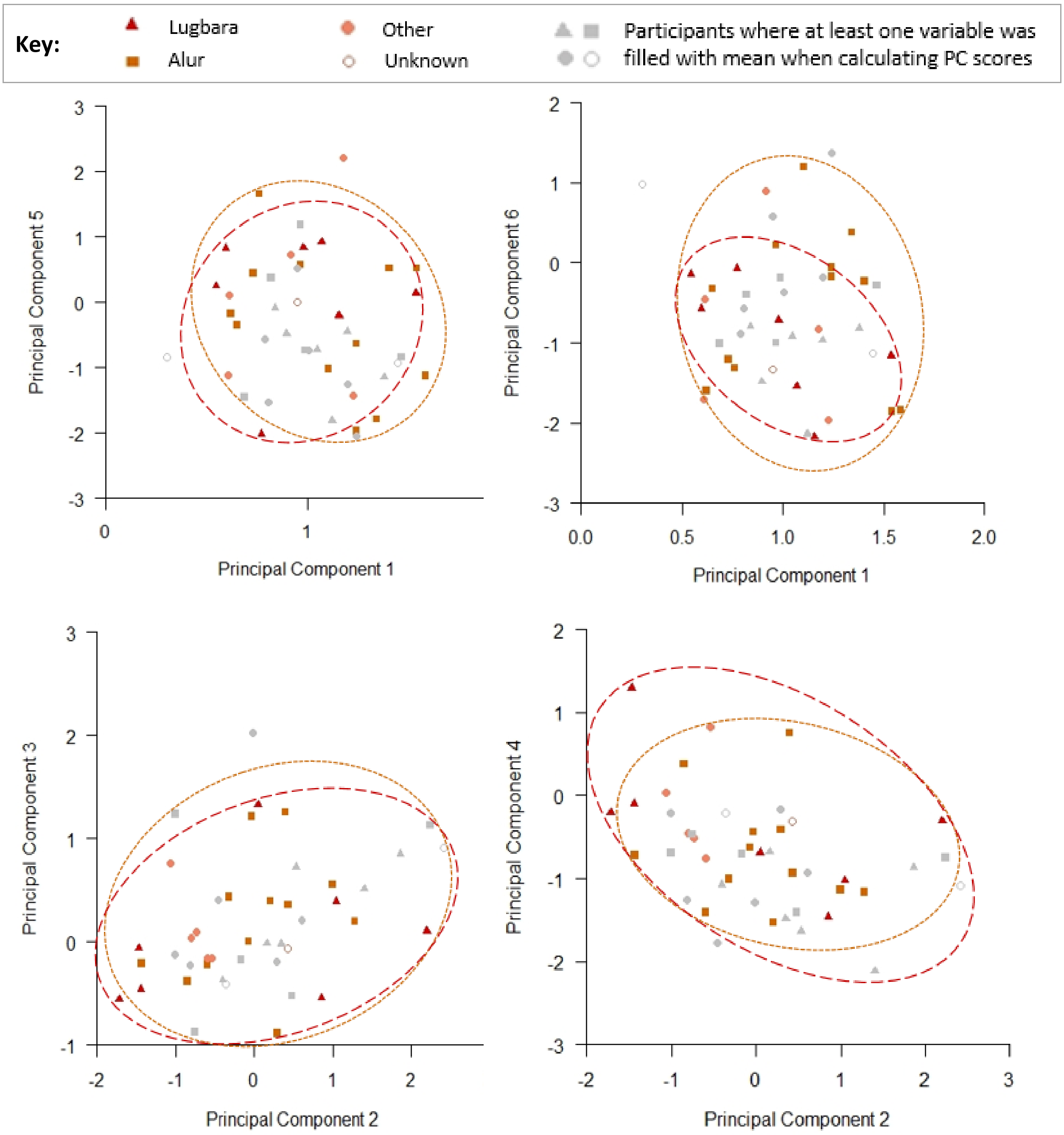
Variable	Standardized Loadings per Principal Component						h2	KMO MSA
	PC1	PC2	PC3	PC4	PC5	PC6		
Parenting Attitude	**-0.86***	0.09	-0.07	-0.03	-0.01	0.01	0.75	.84
Shared Bed	**0.86***	-0.01	0.02	-0.12	-0.06	0.04	0.85	.82
Child Carer	**0.81***	0.01	0.01	-0.15	-0.08	-0.21	0.84	.82
Number of Carers	**0.75***	0.34	0.01	-0.08	-0.11	-0.23	0.86	.79
Shared Bedroom	**0.75***	-0.08	0.19	0.02	-0.08	0.14	0.71	.85
Contact During Play	**0.53***	0.04	-0.09	-0.05	-0.23	0.15	0.44	.80
Sit	**-0.40***	-0.05	0.39	0.10	0.15	0.08	0.35	.84
Adults in Proximity	-0.19	**0.86***	-0.17	0.01	0.00	0.01	0.79	.65
Adult Carer	0.48*	**0.74***	-0.04	-0.02	-0.07	-0.09	0.82	.67
Number of People in Proximity	0.23	**0.63***	0.50*	-0.11	0.11	0.21	0.81	.61
Adult Social Partners	-0.27	**0.61***	-0.15	0.32	0.14	-0.19	0.75	.75
Child Social Partners	-0.13	-0.23	**0.88***	0.04	-0.12	-0.22	0.86	.50
Children in Proximity	0.32	0.05	**0.8***	-0.10	0.02	0.24	0.89	.68
Amount of Social Activity	0.11	-0.01	-0.01	**0.96***	-0.10	0.07	0.87	.66
Amount of Social Play	-0.34	0.20	0.05	**0.68***	0.09	-0.12	0.78	.80
Mother activities for infant	0.10	-0.35	-0.40*	**0.49***	0.13	0.24	0.74	.68
Number of Social Partners	-0.18	0.24	0.39	**0.41***	0.25	-0.31	0.65	.68
Walk	0.06	-0.06	-0.04	-0.07	**0.91***	-0.13	0.8	.55
Crawl	0.01	0.02	-0.03	-0.06	**0.89***	0.11	0.79	.59
Environment exploration	0.21	0.05	-0.13	-0.32	**-0.40***	-0.11	0.46	.82

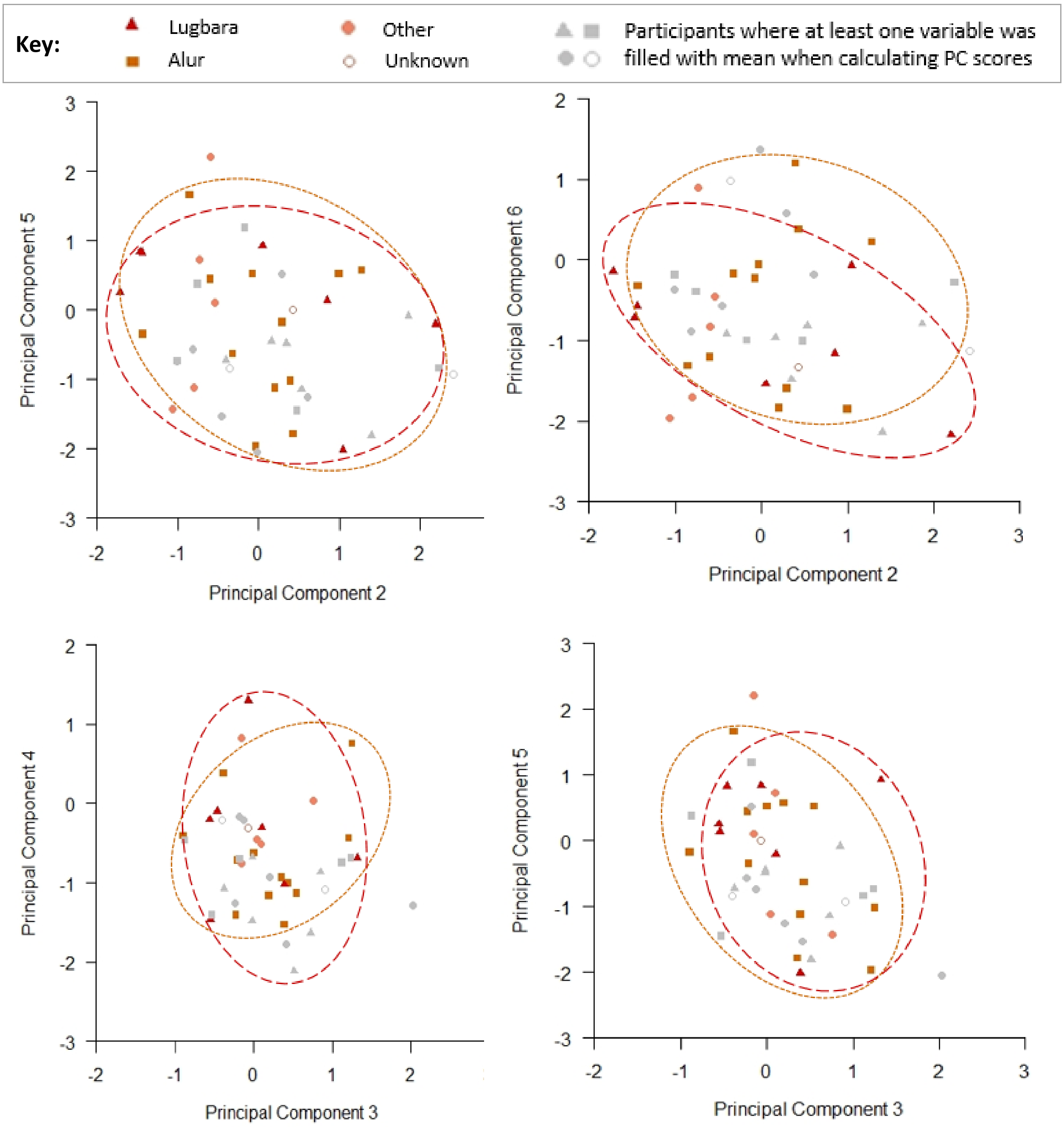
Variable	Standardized Loadings per Principal Component						h2	KMO MSA
	PC1	PC2	PC3	PC4	PC5	PC6		
Mother in Proximity	-0.41*	-0.1	0.02	0.05	-0.02	**0.72***	0.72	.71
Mother in contact	0.54*	-0.18	-0.08	0.24	-0.02	**0.64***	0.83	.51
Socialisation Goals Attitude	-0.45*	0.27	-0.08	-0.07	-0.02	**0.63***	0.59	.85

