The Many Relations Between Language and Thought: Three Case Studies

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Abstract: The nature of the relationship between language and thought is a controversial topic, and it seems every possible position has been defended at some point: from the rationalists of old who equated rationality with language to modern cognitive science which tends to see language as merely a vessel for communicating thoughts. But even these most disparate views share the assumption that the relationship is consistent and stable throughout cognition.

However, the rise of modularity within cognitive science challenges the idea that thought is a single homogenous phenomenon, and in this vein, this thesis challenges the assumption that the relationship between language and thought is identical across all domains of cognition.

By looking at three different areas of cognition in depth this thesis shows that not only does language have a role to play in cognition (a controversial conclusion in its own right) but further that this role varies across cognition.

The first case study deals with how navigational terminology lends a unique flexibility to human reorientation capacities, the second illustrates how swearing helps expand the domain of our disgust response from the visceral to the moral; and the third shows how language allows us to develop concepts of number, for which we have no specialized pre-linguistic mental faculty to deal with.

The existing theories of language's role in each of these areas of cognition often ascribe language too computational a role, casting the language faculty as a domain-general symbolic manipulator. I am wary of ascribing language such computational powers, and instead show how ordinary communicative functioning of language can lead to significant cognitive effects downstream.

The thesis concludes by drawing up a taxonomy of the different mechanisms by which language effects cognition, allowing us to see just how multifaceted the relationship between language and thought is.

Language and thought
An introductory chapter

This thesis explores the nature of the relationship between language and thought. A number of possibly contradictory intuitions guide us in trying to answer the question of how language is related to thought, all of which – at some point or other – have been nurtured into rich and developed accounts of language's interaction with thought.

Sometimes we might intuitively feel that the link between language and thought is very strong. In fact, often it feels like we conduct most of our thinking in words through an internal monologue. Perhaps language is the very stuff of thought? After all, when we try to think about something particular, or particularly challenging, we seem to put the issue to ourselves in words as part of our inner speech and produce sentence-like responses to our own questioning. It seems that, at the very least, our top level cognitive processing is linguistic. The significance of our internal verbal thinking processes is corroborated by studies that probed, via self-report, the inner lives of subjects, which showed them to be engaged in inner speech more than 50% of the time (Hurlburt, 2012).

These intuitions are given philosophical significance in Wittgenstein's famous quote "The limits of my language are the limits of my world,"(Wittgenstein, 2012, §5.6), that proposes that words demark the entirety of the things we can even think about; and many other philosophers, of various stripes, have defended the idea that language is necessary for human thought or that language plays an important part in shaping our thoughts.

However, views that credit language with a critical role in cognition run into trouble when we come to ascribe thoughts to infants and non-human animals. After all, it is clear that they engage in complicated mental activities that are responsive to the situations they find themselves in, that we might well want to call thoughts, but they apparently manage to do so without grammatical language.

Conversely, certain common experiences of using language lead us towards contradictory conclusions. For instance, we sometimes find ourselves "lost for words," when we are unable to capture our thoughts in words at all; or we find that a word is "on the tip of our tongue" as if the thought is already in place but the word for it is temporarily lost. What is more, we direct children to "think before they speak" as if they are separate activities that can be completed, potentially, in the wrong order. These phenomena seem to presuppose that thought precedes language, that we merely use language to express our thoughts, and that on occasion, it is unable to do so faithfully. This kind of thinking makes it seem like language can have no effect on the processes of cognition.

For Chomsky, language is merely a mirror to thought, meaning that we can use it as a means of uncovering the inner workings of the mind. "By studying the properties of natural languages, their structure, organization, and use, we may hope to learn something about human nature" (Chomsky, 1975, p.4). It seems that even the world's most famous linguist sees language as reflecting thought rather than contributing to it, so much so that we can use it as a mirror without fear of language distorting the results.

Both of these extreme views – that language is essential to thought, and that language is inconsequential to thought – and all the possible views on the spectrum between, seem to make the assumption that thought is a single homogenous thing, and therefore that language's relationship with it is constant and stable, performing the same role at all times. If we give up on this assumption then we might be able to make sense of our contradictory intuitions. Maybe during some cognitive tasks language plays almost no part in cognition, acting only as a mirror to the subconscious, non-linguistic cognitive processes, while at the same time determining how we think during other sorts of task.