A2.12 Plots of PCA principal components against one another

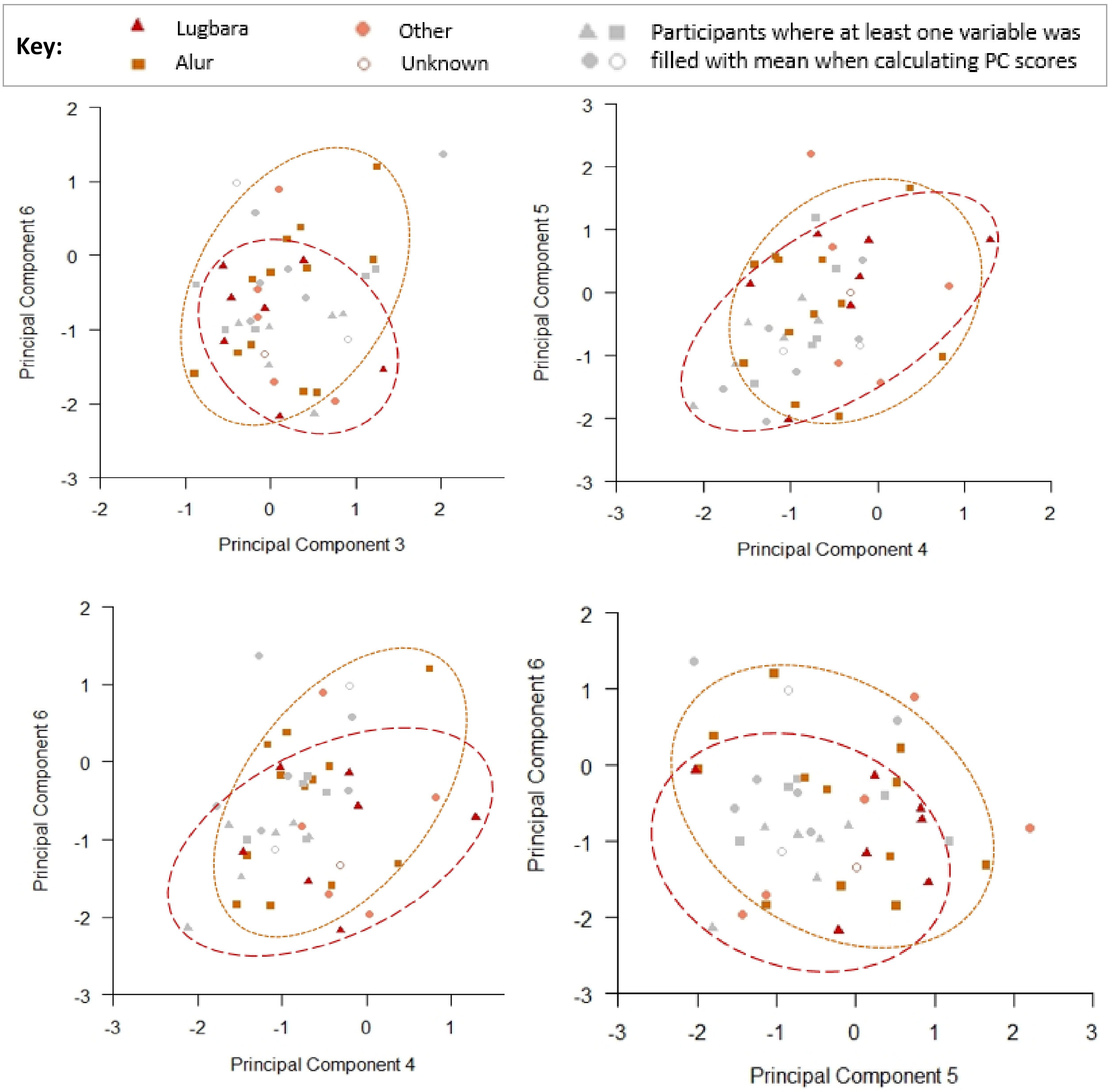
A principal component analysis (PCA) was conducted to determine if the early life environment for infants: a) fall into two distinct groups (UK dyads and Ugandan dyads), b) fall into more than two distinct groups (e.g., there is separation by ethnolinguistic group within Ugandan participants), or c) indicate universality, i.e., no separation between cultural groups. All combinations of pairs of Principal Components after PC1 vs PC2 were plotted against each other and examined for group separation between Ugandan ethnolinguistic groups. As you can see in the graphs below, there is large overlap between ethnolinguistic groups in all comparisons, indicating there is no separation by ethnolinguistic group in the Ugandan sample.




Key:
Lugbara
Alur
Other
Unknown
Participants where at least one variable was filled with mean when calculating PC scores
Principal Component 5
Principal Component 1
Principal Component 6
Principal Component 1
Principal Component 3
Principal Component 2
Principal Component 4
Principal Component 2



Key:
Lugbara
Alur
Other
Unknown
Participants where at least one variable was filled with mean when calculating PC scores
Principal Component 5
Principal Component 2
Principal Component 6
Principal Component 2
Principal Component 4
Principal Component 3
Principal Component 5
Principal Component 3



A2.3 *Plots showing standardised individual scores for all combinations of principal components after the comparison of PC1 vs PC2. The orange ovals with short dotted lines encompass points for all Alur dyads. The red ovals with the long dotted lines encompass points for all Lugbara dyads.*

A2.13 Additional models investigating mother-infant proximity during the day

When considering all scan samples, mothers and infants in the UK were more likely to be in five metres of one another than dyads in Uganda (See *Figure 2.13a*, *Table 2.14)*. This pattern is the opposite direction to predictions that the more relational Ugandan mothers would spend more time in close proximity to their infants. I hypothesised that one of the potential reasons for this mismatch is that the more distributed care in Uganda means that they are less often in close proximity to their infant when not caring for their child, but when they are the caregiver the more 'relational' characteristic of being in more close proximity to their children may come to light. In other words, the results may have been a feature of caregiving being more shared in Uganda than the UK, or a feature of mother's caregiving style. In order to try to distinguish between these interpretations, I ran a follow-up GLMM focusing only on scan samples where the mother was the caregiver. The results from this model indicate that the same pattern persisted, that UK mothers were more often in five metre proximity of their infants, even when only considering scan samples where the mother was noted as the caregiver (*Table A2.4; Figure A2.4a)*

When considering all scan samples, there was an interaction between the culture and age on how likely infants were to be in physical contact with their mothers (*Table 2.14*): as infants in both cultures aged, they were less likely to be in physical contact with their mothers, but this effect was stronger in the UK. This means that at about 3-months, infants from both cultures were equally likely to be in physical contact with their mother, however by 15-months, infants in the UK were less likely to be in physical contact with their mother than Ugandan infants. To examine whether these patterns were a feature of mothers caregiving style or a feature of caregiving being more distributed in Uganda as children age, I conducted a follow up GLMM focusing on scan samples where the mother was the caregiver. The results from this model indicate that when only considering scan samples when the mother was the caregiver, Ugandan infants were more likely to be in contact with their mother than UK infants at all ages (*Table A2.4; Figure A2.4b).*

Table A2.4: ***Model parameters for mother-infant proximity and body contact when the mother was the carer GLMMs.*** *The reference level for Group was UK. The reference level for mother-infant contact was 'not in contact'. LRT = Likelihood Ratio Test. * indicates significance at <.05 level, *** indicates significance at <.001 level.*

	Model parameters					
Model (LRT Chi-Square)	**Factor**	**Estimate**	***SE***	***Z***	***95% confidence interval***	***P***
Proximity with mother: when mother carer GLMM ($\chi^2_{(2)}$=51.3, *p*<.001***)	(Intercept)	1.54	.147	10.5	1.25 to 1.83	<.001***
	Culture	.546	.209	2.61	.136 to .961	.009**
	Infant age	-.042	.009	-4.47	-.061 to -.024	<.001***
	Culture* Infant Age	-.008	.014	-.583	-.037 to .020	.560
Contact with mother: when mother carer GLMM ($\chi^2_{(2)}$=315, *p*<.001***)	(Intercept)	.556	.118	4.71	.324 to .789	<.001***
	Culture	-.557	.166	-3.36	-.883 to -.232	<.001***
	Infant age	-.097	.008	-11.6	-.114 to -.081	<.001***
	Culture* Infant Age	-.021	.013	-1.6	-.046 to .004	.103

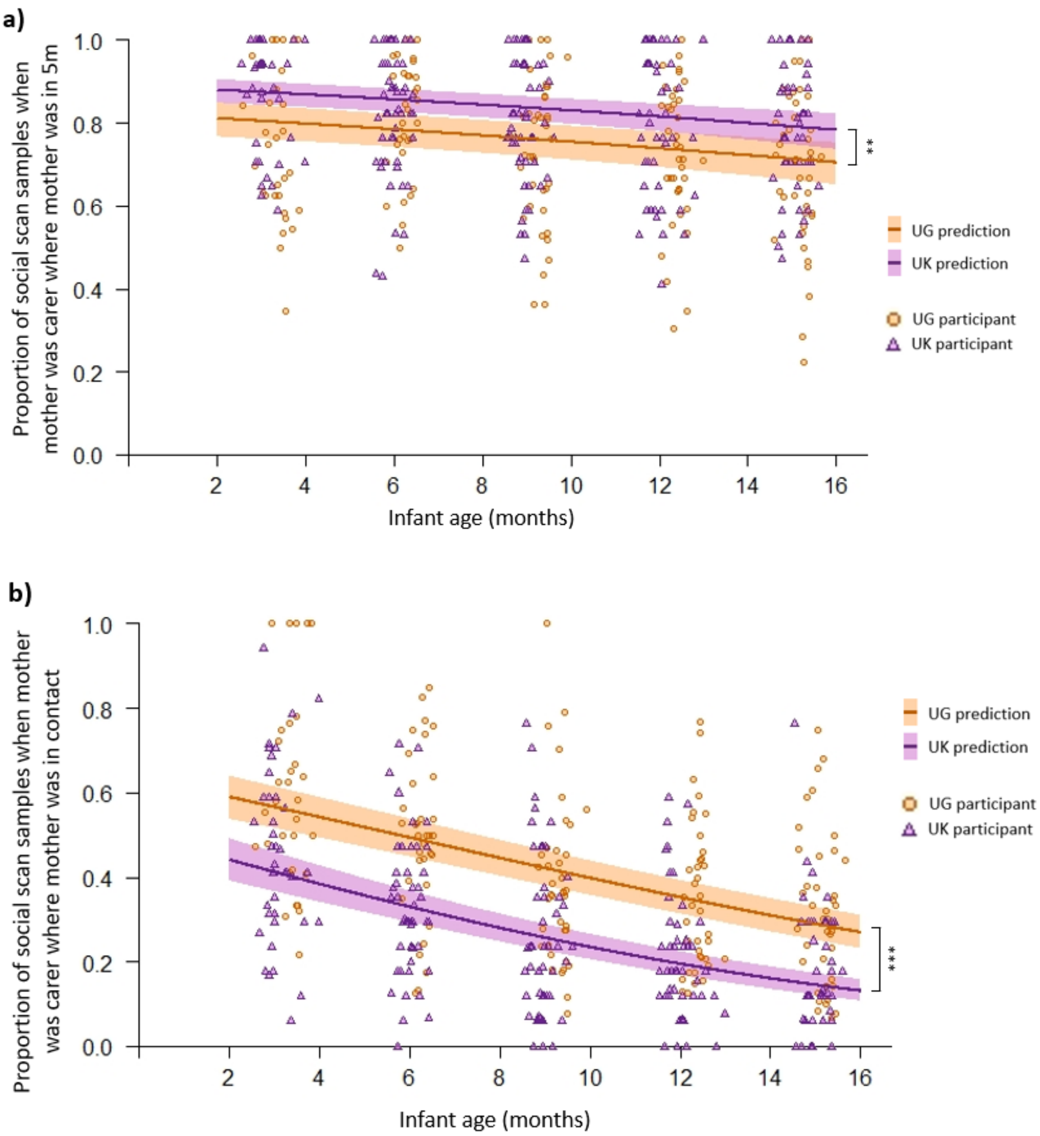


Figure A2.4: a) Proportion of scan samples where when mother was caregiver that the mother was in 5m of the infant (circles/triangles) and the expected probabilities of this given GLMM results (lines) as infants age. b) Proportion of scan samples where when mother was caregiver that the mother was in contact with the infant (circles/triangles) and the expected probabilities of this given GLMM results (lines) as infants age. *UG=Ugandan**.** Shading around the lines show 95% confidence intervals. ** indicates significant main effect of group at p<.01 level. *** indicates significant main effect of group at p<.001 level.*

A3 Appendices for Chapter 3

A3.1 Data collected for non-human primates on CyberTracker

Data was collected every 15-monutes during full-day follows for mother-infant dyads of chimpanzees and crested macaques on CyberTracker (Cape Town, South Africa) application installed on android mobile phones. The following lists the full set of information collected for chimpanzees:

- Observer (who collected data)
- Mother identity
- Mother activity
- Mother partner identity (if social activity)
- Infant identity
- Infant activity
- Infant partner identity (if social activity)
- Body contact/Distance to mother
- Other body contact partner
- Body contact type with other partner
- Uni-directional interaction partner
- Unidirectional interaction type
- Can infant see mother
- Can infant see mothers face
- IDs in 0-5m of infant
- IDs in 5-10m of infant
- Objects in reach
- notes

The following list options for mother and infant chimpanzee activity

- Resting
- Grooming social - Groomee
- Grooming social - Goomer
- Grooming self
- Tool use
- Consortship
- Copulation
- Distress
- Feeding self
- Nursing
- Play solitary
- Play solitary with object
- Play social
- Play social with object
- Active travelling
- Passive travelling
- Exploring
- Other
- Out of sight

The following lists options for Mother-infant chimpanzee and macaque contact/distance:

- Dorsal
- Ventral
- Body contact
- 0 to <1metres
- 1 to <5metres
- 5 to <10metres
- 10+metres
- Uncertain

The following lists the full set of information collected for macaques:

- Mother identity
- Infant identity
- weather
- Infant activity
- Infant partner (if social activity)
- Carer identity
- Allomother activity (if carer not mother)
- Allomother partner (if social activity and if carer not mother)
- Allomother-infant distance (if carer not mother)
- Can infant see allomother? (if carer not mother)
- Can infant see allomother face? (if carer not mother)
- Mother activity
- Mother partner identity (if social activity)
- Can infant see mother?
- Can infant see mothers face?
- Objects in reach
- Identities of individuals in 5metres (if possible)
- notes

The following list options for macaque activity:

- On film
- out of sight
- feeding self
- feeding other
- being fed
- nursing
- groom other
- being groomed
- groom and be groomed
- groom self
- play solo no object
- play solo object
- play social no object
- play social object
- travel (active)
- travel (passive)
- exploring
- resting
- aggression
- affiliation
- distress
- comforting
- sexual/copulation
- other
- unknown

A3.2 Test statistics for cross cultural GLMMs done without influential cases

General linear mixed models (GLMMs) to investigate sex differences in early social environment were run without participants which were deemed to be overly influential. Table A3.1 shows the number of participants deemed overly influential in each model, and Table A3.2 shows the original model parameters and the model parameters when excluding these overly influential participants.

Table A3.1: Number of overly influential participants for each GLMM per cultural group and sex

Model	Number overly influential participants			
	Ugandan		UK	
	Female	Male	Female	Male
Social activity	1	1	1	1
Mother partner	2	1	0	1
Child partner	2	1	2	1
Non-mother adult female partner	2	1	5	2
Adult male partner	2	2	2	2
Multiple partners	2	2	3	2
Mother in contact	3	2	3	1
Mother in 5 metres	3	3	3	3
Number of non-mother individuals in 5 metres	1	4	7	3
Number of children in 5 metres	2	4	6	5
Non-mother adult female in 5 metres	3	5	5	3
Number of adult males in 5 metres	7	4	6	10

Table A3.2: GLMM parameters for cross-cultural comparison including and excluding overly influential participants. **** indicates significance at p <.001 level; ** indicates significance at p<.01 level; * indicates significance at p<.05 level.*

		Parameters for full model				***Parameters for model excluding overly influential participants***			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
Social activity	(Intercept)	-.999	.117	-8.55	<.001***	-.904	.114	-7.94	<.001***
	Infant age	-.026	.010	-2.61	.009**	-.037	.010	-3.54	<.001***
	Infant sex	.098	.145	.678	.498	.014	.140	.099	.921
	Culture	.121	.142	.852	.394	.001	.137	.011	.992
	Infant age*Sex	-.015	.012	-1.28	.201	-.009	.012	-.734	.463
	Infant sex * Culture	.088	.128	.682	.495	.193	.114	1.69	.091
	Infant age* Culture	.010	.012	.853	.394	.019	.012	1.59	.113
Mother partner	(Intercept)	1.87	.280	6.70	<.001***	2.12	.291	7.28	<.001***
	Infant age	-.057	.023	-2.52	.012*	-.078	.024	-3.26	.001**
	Infant sex	-.634	.348	-1.82	.069	-.723	.359	-2.01	.044*
	Culture	.902	.357	2.53	.012*	.909	.369	2.46	.014*
	Infant age*Sex	.060	.027	2.21	.027*	.075	.028	2.65	.008**
	Infant sex * Culture	.068	.326	.208	.835	-.086	.321	-.266	.790
	Infant age* Culture	-.065	.028	-2.36	.018*	-.063	.029	-2.19	.029*
Child partner	(Intercept)	-2.62	.352	-7.46	<.001***	-2.68	.339	-7.91	<.001***
	Infant age	.076	.027	2.81	.005**	.092	.029	3.24	.001**
	Infant sex	.173	.447	.387	.699	-.096	.443	-.218	.828
	Culture	-1.13	.456	-2.48	.013*	-1.20	.454	-2.65	.008**