Indeed, the modularist's picture of the mind as a collection of discrete, specialized faculties, known as modules, challenges the assumption that all thinking processes are of the same type. On this picture, each of these cognitive modules evolved in response to some specific challenges faced by our forebears, each will have its own limited capacities and will respond selectively to stimuli. Accordingly, thinking in one cognitive domain will employ distinct cognitive faculties with different capacities than thought in another domain. We will look at these modularist accounts in greater detail in chapter one, but it is clear that such a multi-faceted picture of cognition makes it possible to see how language might interact with different parts of thought differently; such an account might well explain our mixed intuitions about it.

How much of the mind is split up into these specialized faculties and how much of it is a central intelligence is an open question, and one that falls outside the remit of this thesis. Following the massive modularists (Carruthers, 2005; Sperber, 2001), this thesis will be conducted under an account of cognition that claims that even the most conceptual elements of the mind are made up of specialized faculties, whose ability to represent information conceptually allows us to meet some specific evolutionary demand. Such a view holds that there is no central intelligence, no general purpose symbolic computer that gives us that uniquely human capacity to think about anything in the world. Instead it sees the distinct faculties, both conceptual and peripheral, as embodying a collection of simple automatic processes ("automatic" in the sense that we cannot actively marshal them to our ends) that together build up the complex phenomena of human thought and jointly enable us to respond to events in world appropriately.

It is unclear however what role we should consider the language faculty to play in cognition within a massively modular view of cognition, as many of the features of the language faculty seem at odds with the guiding modularist principles – it is domain general, can represent anything, its workings are often consciously available to us and we seem to be able to intentionally wield it as a computational tool. So perhaps we should conclude that it is not a part of the cognitive machinery at all. After all, the modular account of the mind sets out to show how a full and rich system can arise without the need to postulate a system that has these features, associated as they are with a series of computational problems that we will look at in the next chapter. Accordingly, within most modularist frameworks, the language faculty is treated as if it was extraneous to the computational faculties that make up our mind.

This sort of thinking about the mind as a computational system built up of discrete functional elements has encouraged the propagation of the metaphor that the mind is a computer; under this metaphorical schema, the language faculty then is like the input/output elements of the system, the keyboard and monitor – and as such plays no role in the actual computation.

Under such a picture the limit of the cognitive effect of language on cognition is the transferral between speakers of those concepts which we would not be able to develop independently by investigation or experience. For instance, without being taught about DNA or atoms linguistically, very few of us could come to have thoughts about them, guided solely by experience. Language allows us to spread throughout society knowledge that has been learnt up to that point and means that every individual human does not have to work everything out for herself. This process of transferral of thought from one speaker to another is obviously fundamental to forming a cohesive society and to the progress of science, but can it be the only way language contributes to human thought?

Even within this multifaceted picture of thought, established by the modularist and held by most modern cognitive scientists, we still tend to return to a simplified account of language's role within the mind – one that is at odds with the intuitive insight that language is a fundamental component of our mental lives.

On the other hand, the fact that we share most of our non-linguistic mental faculties with other animals but appear to be very different to them in terms of cognitive capacity might yet be explained by appeal to the cognitive advantages endowed on us from language. It is a matter of on-going debate as to what cognitive capacities set us apart from our nearest relatives but I suspect that language is key to these differences.

Subscribing to a modularist account of the mind need not determine how we view language's role in cognition, and following Peter Carruthers (Carruthers, 2002), I intend to highlight the possibility of language having wide ranging cognitive effects, even within a modular framework.

Instead of leaping to proposals of an overall account of how language might interact with cognition generally, I suggest that there is merit in looking at various areas of cognition in detail, in order to establish the mechanisms by which language plays a role in cognition in these particular domains. After all, if cognition functions differently in each domain, we shouldn't assume the effect language can have on it is constant or that a general approach to language's role in cognition to be especially fruitful. We will therefore be investigating language's role in cognition by looking at a series of detailed case studies.

The first case study deals with humans' capacity to navigate after becoming disorientated; it provides an interesting starting point as experimental work makes it clear that we share most of our non-linguistic navigational machinery with other mammals, yet, as adults, we are able to reorientate ourselves in a qualitatively and measurably different way to animals. This provides us with an ideal case study for exploring the effects of language learning on cognitive development; at the same time it will provide the opportunity to explore the idea that language provides the mental flexibility that we routinely credit humans with, but which the modular theory has trouble explaining.

The second case study investigates the far less measurable effect that language has on the disgust response system that initially evolved to help us avoid infectious disease (Valerie Curtis & Biran, 2001). It has been observed that in modern societies people cite certain moral actions as well as disease vectors as disgusting (Haidt, Rozin, Mccauley, & Imada, 1997). This chapter attempts to explain this expansion of the domain of the disgust response by appeal to the linguistic practice of swearing. This chapter allows us to look at an effect of language on cognition that is not immediate to us during everyday experience and helps to illustrate just how wide reaching the potential effects of language on cognition might be.

The final case study deals with number cognition; here again it seems that humans display distinctly more advanced cognitive behaviours than our closest non-human relatives, despite the fact that on a non-linguistic level many of our faculties responsible for numerical processing are found in other species. This case study allows us to explore the effects language can have on the development of the conceptual repertoire and see how it might play a key role in our overcoming the limits of our pre-linguistic representational capacities.

The choice of case studies is in part guided by the work of Peter Carruthers' *The cognitive functions of language* (Carruthers, 2002) – which in turn is based on existing psychological research on the impacts of language on cognition and the cognitive domains in which these effects have been studied (Carruthers pays particular attention to work done by Elizabeth Spelke and her colleagues (including (R. F. Wang & Spelke, 2002), (Hermer & Spelke, 1996; Spelke & Tsivkin, 2001a; Xu & Spelke, 2000) . In this paper, Carruthers sets up a distinction between what he calls the communicative conception of language (which he claims is the standard view held by cognitive scientists) that ascribes language a purely translational role; and the cognitive conception of language, which holds that language has an important role to play in cognition alongside its communicative roles. He uses the case studies of navigation and number cognition as examples to back up his own particular, strong account of language's role in cognition. This paper, and the account it proposes, attempt to re-establish of a role for language within modern cognitive science. By investigating Carruthers' own case studies in further depth we are able to assess Carruthers' overall claims about language cognition. In this fashion, his work can be seen as a foil throughout this thesis, it provides both the starting point for our challenge against the standard view of languages' role within cognition, and provides a full characterization of an alternative, which we will in turn challenge and asses.

The account Carruthers puts forward sees language as an important representational capacity that is not limited by the domain-specificity of other cognitive modules and thereby provides the possibility of cross-domain cognition in humans. This account is initially appealing as it answers the problem, faced by modularist accounts of the mind, of how humans built up such a flexible intelligence from a modular starting point. What is more, it does this without having to posit some novel, distinct, domain-general intelligence faculty.

However, I fear that his account ascribes to language too much computational power. This point will become clear as we work through each of the case studies Carruthers cites in support of his overall view, relying as it does on a language faculty with computational capacities we have little reason to believe it possesses.

Despite, my criticism of Carruthers particular view, I share his guiding intuition that the standard 'communicative' view of languages role in cognition belittles the actual importance of language in cognition; and so besides acting as a way of assessing Carruthers's own view, the chapters on each of the three case studies will provide novel accounts of distinct mechanisms of interaction between language and cognition.

The final chapter will then weave together all the threads of our investigation to see if there are any general conclusions to be drawn and will produce a taxonomy of all the different ways in which language comes to influence and affect thought. The final chapter will be a sketch of an overall picture of language functioning which readily accommodates both our intuitions that language has some key role to play in cognition and the raft of experimental data that shows how much of cognition is completed by universally shared modular faculties. I will show that in challenging the particular mechanisms appealed to by Carruthers in explaining language's role in cognition we do not necessarily have to give up on giving an account of language which attributes it with some computational role, beyond mere translation and communication of thought.

A note on formatting

Throughout this thesis, we will be dealing with the relationship between non-linguistic mental representations, linguistic representations in the mind (lexical items) and linguistic representations as used in, for example, oral or written communication (words and sentences). To delineate between them I will use the following formatting conventions.