		Parameters for full model				*Parameters for model excluding overly influential participants*			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
	Infant age*Sex	-.026	.033	-.803	.422	-.024	.036	-.665	.506
	Infant sex * Culture	-.230	.425	-.542	.588	-.175	.356	-.490	.624
	Infant age* Culture	.109	.033	3.27	.001**	.102	.037	2.79	.005**
Non-mother adult female partner	(Intercept)	-3.23	.540	-5.97	<.001***	-3.45	.554	-6.22	<.001***
	Infant age	-.023	.044	-.527	.598	.018	.050	.361	.718
	Infant Sex	.183	.682	.269	.788	-.627	.800	-.785	.433
	Culture	-1.35	.699	-1.93	.053	-1.23	.748	-1.65	.100
	Infant age* Sex	-.140	.053	-2.66	.008**	-.104	.069	-1.51	.132
	Infant sex* Culture	1.11	.707	1.56	.118	1.22	.676	1.80	.072
	Infant age* Culture	.195	.054	3.61	<.001***	.163	.064	2.54	.011*
Adult male partner	(Intercept)	-4.52	.807	-5.61	<.001***	-6.54	1.25	-5.25	<.001***
	Infant age	-.074	.073	-1.01	.311	.069	.095	.727	.467
	Infant Sex	.663	.796	.834	.405	2.46	1.09	2.26	.024*
	Culture	1.56	.826	1.88	.060	2.97	1.22	2.44	.015*
	Infant age* Sex	.029	.053	.533	.594	-.118	.065	-1.83	.067
	Infant sex* Culture	-.332	.764	-.435	.664	-.783	.963	-.813	.416
	Infant age* Culture	.064	.070	.918	.358	-.035	.088	-.396	.692
Multiple partners	(Intercept)	-5.97	.983	-6.07	<.001***	-8.07	1.89	-4.28	<.001***
	Infant age	.112	.077	1.44	.149	.237	.141	1.68	.093
	Infant Sex	-.092	.861	-.107	.915	-.369	1.23	-.300	.764
	Culture	2.05	1.01	2.03	.042*	3.60	1.91	1.89	.059

		Parameters for full model				*Parameters for model excluding overly influential participants*			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
	Infant age* Sex	-.015	.048	-.303	.762	-.021	.058	-.368	.713
	Infant sex* Culture	.424	.766	.554	.580	.739	1.07	.693	.489
	Infant age* Culture	.049	.078	.635	.526	-.039	.142	-.271	.786
Mother in contact	(Intercept)	.220	.155	1.42	.157	.266	.154	1.73	.083
	Infant age	-.110	.010	-11.1	<.001***	-.117	.011	-2.00	<.001***
	Infant Sex	-.300	.205	-1.46	.143	-.503	.203	-2.48	.013*
	Culture	-.126	.198	-.637	.524	-.136	.192	-.708	.479
	Infant age* Sex	.038	.012	3.19	.001**	.054	.013	4.18	<.001***
	Infant sex* Culture	-.105	.237	-.444	.657	-.052	.224	-.234	.815
	Infant age* Culture	-.021	.012	-1.74	.083	-.025	.013	-1.92	.055
Mother in 5 metres	(Intercept)	1.02	.183	5.56	<.001***	1.05	.182	5.80	<.001***
	Infant age	-.062	.009	-6.57	<.001***	-.065	.010	-6.50	<.001***
	Infant Sex	-.060	.244	-.248	.804	-.343	.242	-1.42	.157
	Culture	1.06	.243	4.36	<.001***	1.17	.242	4.81	<.001***
	Infant age* Sex	.019	.012	1.59	.113	.048	.013	3.79	<.001***
	Infant sex* Culture	-.248	.295	-.842	.400	-.131	.288	-.455	.649
	Infant age* Culture	.001	.012	.062	.951	-.013	.013	-.990	.322
Number of non-mother individuals in 5 metres	(Intercept)	.199	.129	1.54	.124	.226	.126	1.80	.073•
	Infant age	.003	.006	.477	.633	.001	.007	.079	.937
	Infant Sex	.217	.170	1.28	.201	.115	.158	.725	.469

		Parameters for full model				*Parameters for model excluding overly influential participants*			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
	Culture	-.121	.165	-.732	.464	-.147	.156	-.940	.347
	Infant age* Sex	-.023	.007	-3.09	.002**	-.016	.008	-2.02	.044*
	Infant sex* Culture	.246	.209	1.18	.240	.439	.192	2.29	.022*
	Infant age* Culture	.009	.007	1.27	.203	.007	.008	.821	.412
Number of children in 5 metres	(Intercept)	-.040	.167	-.239	.811	-.092	.163	-.563	.573
	Infant age	-.009	.006	-1.37	.169	.002	.007	.332	.740
	Infant Sex	-.109	.241	-.452	.651	-.034	.211	-.159	.874
	Culture	-.788	.233	-3.38	<.001***	-.802	.212	-3.77	<.001***
	Infant age* Sex	.011	.008	1.41	.158	-.006	.008	-.668	.504
	Infant sex* Culture	.001	.313	.005	.996	.336	.272	1.24	.216
	Infant age* Culture	.015	.008	1.86	.063	.011	.009	1.32	.188
Non-mother adult female in 5 metres	(Intercept)	-1.70	.206	-8.24	<.001***	-1.71	.220	-7.76	<.001***
	Infant age	.010	.011	.874	.382	-.025	.014	-1.74	.081
	Infant sex	.358	.268	1.34	.181	.348	.268	1.30	.195
	Culture	.082	.260	.316	.752	.258	.261	.990	.322
	Infant age* Sex	-.043	.013	-3.28	.001**	-.014	.015	-.912	.362
	Infant sex* Culture	.200	.319	.626	.532	-.193	.301	-.640	.522
	Infant age* Culture	.013	.013	.990	.322	.017	.015	1.12	.261
Number male adults in 5 metres	(Intercept)	-2.70	.264	-1.25	<.001***	-3.46	.324	-1.67	<.001***
	Infant age	.025	.012	2.08	.038*	.055	.017	3.15	.002**
	Infant Sex	1.13	.355	3.18	.001**	.691	.453	1.53	.127

		Parameters for full model				***Parameters for model excluding overly influential participants***			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
	Culture	.853	.339	2.51	.012*	1.34	.424	3.17	.002**
	Infant age* Sex	-.108	.018	-6.12	<.001***	-.053	.026	-2.07	.039*
	Infant sex* Culture	-.548	.468	-1.17	.242	.239	.586	.408	.683
	Infant age* Culture	-.006	.016	-.397	.692	-.041	.023	-1.78	.075
	Infant age* Infant Sex* Culture	.081	.022	3.61	<.001***	-.009	.032	-.288	.774

A3.3 Test statistics for cross species GLMMs done without influential cases

General linear mixed models (GLMMs) to investigate sex differences in early social environment were run without participants which were deemed to be overly influential. Table A3.3 shows the number of participants deemed overly influential in each model, and Table A3.4 shows the original model parameters and the model parameters when excluding these overly influential participants.

Table A3.3: Number of overly influential participants for each GLMM per species and sex. *N/A indicates that the species wasn't included for that GLMM.*

Model	Number overly influential participants					
	Human		Chimpanzee		Macaque	
	Female	Male	Female	Male	Female	Male
Social activity	0	0	4	3	4	4
Mother partner	0	0	3	3	2	1
Child partner	2	1	1	2	1	1
Non-mother adult female partner	2	3	2	3	1	0
Mother in contact	3	0	2	4	6	5
Mother in 5 metres	5	2	n/a	n/a	4	2
Number of non-mother individuals in 5 metres	6	5	2	3	n/a	n/a
Number of children/ juveniles in 5 metres	8	6	2	3	n/a	n/a
Number non-mother adult female in 5 metres	12	4	3	2	n/a	n/a
Number of adult males in 5 metres	12	9	4	5	n/a	n/a

Table A3.4: GLMM parameters for cross-species comparison including and excluding overly influential participants. *The reference level for Species was human. The reference level for Sex was male. *** indicates significance at p <.001 level; ** indicates significance at p<.01 level; * indicates significance at p<.05 level.*

		Parameters for full model				***Parameters for model excluding overly influential participants***			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
Social activity	(Intercept)	-.857	.097	-8.80	<.001***	-.858	.098	-8.74	<.001***
	Infant age	-.031	.011	-2.97	.003**	-.031	.011	-2.84	.004**
	Infant sex	.046	.127	.359	.719	.051	.133	.383	.702
	Species (chimp)	-1.73	.236	-7.36	<.001***	-1.88	.287	-6.55	<.001***
	Species (macaque)	.550	.127	4.33	<.001***	.581	.135	4.31	<.001***
	Infant age* Sex	-.005	.013	-.346	.729	-.005	.015	-.367	.714
	Infant sex * Species (chimp)	.087	.205	.425	.671	.119	.271	.438	.661
	Infant sex * Species (macaque)	-.083	.159	-.521	.602	-.243	.178	-1.36	.173
	Infant age* Species (chimp)	.092	.024	3.85	<.001***	.097	.030	3.22	.001**
	Infant age* Species (macaque)	-.072	.015	-4.91	<.001***	-.073	.018	-3.99	<.001***
Mother partner	(Intercept)	1.98	.227	8.70	<.001***	2.02	.229	8.83	<.001***
	Infant age	-.044	.024	-1.81	.071.	-.053	.025	-2.10	.036*
	Infant sex	-.312	.282	-1.11	.268	-.445	.290	-1.53	.125
	Species (chimp)	-2.03	.535	-3.79	<.001***	-1.74	.641	-2.71	.007**
	Species (macaque)	.303	.278	1.09	.276	.392	.275	1.43	.154
	Infant age* Sex	.026	.029	.886	.376	.043	.031	1.37	.170
	Infant sex * Species (chimp)	.454	.474	.957	.339	.438	.620	.707	.479
	Infant sex * Species (macaque)	.110	.329	.333	.739	.148	.320	.461	.645
	Infant age* Species (chimp)	-.119	.056	-2.12	.034*	-.148	.070	-2.11	.035*