Non-linguistic mental representations will be written in SMALL CAPS – the contents of these concepts may well not parse very nicely into ordinary language and so the phrases chosen to represent the conceptual representations might be a little bit clumsy at times – the difficulty of this translation is, after all, the key topic of this thesis.

Lexical items are the mental representations of words stored as part of our language faculty, their nature will be explored at length throughout the thesis but in summary they are the atomic elements of our mental language and get built up into larger mental linguistic representations. They will be denoted by a 'single quotations'.

Words, on the other hand, are the atomic elements of public language, spoken aloud or joined together to form ordinary language sentences will be in "double quotation marks".

The distinction between these different levels of representations should become clearer as we progress, and this will be made easier by having the formatting established ahead of time.

Case study 1.

Two accounts of the relationship between language and Reorientation

How much of a role does language play in everyday human cognition? This is a particularly difficult question to answer, since on the one hand we might be led by our intuition that language and thought are almost one-and-the same (after all, much of our explicit mental activity is presented to us the form of inner speech), while on the other hand it seems that new findings in psychology and cognitive science attribute more and more of our behaviour to subconscious, non-linguistic cognitive processes.

Instead of looking at the question as a whole, some progress might be made if we approach it by looking at particular types of mental activity in detail. It is experimentally much easier to isolate and study language's involvement in particular cognitive tasks than it is to experimentally probe the function of language in a wider context. And by looking, in depth, at the language faculty's involvement in one particular domain of cognition we might be able to draw conclusions about language's function in cognition more widely.

Such, focussed, experimental work has begun to be done within the field of navigation behaviour, with clear indications of the involvement of language in adult human navigation behaviour. In this chapter, I will look in-depth at two different proposals for the mechanism of interaction between the language faculty and the non-linguistic cognitive faculties associated with navigation.

All animals require some form of navigational capabilities, life depends on animals being able to find mates and food; clearly the ability to successfully navigate one's environment is essential to survival but do all animals rely on the same cognitive tools to navigate? This seems unlikely; over millennia, different species will have been faced with very different evolutionary challenges, and evolved different cognitive resources to meet them.

Part 1. Reorientation

One key form of navigational behaviour is reorientation. When an animal's other navigational capacities fail (either by natural or experimentally induced means) they become disorientated and must locate themselves within their environment before normal navigation can proceed. This capacity is known as reorientation and has been identified, in some form or other, in all species studied so far (see(Cheng & Newcombe, 2005) for an overview of research). The cognitive mechanisms employed by humans to perform this navigational feat will be the focus of this chapter – but first let us look at how other species have been shown to reorientate themselves.

In 1986 Cheng showed that rats rely entirely on the geometric qualities of an environment to reorientate themselves (Cheng, 1986), ignoring other types of pertinent information – despite other experiments illustrating that during normal navigation (i.e. when not disorientated) rats were able to utilize these kinds of information. In a clever experimental paradigm, Cheng placed rats in a rectangular room that had partially exposed food in one corner, the rats were then disorientated (by being spun around) and the food buried. Once the rats were returned to the test room they proceeded to search for the food in the corner where the food was buried and the one geometrically identical to it (e.g. short wall to the left, long wall to the right), ignoring the other corners. This finding showed that rats could form representations of the geometry of an environment and use these representations to reorientate themselves. Cheng went on to investigate whether other forms of information could be used to aid reorientation, placing various landmarks (both visual and olfactory) at the corner with the buried food. If the rats could use this landmark information alongside the geometric information we would expect them to search for the food solely at the correct corner. However even in the presence of such polarizing landmark information rats continued to search both geometrically identical corners with equal frequency. This finding shows that rats rely solely on geometry during reorientation, despite utilizing other information during other types of navigation.

These findings led Cheng to posit the existence of a geometry module in rats, a specialized mental faculty that encodes and stores geometric information about an environment. It has been argued that from an evolutionary point of view reliance solely on the geometry of an environment may have proved fit because geometrical features of a landscape (such as cliff faces) are relatively unchanging over time, whereas mechanisms that rely on visual recognition of landmarks are more likely to be disrupted by seasonal variation or weather conditions (such as trees losing their leaves) (Gallistel, 1990a). Cheng suggests that the geometry module is an inferentially isolated mental faculty, meaning that the representations it creates are not affected by information generated by other conceptual modules. From Cheng's data it is not possible to tell whether the geometry module is utilized during normal navigation or is called upon solely during reorientation.