		Parameters for full model				*Parameters for model excluding overly influential participants*			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
	Infant age* Species (macaque)	-.259	.031	-8.46	<.001***	-.304	.034	-8.82	<.001***
Child/juvenile partner	(Intercept)	-2.65	.278	-9.52	<.001***	-2.69	.275	-9.77	<.001***
	Infant age	.062	.029	2.15	.032*	.069	.030	2.28	.022*
	Infant sex	-.216	.343	-.628	.530	-.058	.338	-.172	.864
	Species (chimp)	-.590	.675	-.874	.382	-1.08	.757	-1.43	.154
	Species (macaque)	.278	.342	.814	.416	.282	.305	.923	.356
	Infant age* Sex	.000	.033	.002	.999	-.024	.035	-.686	.493
	Infant sex * Species (chimp)	.079	.551	.143	.886	.545	.479	1.14	.255
	Infant sex * Species (macaque)	.252	.417	.605	.545	.274	.324	.846	.397
	Infant age* Species (chimp)	.206	.062	3.30	<.001***	.243	.071	3.44	<.001***
	Infant age* Species (macaque)	.211	.034	6.15	<.001***	.240	.036	6.61	<.001***
Non-mother adult female partner	(Intercept)	-3.70	.398	-9.30	<.001***	-4.25	.462	-9.19	<.001***
	Infant age	.086	.040	2.13	.033*	.130	.046	2.83	.005**
	Infant Sex	.648	.486	1.33	.182	1.03	.553	1.86	.062 .
	Species (chimp)	4.16	.624	6.66	<.001***	4.59	.762	6.02	<.001***
	Species (macaque)	-.912	.540	-1.69	.092	-.514	.589	-.873	.383
	Infant age* Sex	-.128	.050	-2.54	.011*	-.169	.058	-2.92	.004**
	Infant sex* Species (chimp)	.084	.610	.137	.891	.440	.693	.634	.526
	Infant sex* Species (macaque)	.172	.619	.277	.781	-.060	.649	-.092	.927
	Infant age* Species (chimp)	-.158	.058	-2.71	.007**	-.189	.072	-2.61	.009**
	Infant age* Species (macaque)	.092	.063	1.47	.142	.083	.068	1.23	.219

		Parameters for full model				*Parameters for model excluding overly influential participants*			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
Mother in contact	(Intercept)	.197	.122	1.61	.108	.196	.119	1.65	.100
	Infant age	-.129	.012	-11.1	<.001***	-.129	.011	-11.1	<.001***
	Infant Sex	-.301	.176	-1.71	.087	-.319	.176	-1.81	.070
	Species (Chimp)	4.56	.354	12.9	<.001***	5.24	.444	11.8	<.001***
	Species (Macaque)	1.62	.209	7.76	<.001***	1.81	.235	7.68	<.001***
	Infant age* Sex	.035	.016	2.10	.036*	.029	.017	1.73	.084
	Infant sex* Species (Chimp)	1.52	.726	2.10	.036*	.903	.868	1.04	.298
	Infant sex* Species (Macaque)	.349	.325	1.08	.283	.329	.405	.814	.416
	Infant age* Species (Chimp)	-.201	.032	-6.31	<.001***	-.271	.041	-6.69	<.001***
	Infant age* Species (Macaque)	-.150	.024	-6.27	<.001***	-.172	.030	-5.76	<.001***
	Infant age* Infant sex* Species (Chimp)	-.144	.065	-2.20	.028*	-.071	.080	-.884	.377
	Infant age* Infant sex* Species (Macaque)	-.035	.035	-.986	.324	-.065	.048	-1.36	.175
Mother in 5 metres	(Intercept)	1.62	.164	9.88	<.001***	1.68	.166	1.13	<.001***
	Infant age	-.060	.012	-5.02	<.001***	-.062	.013	-4.96	<.001***
	Infant Sex	-.125	.232	-.539	.590	-.087	.241	-.361	.718
	Species (Macaque)	2.77	.336	8.24	<.001***	3.27	.371	8.82	<.001***
	Infant age* Sex	.003	.017	.170	.865	.000	.019	-.024	.981
	Infant sex* Species (Macaque)	.202	.534	.378	.705	.617	.772	.800	.424
	Infant age* Species (Macaque)	-.410	.033	-12.5	<.001***	-.479	.040	-12.1	<.001***

		Parameters for full model				***Parameters for model excluding overly influential participants***			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
	Infant age* Sex * Species (Macaque)	.101	.048	2.09	.037*	.102	.087	1.17	.240
Number of non-mother individuals in 5 metres	(Intercept)	.184	.089	2.08	.038*	.158	.088	1.79	.074
	Infant age	-.006	.006	-1.01	.313	-.012	.007	-1.83	.068
	Infant Sex	.313	.123	2.55	.011*	.296	.122	2.42	.015*
	Species (chimp)	.362	.161	2.25	.024*	.440	.162	2.71	.007**
	Infant age* Sex	-.017	.008	-2.05	.041*	-.008	.009	-.877	.380
	Infant sex* Species (chimp)	-.363	.236	-1.54	.123	-.329	.232	-1.42	.157
	Infant age* Species (chimp)	.026	.010	2.67	.008**	.026	.011	2.41	.016*
Number of children/ juveniles in 5 metres	(Intercept)	-.565	.134	-4.21	<.001***	-.583	.128	-4.57	<.001***
	Infant age	-.003	.007	-.434	.664	-.005	.008	-.577	.564
	Infant Sex	.138	.188	.736	.462	.216	.179	1.21	.227
	Species (chimp)	.159	.252	.631	.528	.239	.243	.981	.327
	Infant age* Sex	-.007	.010	-.731	.465	-.003	.011	-.280	.780
	Infant sex* Species (chimp)	-.503	.384	-1.31	.190	-.612	.368	-1.66	.096
	Infant age* Species (chimp)	-.021	.014	-1.57	.115	-.026	.015	-1.68	.094
Non-mother adult female in 5 metres	(Intercept)	-1.22	.130	-9.40	<.001***	-1.18	.126	-9.38	<.001***
	Infant age	-.009	.008	-1.21	.227	-.028	.009	-3.28	.001**
	Infant Sex	.442	.177	2.50	.013*	.278	.177	1.57	.116
	Species (chimp)	.904	.226	4.00	<.001***	.930	.212	4.38	<.001***

		Parameters for full model				***Parameters for model excluding overly influential participants***			
Model	**Factor**	**Estimate**	***SE***	***Z***	***P***	**Estimate**	***SE***	***Z***	***P***
	Infant age* Sex	-.028	.009	-3.11	.002**	-.020	.011	-1.84	.065
	Infant sex* Species (chimp)	-.343	.352	-.975	.330	-.176	.348	-.505	.614
	Infant age* Species (chimp)	.060	.009	6.49	<.001***	.073	.011	6.74	<.001***
Number male adults in 5 metres	(Intercept)	-2.27	.183	-12.4	<.001***	-2.73	.218	-12.5	<.001***
	Infant age	.019	.011	1.80	.072	.035	.015	2.37	.018*
	Infant Sex	.670	.249	2.69	.007**	.825	.300	2.75	.006**
	Species (chimp)	.701	.326	2.15	.031*	1.19	.395	3.02	.002**
	Infant age* Sex	-.044	.014	-3.21	.001**	-.072	.020	-3.56	<.001***
	Infant sex* Species (chimp)	-.545	.493	-1.11	.269	-.816	.671	-1.22	.224
	Infant age* Species (chimp)	-.002	.017	-.115	.909	-.021	.026	-.817	.414
	Infant age* Infant Sex* Species (chimp)	-2.27	.183	-12.4	<.001***	-2.73	.218	-12.5	<.001***

A4 Appendices for Chapter 4

A4.1 Adaptations for Ugandan presentation of the Bayley Scales of Infant and Toddler Development Third Edition

When reviewing the Bayley-III scales for cultural appropriateness, some objects which infants were required to identify were deemed uncommon in the community, and thus inappropriate object to test infant receptive and expressive communication. Nine items in the Receptive communication sub-scale, and four items in the Expressive communication subscale were deemed culturally inappropriate in the published Bayley-III scales. Table A4.1 describes the original items as published, and the alterations we made when presenting the Bayley-III scales in Uganda.

Table A4.1 Adjustments for Bayley-III presentation in Uganda.

Bayley III subscale and item numbers	Original item materials and procedure	Adjustment for presentation in Uganda
Receptive communication item 12	An object of interest to the child is placed on a portable table. If the child reaches towards the object, the mother has to say “no-no”. If the child stops reaching for the object in response to the mother they receive the score for this item.	Since “no-no” is an English way to get a child to stop doing a behaviour, this is not an appropriate phrase to use with the Ugandan infants. Instead, mothers will use a word, or simple phrase, usually used with their children to stop them doing a behaviour.
Receptive communication item 15 and item 19	Infants are presented with five objects, a book, a spoon, a plastic cup, a small ball, and a doll. The experimenter names each of the objects. For item 15 the child has to identify at least one object correctly to receive the score for the item. For item 19 the child has to identify at least three objects correctly to receive the score for the item.	Ugandan children may not be familiar with the objects presented as they are not all common objects around their homes, so expecting them to know the word for these objects may be unreasonable. Unfamiliar objects were thus replaced by more familiar objects. The objects used in Uganda were a plate, a spoon, a plastic cup, a small ball, and a doll.
Receptive communication item 17 and item 21	Infants are presented with a picture book, with multiple images on each page. The pictures included were: cookie, shoe, car, balloon, bird, bed, kitten, spoon, ball, book, bottle, and apple. The experimenter turns the pages of the book and names the pictures asking if the child knows which it is.	Ugandan children may not be familiar with the pictures presented as they are not all common objects around their homes, so expecting them to know the word for these objects may be unreasonable. Unfamiliar pictures were thus replaced by more familiar pictures. The pictures used in Uganda were: chair, jackfruit, shoes, ball, bird, bed,

	For item 17, the child has to identify at least one picture correctly to receive the score for the item. For item 21, the child has to identify at least three pictures correctly to receive the score for the item.	car, bowl, mango, bottle, dress, and goat.
Receptive communication item 20	Infants are presented with a doll or bear, a spoon, a comb, and a facial tissue. Infants are directed to feed the doll or bear with a spoon, comb the doll or bear's hair, and wipe the nose of the doll or bear with a tissue. Child has to respond correctly to at least two directions with the doll or bear.	Ugandan children may not be familiar with these actions, so we will replace them with: (i) present the child with a small bowl and ask the child to feed the doll or bear with the contents of the bowl, (ii) present the child with a colourful piece of material and ask the child to dress the dolly in the material (e.g. wrap it around her), (iii) present the child with a piece of cloth and ask the child to clean the doll's face.
Expressive communication	Item 20 and item 27: Infants are presented with five objects, a book, a spoon, a plastic cup, a small ball, and a doll. The experimenter presents each object one at a time and requests the infant to name the object. For item 20 the child has to identify at least one object correctly to receive the score for the item. For item 27 the child has to correctly name at least three objects to receive the score for the item.	Ugandan children may not be familiar with the objects presented as they are not all common objects around their homes, so expecting them to know the word for these objects may be unreasonable. Unfamiliar objects were thus replaced by more familiar objects. The objects used in Uganda were a plate, a spoon, a plastic cup, a small ball, and a doll.
Expressive communication	Item 22 and 28: Infants are presented with a picture book, with multiple images on each page. The pictures included were: cookie, shoe, car, balloon, bird, bed, kitten, spoon, ball, book, bottle, and apple. The experimenter turns the pages of the book and points to each picture and asks the child to name the picture. For item 22, the child has to name at least one picture correctly to receive the score for the item. For item 28, the child has to name at least five pictures correctly to receive the score for the item.	Ugandan children may not be familiar with the pictures presented as they are not all common objects around their homes, so expecting them to know the word for these objects may be unreasonable. Unfamiliar pictures were thus replaced by more familiar pictures. The pictures used in Uganda were: chair, jackfruit, shoes, ball, bird, bed, car, bowl, mango, bottle, dress, and goat.

A4.2 List of gestures and facial expressions that were considered potentially communicative in laser experiment context

During coding of the laser videos to categorise whether there was a joint attention event, we coded communication. To establish clarity in terms of what facial expressions and arm/hand movements were considered communicative (rather than functional, e.g. to vocalise the face has to move, or to pick something up the arm has to move), we generated an agreed list of gestures and facial expressions. Agreed gestures are listed in *Table A4.2*,

Agreed facial expressions are as follows: we will only code Smiling, Surprise and Sad expressions in this coding scheme.

- Smiling – Only open mouth smiling is coded. Closed mouth smiling is not included because it can be very subtle and inter-observer reliability was difficult to achieve when included.
- Surprised face – only include if eyebrows are raised up, accompanied by open smile or 'oo' mouth
- Sad face – lower lip out or frown

Table A4.2: Gestures considered communicative during laser experiment (separate for mothers and infants).

Gesture	Definition	Source
	Human - mothers	
Point	Finger extended towards an object or event *NOTE: the definition for pointing in gestures is much more general than in engagement and does not rely on distance to what the person is 'pointing' at.*	O'Neill, Bard, Linnell, & Fluck, 2005
Indicate	Object or event was singled out through movements of the head or hand towards the object or event, or direct contact with (i.e. tapping or touching) the object or location of the event	O'Neill, Bard, Linnell, & Fluck, 2005
Beckoning	Beckoning with either the whole hand or the index finger	O'Neill, Bard, Linnell, & Fluck, 2005
Raising palm upwards	"All gone" Emphasizing question Can be one or both hands	Agreed decision among JointAtt lab group
Request reach	Requesting an object. Reaching out with their hand	Agreed decision among JointAtt lab group
Shaking head	Shaking the head from side to side to indicate 'no'	O'Neill, Bard, Linnell, & Fluck, 2005
Nodding the head	To indicate yes	Iverson, Capiric, Longobardi, Caselli, 1999
Clap hands		Crais, Douglas, & Campbell, 2004

Shrugs	Raises and lowers shoulders to indicate "all gone" or "where did it go"	CDI
Waving	Either with open/closed hand alternating or waving open hand from side to side	Agreed decision among JointAtt lab group
Blow kisses		Agreed decision among JointAtt lab group
Tactile	Includes hitting, slapping or grab-pulling (tug) which should be delivered with some force (must be salient) or occur repeatedly. Embrace (tactile) - Hugging other with both arms Nuzzle – rub head/face on other in affectionate way Kiss	Agreed decision among JointAtt lab group
	Human - infants	
Pointing	Points (with arm and/or index finger extended) at some interesting object or event. If child touches object (poking) while directing attention to, that can also count as pointing (but not when they are touching it to explore the object itself or are going to grab it)	CDI; Blake, O'Rourke, & Borzellino, 1994
Reaching for something out of reach	Arm extended, hand open, palm facing down OR hand opening and closing, directed towards person or object	CDI; Blake, O'Rourke, & Borzellino, 1994 Crais, Douglas, & Campbell, 2004
Requesting reach	Arm extended, palm open, upwards, requesting object. Infant is not trying to reach to touch, but to communicate. Pay attention to body movements: if they are leaning in with their body they are likely reaching to touch; if they are not putting effort in their body movement (e.g. not walking closer or leaning in) they are likely request reaching	Agreed decision among JointAtt lab group
Give/offer as a request	Reaches out and gives a toy or some object that he/she is holding. Eye contact with partner and partner takes it (not just dropping an object on some one or pushing object towards someone). Infant hands object to another. There is movement of arms and object changes hands.	CDI; Blake, O'Rourke, & Borzellino, 1994
Raising arms to be carried; "Up"	Extends arm upwards to signal wish to be picked up. One or both arms are raised toward another or merely moved away from the body to allow room for another's hands to pick infant up. (The latter is usually in response to another's motion toward infant with hands out.)	CDI; Blake, O'Rourke, & Borzellino, 1994

Show	Extend arm to show object in hand	CDI; Carpenter, Mastergeorge, & Coggins, 1983
Nod	Affirmative head nod	CDI; Carpenter, Mastergeorge, & Coggins, 1983
Head shake	Shakes head "no"	CDI; Crais, Douglas, & Campbell, 2004
Clap hands		Crais, Douglas, & Campbell, 2004
Shrugs	Raises and lowers shoulders to indicate "all gone" or "where did it go"	CDI
Raising palm upwards	"All gone" Emphasizing question Can be one or both hands	Agreed decision among JointAtt lab group
Waving	Either with open/closed hand alternating or waving open hand from side to side	Agreed decision among JointAtt lab group
Blow kisses		Agreed decision among JointAtt lab group
Tactile	Includes hitting, slapping or grab-pulling (tug) which should be delivered with some force (must be salient) or occur repeatedly. Signaller should have eye-contact with the recipient when producing the gesture. Embrace (tactile) - Hugging other with both arms Nuzzle – rub head/face on other in affectionate way Kiss	Agreed decision among JointAtt lab group

A4.3 Full global ratings instructions

Five minutes of mother-infant play videos were coded using global ratings scales to assess mother reactiveness, mother intrusiveness, and infant positive affect. The coding instructions for these measures are below.

A4.3.1 Mother reactiveness

Mother reactiveness overall category description: How much do mothers notice and react appropriately to their infant's signals when interacting with the infant?

To be rated highly on reactiveness, mothers must be responsive and the responses must be appropriate. It may be useful to think about the interaction from the infant's perspective: what is their experience?; What are they getting out of the interaction?; What are they trying to communicate?

Infant signals can be:

- expressions of emotion, e.g. happiness, feeling uncomfortable
- attempts to initiate play, can be attempts to reach objects
- attempts to request something from mother, e.g. reaching to be picked up
- signals of willingness or reluctance to interact
- requesting/looking for help or wanting to be left alone
- obvious or subtle

We are interested in how responsive mothers are to their infant's signals. The following questions will help you to pay attention to what is important:

- Does the mother show some awareness to very subtle infant signals?
- Does the mother respond to subtle signals as well as obvious signals?
- Does the mother only respond to overtly obvious signals?
- Does the mother seem able to empathise with the infant?

We are interested in how appropriately mothers react to their infant's signals. The following questions will help you to pay attention to what is important:

- Does the mother seem able to read their infant's cues correctly?
- Does the mother seem able to understand what the infant is looking for with their communication? (E.g. what outcome would satisfy the infant?)
- Are the mothers responses appropriate? For example, is the intensity of the mother's response at the right level? It would be inappropriate if the mother's response is extreme in form and intensity of affect if the infant's cues were subtle. E.g. the infant makes a soft "oh" vocalisation and the mother responds with an inappropriately loud "AH!" utterance, possibly startling the infant.

We are interested in how quickly the mother responds to their infant's signals, and for how long she responds for. The following questions will help you to pay attention to what is important:

- Does the mother respond in a temporally continent manner?
- Does the mother respond for long enough to satisfy the infant?

When rating this measure:

- Consider whether the infant is free to move or if their movement is restricted (keep in mind the infants abilities)
- Consider how the mother tries to draw infants attention towards objects or toys
- Consider changes in stimulation during play and whether these changes are in response to infant cues
- Consider how the mother gives infants feedback/how she comments on the infants behaviour (e.g. are comments affirming, or encouraging? Or criticising?)
- If an infant is avoidant consider how the mother reacts – is she following in on their attention? Or criticising them for looking elsewhere? Does she give them space to pause?
- If an infant shows distress, does she comfort? Demand a chance of state? Or criticise the upset?

Mother reactiveness Score 1: Minimal or low reactivity

Mothers will be given this rating if they are (see elaborations below):

- Preoccupied or missing infants cues

- If she doesn't attempt to understand cues she picks up on, or does not respond appropriately to cues she does pick up on
- Or if she does respond appropriately, it is not in a temporally contingent manner, or not persisting enough until infant is satisfied.

The mother may show some sensitivity in how she interacts or responds with her infant but it is not consistent – overall she is more often insensitive than sensitive. Mother may be unresponsive.