Hermer-Vazquez & Spelke ran a slightly modified version of Cheng's classic experiment to investigate whether humans rely on a similar strategy during reorientation(Hermer & Spelke, 1994). They found that adult humans, in the absence of polarizing landmark features, behave exactly like rats – searching in the two geometrically identical corners. This finding is pretty clear evidence for the presence of the geometry module in adult humans. However, unlike rats, when completing the reorientation task in an environment containing landmark information adult humans navigated exclusively to the correct corner. This finding indicates that, during reorientation, adult human navigators' behaviour is sensitive to information from both cognitive faculties, in contrast to other animals such as rats.

How is it that representations which appears to be isolated in other animals come to be used simultaneously in solving a single cognitive problem in humans? Spelke suggests that language plays an important role in reorientation by conjoining the two sources of information into a single representation that can be used to reorientate oneself successfully(Spelke, 2003; 2011; Spelke & Tsivkin, 2001a).

Evidence for the claim that language is involved in adult reorientation comes from experimental work done by Hermer-Vazquez (Hermer & Spelke, 1994; Hermer-Vazquez, Spelke, & Katsnelson, 1999). During a series of studies investigating children's ability to combine landmark and geometric information Hermer-Vazquez noticed that they started being able to solve the reorientation problem, like an adult would, at about the age of four; around the same time that they start to spontaneously produce sentences containing the words "left" and "right". She also noticed that adult subjects often spontaneously produced sentences containing the terms "left" and "right" when asked after testing to describe how they navigated; *prima facie* evidence, at least, of a link between speech and successful reorientation.

To investigate this observation young children's performance on a number of different cognitive tests were correlated with their performance on a slightly modified reorientation room. Six-year-old subjects were tested on non-verbal intelligence, vocabulary size, working memory capacity, ability to comprehend sentences containing “left/right” vocabulary, ability to produce such sentences and ability to comprehend and produce sentences using a more general selection of spatial terminology e.g. “behind” or “above”. These tests were supposed to answer the question as to whether language, in particular, is responsible for success at reorientation tasks; or whether we should attribute it to a more general cognitive development. Hermer-Vazquez’s statistical analysis of the results showed no significant correlation between age or IQ and success; in fact, the only factor Hermer-Vazquez identified as correlating significantly with success at the navigational task was the spontaneous production of sentences containing the terms “left” and “right”.

This result indicates that knowing one’s left from one’s right is not enough to succeed at the task at hand; children must have significant enough mastery of the terms relating to the concepts to generate, unprompted, sentences that include them. This is the first clue that it is the language faculty that is essential for successful integration of different forms of information during reorientation. However, it is important to note that these findings only show a correlation between possession of a linguistic concept and success at a seemingly unrelated task; these results are not in-and-of-themselves evidence of a causal link between language and one’s ability to reorientate oneself.

In an attempt to show that the link between speech production and flexible reorientation cognition was more than mere coincidence, Hermer-Vazquez and her colleagues developed a novel experimental paradigm that hoped to probe whether or not the language faculty was being employed, explicitly, by human adults as part of reorientation cognition (Hermer-Vazquez et al., 1999). In a test environment, much like those in the previous experiment, adult human subjects were required to navigate to one of the room’s corners after disorientation whilst also engaging in a secondary task. These secondary tasks were either (i) verbal-shadowing, repeating phrases heard through a set of headphones, or (ii) rhythm-shadowing, copying a clapping a rhythm. The working assumption of these experiments was that while the verbal shadowing paradigm would occupy, and therefore effectively *knock-out* the subjects' language faculties, the rhythm shadowing would require the same level of working memory to complete but leave the language faculty free to perform its potential role in reorientation. Hermer-Vazquez' results were quite striking, with those subjects engaged in the rhythm shadowing tests behaving exactly as a normal adult human might – integrating both geometric and landscape information, and those engaged in the verbal shadowing paradigm behaving like infants or rats – relying solely on geometric information to guide reorientation.