Mothers who are preoccupied or missing infant's cues may show this by:

- Showing no desire to take the infants perspective
- Missing infants signals due to being frequently preoccupied with other things (e.g. more focused on a toy that the infant isn't playing with)

Mothers who frequently don't attempt to understand cues, doesn't respond appropriately to cues, or distorts meaning of cues she picks up on may show this by:

- The mother often being geared to her own desires, causing a disparity between the infants wishes and the activity, i.e. mother's interventions and initiations of interaction are prompted or shaped largely by her own desires (without cues from the infant that they want them change activity
    - For example overwhelming the infant with toys they don't indicate interest to
    - Changing the activity and pace of the interaction frequently
    - Playing rough games without engagement from infant
- Frequently not reacting, or reacting inappropriately, to infant signals due to not trying to interpret them, or reacting inappropriately to infant signals because of misperception
- Reacting inappropriately despite correct interpretation of infant signals because of her own desires – for example, she wants the infant to do something else, she is not inclined to give them what they want, or she does not respect infants motivations (e.g. she doesn't want to 'spoil' the child, or it is 'inconvenient' or because she is 'not in the mood' for it). This could be shown by, for example, an infant giving cues to indicate they are content or enjoying playing with a toy, but the mother tries to remove the toy to play with it in a different way, or to try and make them infant attend to something other than that toy.
- The mother may show little acceptance of infants behaviour, with little evidence of trying to take the infants perspective - the mother showing little sympathy for the child, and potentially laughing at or mocking them for something.

Mothers who do respond appropriately, but not in a temporally contingent manner, or not persisting enough until infant is satisfied may show this by:

- Seeming impatient with their infant or giving a half-hearted response to their signals, but the response is not prolonged or intense enough, thus breaking off their response before the infant is satisfied (e.g. infant may persist their signals, or reignite their signals after mother stops her reactive behaviour). This may results in the interactions seeming fragmented.
- A mother may delay her response in comparison to the first cue from the infant, this may mean that the otherwise appropriate response is no longer appropriate, or that the infant needs to intensify their cues before the mother reacts.

Note: mothers of this rating may show some modifications of behaviour and goals, and may show some sensitivity when:

a) infants activity or wants are in line with that of her own (i.e. it may be coincidence that her interactions align with the infants signals)

b) OR when infants communication is intense or forceful (e.g. infant is truly distressed)

Mother reactiveness Score 2: Moderate/Inconsistent reactivity

Mothers will be given this rating if they are (see elaborations below):

- Sometimes preoccupied or missing infants cues (if they miss more than one overt cue they must be given a rating 2 or less)
- Sometimes she doesn't attempt to understand cues she picks up on, or does not respond appropriately to cues she does pick up on
- Or sometimes although she does respond appropriately, it is not in a temporally contingent manner, or she does not persist enough for the infant to be satisfied.

The mother may show some insensitivity in how she interacts or responds with her infant but it is not consistent – overall she is more often sensitive than insensitive (or she is sensitive for half of the interaction, and insensitive for the other half).

The mother may have intermittent awareness of the infant – at times she may be fairly attentive, sensitive, and reactive in a gentle manner but are not consistently so as sometimes she may be overbearing, inattentive, or insensitive

The mother is sometimes preoccupied or missing infants cues. This could be indicated by:

- There may be times where mother doesn't see things from the infants point of view and thus doesn't realise the infant is communicating
- She may show instances of being preoccupied and so misses infant signals.

The mother sometimes doesn't attempt to understand cues she picks up on, or does not respond appropriately to cues she does pick up on. This could be indicated by mothers on occasion:

- Misunderstanding, or distorting the meaning of infant signals in regard to some signals, but accurate in other respects.
- Not responding to infant signals appropriately (either ignoring the signal, or giving an inappropriate reaction which doesn't align with the infants motivations/intentions)
    - E.g. she may not try to interpret some of the infant's communications
    - Or she may be more interested in her own desires at times and so tries to control infants behaviour or ignores some signals because she may not want to give them what they want, or may interrupt or overwhelm the infant with toys
    - She may react inappropriately such as mocking or laughing at the infant/or showing no sympathy towards them
    - Or react on a level inappropriate for the level of the infants cue (e.g. infant does a soft coo, and mother gets overly excited and loud potentially making the infant jump)

Sometimes although mother responds appropriately and promptly, sometimes it is not in a temporally contingent manner, or she does not persist long enough for infant to be satisfied

- The reaction of the mother may be timely appropriate to infants cues but sometimes it may be delayed in comparison to the infants signal

- The reaction of the mother may be appropriate to infant's cues but sometimes she may stop her interaction before the infant is contented with the reaction.

Mother reactiveness Score 3: Predominantly high reactivity

Mothers will be given this rating if they:

- Miss a maximum of one overt cue, and rarely miss less overt cues
- Attempt to understand most cues
- Respond appropriately to most cues she picks up on
- Mostly respond in temporally contingent manner, and persists for long enough for infant to be satisfied

The rarely shows insensitivity in how she interacts or responds to her infant – and if she does show insensitivity it is mild e.g. missing a couple of mild signals, or making a mild demand.

The mother is mostly attentive towards her infant and is reactive in a gentle manner. She may give one or two demands or mild criticism to infant, but otherwise close to rating 4 description.

The mother is mostly attentive towards her infant, rarely preoccupied and rarely misses infant's cues. This could be indicated by:

- The mother usually tries to take the infants perspective, is empathic towards the infant, is rarely preoccupied and only misses mild instances of infant signals
- Mothers cannot receive this rating if she misses a clear and definite signal

The mother attempts to understand cues she picks up on, and usually responds accurately and appropriately.

- Mother tries to interpret all overt infant communications
- Mother may miss more subtle signals, or have occasional mismatches in mother-infant behaviour as compared to a mother rated with a 4.
- Mother is mostly accurate in understanding infant cues, and if she does misunderstand cues, they are subtle cues, or misunderstood in a subtle way. She does not distort the meaning of the infant's cues to match her own desires.
- Mothers cannot receive this rating if she misinterprets a clear and definite signal
- The interaction is infant-centred with the mothers behaviours usually reacting to infant cues rather than being led by her own desires
- The pace and intensity of the interaction is appropriate to the infant's mood

Mother usually responds appropriately and promptly, and persists long enough for infant to be satisfied

Mothers cannot receive this rating if she is delayed in responding to a clear and definite signal

Mother reactiveness Score 4: Highly reactive

Mothers will be given this rating if they:

- Do not miss any obvious infant cues, rarely misses subtle cues
- Attempt to understand all infant's cues
- Respond appropriately to all cues she picks up on

- Respond in temporally contingent manner, and always persists for long enough for infant to be satisfied

The following may help you categorise mothers:

- The mother does not show insensitivity in how she interacts or responds to her infant, she is attentive and reactive in a manner appropriate to infant's cues and mood.
- The mother affirms infant's behaviours, and never criticises or mocks the infant's interest or behaviour, and does not demand of the infant. She does not interrupt infant's behaviours or communications.
- The mother tries to take the infants perspective, is empathic towards the infant, and does not miss even subtle infant signals
- Interactions seem smooth and not disjointed
- If the mother does not want the child to do something she is tactful at acknowledging the child's desires, while preventing the action for example by offering an acceptable alternative (e.g. it may be dangerous for child so mother wants to prevent harm, or maybe the infant is doing something they shouldn't such as hitting the mothers face, but mother shows the child's favourite toy to distract them from the unwanted behaviour).
- If infants show unwillingness to interact, the mother gives them space, and if they display sadness or distress she is able to acknowledge the feelings and bring them out of it.
- The mother is unlikely to move the infant unless they indicate it is what they want, if she wants to change the relation between herself and the infant she is more likely to move herself

The mother attempts to understand cues she picks up on, and responds accurately and appropriately.

- Mother tries to interpret all infant communications, responds to all cues, and gives feedback to her infant on their actions
- Mother is accurate in understanding even subtle infant cues, and does not distort the meaning of the infant's cues to match her own desires.
- The interaction is infant-centred with the mothers behaviours reacting to infant cues rather than being led by her own desires
- The pace and intensity of the interaction is appropriate to the infant's mood

Mother responds appropriately and promptly, and persists long enough for infant to be satisfied

A4.3.2 Mother intrusiveness

Mother intrusiveness overall category description: This category looks at how intrusive of infant's space, or how interruptive the mother is of infant's attention or activity. It encompasses mothers physical interactions with her child as well as whether she is coercive in play.

Intrusive Physical activity: We are interested in how roughly or gently the mother handles her infant, or how much she physically interacts with her infant. 'Intrusive' physical contact would be actions like poking, prodding, tickling, or pinching the infant. Non-intrusive physical contact would be if mothers stroked the infants head gently. If the mother's physical interaction with the infant is to provide support and stop the infant falling then this would not be considered intrusive. Wiping infants face to clean it is not considered intrusive. Other touches to the face, such as touching them on the nose, even if playfully, would be considered intrusive, especially if the infant jumps or flinches.

Intrusive actions*:* We are interested in if the mother interrupts, or disrupts, infant attention or activity, and how she acts within the infant 'space'. Actions which involve physical proximity to the infant's face, such as clicking fingers in their face, would be considered intrusive. If the mother consistently tries to distract, demand attention (if infant attending elsewhere), or interrupt the infant this would also be counted. Vocalisations which are loud and not in-line with the infant's mood, or forceful instructions can also be considered intrusive.

Coercions: Coercions are considered when the mother manipulates the infant to do something that they do not appear to desire. Forceful positioning of the infant or forceful physical direction are considered coercion – for example to make an infant achieve a task which they do not seem motivated to do. E.g. the infant is hitting a block against the sorter and seems content, but the mother manipulates the infants hand so that they place the block in the correct hole. Coercion is different from showing and infant how jointly – e.g. if an infant is trying to post the shape but not doing so well, and so the mother helps, this is guiding *not* coercing.

It can be useful to pay attention to the following when scoring intrusiveness:

- The number of times the mother intrudes on the infant's space (e.g. puts her face, hand, or a toy very close to infants face)
    - How often do these actions by the mother make the infant flinch, startle, cause distress, or make the infant become avoidant? (consider intrusive)
    - How often does the infant not react to these actions? (consider mildly intrusive)
    - Does the infant react positively to this action by the mother (thus indicating that they like it and encouraging the mother behaviour)? (don't consider intrusive)
- How often the mother interrupts the infant's communication, or interrupts infant's attention in a way that the infant doesn't have choice.
- How often mother takes an object from the infant that they are attending to
- How often the mother touches infant in a non-gentle or non-affectionate way (e.g. 'rough' handling, prodding or poking)
- How does the mother get the infants attention? Is it through extreme or exaggerated movements?

If infants give a positive reaction to the mother's behaviour do not count it as intrusive, but it can still be coded as intrusive if there is no reaction, or if reaction is neutral (thus a mother can still receive a high intrusiveness scores even if the infant does not react negatively). If there is a negative reaction to a mothers action you should keep an eye out for intrusiveness (but infant distress does not necessarily mean the mother is intrusive – e.g. if the infant hurts themselves or is grouchy to do with things which aren't in response to the mothers actions).

When trying to distinguish between scores, consider how much disruption is caused to the infants activities by the mother's behaviour. If the mother is the cause for infant distress then she is likely to receive a high score.

Mother intrusiveness Score 1: No intrusiveness

The mother does not display any intrusive or interruptive behaviour.

- If the mother touches the infant it is in an affectionate and gentle manner. Her touches never cause distress or avoidance
- The mother does not put her hands, face, or objects very close into the infants face unless the infant is reacting positively to it.
- She does not poke, prod, or pinch the infant
- If the mother wants the infant to attend somewhere else, she first follows in on the infant's attention, and only then tries to encourage attention elsewhere.
- If mother wants to make infant attend to something else, she would offer it as an option by placing it in the visual field. If she puts it so close to the infants face that they can't look at other things, or in the line of sight from something the infant is looking at then it would be considered an interruption and a higher score should be given.

The mother does not use extreme or exaggerated movements to get their attention.

Mother intrusiveness Score 2: Minimal intrusiveness

The mother rarely displays any intrusive or interruptive behaviour, however on up to five instances she may show a mild intrusion or interruption, or one or two moderately intrusive instances. If there are more than five mild instances, or any intense instances the mother should receive a higher score.

- If the mother touches the infant it is usually in an affectionate and gentle manner. Her touches rarely cause distress or avoidance
- On occasion the mother may interrupt the infants attention or activity, but not in a very abrupt or rough way
- On occasion the mother may sometimes put something close to the infants face, or tickle prod or poke them, without a positive reaction
- The mother may have a mild physical intervention, or restrict a movement by the infant by holding their arm or leg, but never in a rough way

The mother usually does not use extreme or exaggerated movements to get their attention.

Mother intrusiveness Score 3: Mixed or moderate intrusiveness

While there are periods where the mother is non-intrusive, she shows about two or more instances of moderate (rougher) intrusiveness or interruption, or more than about five instances of mildly intrusive or interruptive behaviour. If the mother shows any highly intrusive behaviours they must score at least a 3.

- There are some periods where the infant is able to attend to what they want
- The mother may put her hands, face, or objects very close into the infants face, or put them in the infant's line of sight to make them pay attention to it.
- The mother may manipulate the infant's body to make them perform an action without apparent motivation from the child.
- The mother may use extreme or exaggerated movements to get their infant's attention.
- The mother may interrupt the infant's attention or activity in a physical way, or prevent them from attending to something by physically interacting with the child.

- She may roughly tickle the infant, or restrict their movements.

Mother intrusiveness Score 4: predominant or high intrusiveness

Mother may receive this score if she regularly interrupts or intrudes on her infant, or if she shows more than about two instances of handling her infant in a rough way.

- The mother's predominant way of interacting may prevent the infant from attending to what they want, this may be due to physical manipulation, through taking toys away, or through interrupting the visual pathway of the infant.
- She may jerk their limbs, or torso, or roughly tickle or poke her infant.
- This mothers actions may cause her infant distress, discomfort, or avoidance
- She may manipulate infants arms or legs in ways which do not seem to be in line with infants desires (coercion)
- She may persist with a game or toy even if the infant doesn't seem to want it.
- She may touch or put toys close into the infants face regularly.

A4.3.3 Infant positive affect

Score 1: Infant did not express any positive affect

Score 2: Infant expressed minimal positive affect. For example, a few instances of closed mouth smiling, or one instance of open mouth smiling.

Score 3: Infant expressed moderate or inconsistent positive affect. For example at least one instance of intense positive affect such as laughter, but this is not characteristic of the infant during the segment. Would also include two or more instances of open mouthed smiling, or closed mouth smiling throughout.

Score 4: Infant expressed multiple intense bouts or predominantly moderate affect throughout segment. This would include, for example, open mouth smiling throughout, or two or more instance of laughter.

A4.4 Percentage of time looking towards laser stimulus split by age, sex, and culture.

Infants showed high interest in the laser stimulus during the laser experiment, as indicated by high levels of looking towards the stimulus during the experiment. Infants of all age-sex-culture groups showed high looking times towards the stimulus – details in *Table A4.3*.

Table A4.3: Percentage of time looking towards stimulus during laser experiment split by age, sex, and culture. *Looks towards the stimulus were defined as looking towards the laser, or area where laser was most recently shown before being turned off.*

Age, sex, culture group	Mean % time looking at stimulus	SD	Number of trials
Ugandan female 11-months	56.6	17.8	15
Ugandan female 15-months	66.8	14.7	21
UK female 11-months	59.9	16.8	19
UK female 15-months	66.5	13.7	22

Age, sex, culture group	Mean % time looking at stimulus	SD	Number of trials
Ugandan male 11-months	48.4	19.1	17
Ugandan male 15-months	60.2	14.7	16
UK male 11-months	65.8	11.5	23
UK male 15-months	54.2	16.6	17

A4.5 Full model parameters for factors investigated as predictors of engagement in joint attention events

I found no predictors of infant engagement in joint attention as indicated by full models not explaining significantly more variance than a null model only containing random factors. Full model statistics are presented in table A4.4.

Table A4.4 full model parameters for predictors of engagement in joint attention events. LRT=Likelihood ratio test.

Model (LRT test results)	Fixed Factors	Estimate	*SD*	*Z*	*P*
Infant Culture, Sex, Age ($\chi^2(6)=12.5$, p=.051)	(Intercept)	-3.03	2.70	-1.12	.262
	Infant age	.094	.197	.478	.632
	Infant Sex	-.840	2.72	-.308	.758
	Group	.407	2.79	.146	.884
	Infant age*Infant Sex	.093	.194	.479	.632
	Infant sex*Group	.082	.206	.399	.690
	Infant age*Group	-.749	.824	-.908	.364
Interest in objects ($\chi^2(5)=3.10$, p=.376)	(Intercept)	-1.96	.708	-2.77	.006
	3-month solo object play	.098	4.47	.022	.983
	6-month solo object play	3.25	2.92	1.11	.265
	9-month solo object play	2.86	2.72	1.06	.292
General cognitive development ($\chi^2(3)=1.82$, p=.177)	(Intercept)	-3.68	2.18	-1.69	.091
	Cognitive score	.072	.055	1.31	.191
Communication development ($\chi^2(4)=.938$, p=.626)	(Intercept)	-.681	1.48	-.459	.646
	Expressive communication score	-.065	.074	-.872	.383
	Receptive communication score	.058	.110	.528	.597
Emotional expression/ temperament 1 (χ^2 (3)=.032, p=.859)	(Intercept)	-.674	.813	-.829	.407
	Infant positive affect during social play	-.054	.308	-.176	.860
Emotional expression/ temperament UK 2 ($\chi^2(5)=.174$, p=.982)	(Intercept)	-.268	.706	-.379	.704
	3-month crying	-.005	.020	-.235	.814
	6-month crying	-.009	.035	-.250	.803
	9-month crying	.001	.019	.080	.936

Model (LRT test results)	Fixed Factors	Estimate	*SD*	*Z*	*P*
Experience of environment ($\chi^2(5)=4.00$, $p=.261$)	(Intercept)	-2.67	1.40	-1.90	.058
	Sit	.024	.115	.204	.838
	Crawl	.165	.118	1.40	.163
	Walk	.000	.106	-.003	.997
Social experience ($\chi^2(5)=.377$, $p=.945$)	(Intercept)	-.749	1.13	-.666	.506
	3-month social activity	-.182	2.62	-.070	.944
	6-month social activity	-1.33	2.23	-.597	.550
	9-month social activity	.186	2.48	.075	.940
Triadic experience ($\chi^2(5)=5.52$, $p=.137$)	(Intercept)	-1.54	.511	-3.01	.003
	3-month social object play	-3.41	4.36	-.782	.434
	6-month social object play	4.51	2.72	1.66	.096
	9-month social object play	.371	3.10	.120	.904
Social environment ($\chi^2(5)=7.63$, $p=.054$)	(Intercept)	-.524	.464	-1.13	.259
	Number in five meters at 3-months	-.660	.480	-1.38	.169
	Number in five meters at 6-months	-.665	.406	-1.64	.102
	Number in five meters at 9-months	.743	.431	1.72	.085
Mother-infant interaction style 1 ($\chi^2(4)=5.79$, $p=.055$)	(Intercept)	2.39	1.37	1.74	.081
	Reactiveness	-.651	.351	-1.86	.064
	Intrusiveness	-.598	.305	-1.96	.050
Mother-infant interaction style 2 ($\chi^2(3)=.046$, $p=.830$)	(Intercept)	-.808	.672	-1.20	.229
	Percentage play where mother vocalising	.002	.011	.214	.830
Mother-infant interaction style 3 ($\chi^2(3)=.488$, $p=.485$)	(Intercept)	-.369	.502	-.735	.462
	Percentage play face-face	-.005	.007	-.691	.490

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