This experimental paradigm has fallen under significant criticism and it has been suggested that Hermer-Vazquez's subjects failed to reorientate themselves effectively in the verbal-shadowing task but succeeded in the rhythm-shadowing task simply because the verbal-shadowing task is cognitively more taxing, and just requires too much working memory to complete reorientation while engaging in it. That the working memory requirements are the same is a fundamental assumption of the experimental design and so any challenge to this brings into question any positive results obtained. Furthermore, Samuels (2002b) suggests that there is good reason to believe that the verbal-shadowing task requires the involvement of certain extra-linguistic, cognitive processes, that are simply not required in rhythm-shadowing. He puts forward briefly a theory of speech production that requires a greater degree of general processing than it is presumed rhythm shadowing requires (Samuels, 2002b). Hermer-Vazquez's experimental results can, just as readily, be viewed as supporting Samuels's account of speech production as of the account favoured by Hermer-Vazquez, that language is key to adult reorientation.

Even besides these criticisms, the data from these experiments give little insight into how the causal mechanism between language and reorientation might work. This question will be addressed throughout the remainder of this chapter. I will put forward two distinct accounts of how the language faculty leads to flexible reorientation cognition. As we develop the accounts and an understanding of the differences between them it will become clear that the different sets of experimental data do not offer equal levels of support to both mechanisms. Accordingly, we shall return to the data at various points in the exegesis to see exactly which conclusions about the nature of the relationship between language and thought that each data-set warrants.

Part 2. Syntactic conjunction

The first account I want to look at comes from Peter Carruthers and is primarily expounded in his 2002 BBS target article *The cognitive functions of language.* In this paper Carruthers's primary focus is to demonstrate the plausibility of the claim that language is essential to human cognition, particularly in those types of thinking that contain elements from more than one conceptual domain.

Carruthers's account focuses on the language faculty's syntactic capacities to conjoin representations from conceptual modules and generate novel, compound representations in a linguistic format that contains information from both conceptual sources. He suggests that these representations go on to figure in further cognitive activities such as reasoning and action planning. These novel linguistic representations thereby allow us to reason about certain things in ways that we could not have done without language.

In Carruthers's view, language evolved a unique ability to access all of the conceptual modules so as to be able to communicate each of them to other members of a social group. To achieve this given the diverse outputs of these distinct mental capacities (which modularism holds each have their own representational format), the language faculty must first convert all of these distinct representations into a single, unified, homogenous format. Following Chomsky, Carruthers calls this format "logical form" (or LF). For Carruthers LF is a symbolic mental format that preserves all the syntactic qualities of words but strips them of their phonological and sensory qualities. Carruthers claims that representations in LF can be entertained subconsciously, interact with each other, and most importantly, act as an interface between the conceptual modules and the language faculty.

By transforming these distinct representations into a single format the language faculty can process representations from distinct modules together, conjoining them into one single linguistic representation. The syntactic structure of LF mirrors that of natural language sentences, such that information from the conceptual modules can slot into syntactic gaps in the LF representation, much like adjectives do in natural language sentences.

In describing how this conjunction might work Carruthers looked at the sentences subjects in Hermer-Vazquez's original reorientation study spontaneously produced when asked how they had gone about reorienting themselves. Often test subjects reported navigating to a spot because they knew the target location to be (for example) "left of the blue wall". Carruthers notes that these sentences contained, in one single representation, information from both the landmark ("the blue wall") and geometry module ("left of the …"). If such a representation could be reported when describing *post hoc* how one navigated, then such a representation could presumably also be generated during the process of navigation cognition to aid navigation, although we should not assume this representation would necessarily be consciously accessible during reorientation. To look at how these representations are first generated and then utilized we need to look briefly at the structure of the language faculty.

We can split the language faculty into three distinct functional elements: speech production, speech comprehension, and the lexicon (lexical item storage). Speech production allows us to pick out words from the lexicon and generate linguistic representations (composed of smaller atomic lexical items) that express the meaning we want to get at. Many different accounts have been proposed as to exactly how this is done and to what degree different factors affect word choice; it is not necessary, at this point, to go into this mechanism in too much detail. It is safe to presume that however it is done in the case of generating sentences containing information from one single conceptual module, it is similar to how sentences containing information from two distinct concept modules are constructed, save for the act of conjoining the two sources of information.

Speech comprehension is in some ways the mirror image of speech production: it allows us to break down communicated representations and feed them back into the conceptual modules, so that we might understand the meaning of the sentence similarly to how we would if we had experienced the reported facts ourselves. The hearing of a known word activates the associated pre-linguistic cognitive representation, and it is on this basis that we can come to understand others' spoken sentences and can come to believe things via testimony. The nature of the relationship and the mechanism of activation between linguistic representations and pre-linguistic representations will be looked at in greater depth later in the thesis.

The final functional element is quite different from the other two: the lexicon, it is where the basic atomic lexical representations of words are stored; during speech production the appropriate lexical items to express the intended meaning are picked out. The lexicon can be seen as a form of memory, as it stores the lexical items and information associated with them for retrieval at a later time. The syntactic characteristics of each lexical item are contained as part of its entry in the lexicon and these go on to guide proper sentence production alongside the information relating to their phonetic characteristics. Lexical items probably also contain at least some semantic or meaning information so as to guide sentence production (as indicated by the fact that we find sentences that contradict common sense almost as repulsive as sentences that contradict grammatical rules, and rarely generate them). Alternatively production may more simply be guided by learnt associations between lexical items without the need to store information pertaining to meaning as part of the lexical item. Exactly what amount of conceptual information is stored with each word is not straightforward and will also be returned to at length in second half of this chapter.

With this cursory understanding of both the pre-linguistic navigational capacities of humans and of the structure of the language faculty in place, we are in a position to look at exactly how Carruthers thinks the functioning of the language faculty comes to play a key role in the flexible navigational behaviour witnessed in humans.

Under Carruthers's account, when we are confronted with a visual array that triggers representations from two distinct conceptual modules, language gives us a means of expressing both at once - in a single representation. The syntactic process of conjunction provides ready-made slots into which representational information from the various modules can neatly fit (Carruthers, 2002, pg. 669), producing a single representation containing information from both conceptual modules. The representations this process generates are compound and can exist solely in a linguistic format. The syntactic qualities of certain lexical representations, in this case 'left of …' and 'right of …', provide the framework into which the information contained in representations from the geometry and landmark recognition modules can be added. Once these representations are generated Carruthers suggests that they are utilized in action planning – allowing us to formulate a course of action from a representation of the environment that contains information from both sources.

These novel compound representations are formed online during navigational tasks and are situation-specific. The content that makes one such representation fit for purpose during navigation is relevant and useful only in its one particular reorientation situation. These representations have little function once the process of reorientation is completed. For Carruthers, language is not responsible for creating new cognitive tools that can be used over and over again in a range of situations, but instead generates flexible and broad representations of concrete, particular situations that cannot be otherwise produced. The upshot of this mechanism is that the speech production subsystem must be active and available at all times for reorientation to make use of it.

Carruthers's account covers how these representations are formed, but he has less to say about how they get utilized in solving reorientation problems. On the one hand it seems simple: once we have a representation that contains enough information to solve the problem we fix our attention on that representation and consult it whilst reorienting, reading from it as we go. However, it is not at all clear how the interface between the language faculty and higher level of action planning is supposed to work or how these processes are supposed to utilize representations that can potentially only be entertained in a linguistic form.

To answer these general questions about the relationship between linguistic representation and the higher decision making processes, let us look again at the process occurring during navigation, in a little more detail. During initial exposure to the test environment we might say to ourselves (either out loud or internally) the goal is 'to the left of the blue wall' or some such verbal representation of the layout of the space[1]. After disorientation, when confronted by the same scene the navigators summon to their attention the representation – and use it to remind themselves where the food is. This is a familiar story, often when we need to remember something or when we are confronted with a problem we find ourselves repeating a phrase over and over in our heads - utilizing short term verbal memory loops to keep something critical in our attention. But this obviously cannot always be the case in reorientation, since we often navigate and reorientate ourselves without repeating mantras regarding the layout of the place. In this case, the LF representation containing the appropriate spatial information must therefore be entertained and utilized at a subconscious level. How do these LF representations go on to play a role in action planning without being broadcast as inner speech to be dwelt on and consulted directly?

[1] Carruthers makes it clear that this mental phonological representation (saying it to ourselves in our heads) is not strictly necessary – the representation can be generated at the level of LF, below the conscious threshold.

During normal functioning language faculty must have the ability to send at least some information back down to the conceptual modules, because without this neural back-pathway we would not be able to comprehend or utilize the information relevant to the conceptual module's cognitive domains that we receive in testimony. However this cannot be the mechanism by which novel forms of thought are generated: the conceptual modules can only utilize a strictly limited amount of information in their processing so the language faculty feeding them back representations that contain information they cannot use will have no effect. The novel information contained within the linguistic compound representation is not the kind of information that the conceptual modules deal with and so cannot lead to any form of novel cognitive behaviour. Only during processes operating on the representations from the language faculty can the two distinct forms of information be cognized simultaneously. It does not seem possible that the conjoined representations in LF go onto generate flexible human thought by feeding novel information back into the conceptual modules – these modules are by their very nature unable to operate on information outside of their strict input.

So if these new compound linguistic representations cannot be fed back into the conceptual modules to generate novel and flexible thought processes, how do they go on to be utilized in the mind in such a way as to generate the cross-domain thoughts Carruthers claims that they do? Carruthers is clear that he believes the representations go on to play a part in further inferences and provide the flexibility that we see in human cognition. For this to be so, some other reasoning faculty must take up the representations from the language faculty and be able to utilize them in further computations; Carruthers posits the existence of a general purpose abductive reasoning faculty capable of generating a hypothesis to the best explanation, processing and utilizing representations in LF format. The hypotheses generated by the abductive reasoning faculty go on to be utilized in action-planning cognition. It is through positing the existence of such a general-purpose reasoning module that Carruthers sees the language faculty's representations being involved in wide-reaching, cross-domain reasoning. Having information from the different conceptual modules as part of a single representation allows the various sources of information to be weighed against each other during action planning, something that would be impossible without language's ability to conjoin conceptual representations.

Carruthers's account relies on a very particular evolutionary history; he sees the abductive reasoning faculty evolving after, and out of the LF representational capacities of the language faculty and as "taking LF sentences as input and generating LF sentences as output"(Carruthers 2002, p.671). It seems like he is effectively claiming that the evolutionary demand for effective communication of mental representations through language arose before the need for abductive reasoning. Hence the abductive reasoning faculty utilizes the representational capacities of the language faculty and not the other way around.

This does not seem quite right – it is not so obvious that our pre-linguistic ancestors could not perform cross-domain abductive inference. In fact, the story Carruthers uses to exemplify abductive reasoning is about hunter-gatherers inferring the movements and mood of their prey from marks and tracks, which is a sort of behaviour that surely predates language. Consider how successful hunting requires the combination of information from lots of pre-existing conceptual domains. For example, judging the relative age of tracks requires information from the accumulator (the mental time keeper), while judging heading of the quarry's heading requires folk biology (which way hooves face) and an understanding of walking/running patterns of animals (potentially from a biological movement detector). It seems that the ability to integrate and utilize all of this information in our behaviour would need to be in place at a fairly early juncture for us to have survived long enough to have evolved fully fledged language.

One way of avoiding the very difficult question of which came first (abductive reasoning or language) is by suggesting that both the language faculty and abductive reasoning utilize a set of representations from a shared prior system – the system that integrates the outputs of the conceptual modules into a single unified form. Up to now we have been referring to this encoding system as a subsystem of the language faculty and the representations it generates in a format referred to as LF (in accordance with Chomsky (Chomsky, 1995)). But what reason do we have for characterizing this ability to translate all the various forms of mental representation into a single homogenous form as part of the language faculty? Is it just the enticement of the "translation" metaphor that makes us think that it must be a part of the language faculty?

We might alternatively flip Carruthers's view on its head, and suggest that the system responsible for integrating the representations of the conceptual modules into a single unified format actually evolved as part of the more general reasoning capacities of humans and that later on language capitalized on these single format representations as the evolutionary demand to communicate grew with the increase in social group size. According to this picture, language would play no role in cognition beyond merely communicating the representations generated by pre-linguistic mental faculties – which is exactly the view that Carruthers's paper sets out to challenge.

On the basis of the verbal shadowing data discussed earlier, which Carruthers sees as the primary reason to accept his account, we have no reason to believe that the LF interface between conceptual modules and high order reasoning systems is part of the language faculty *specifically*. It just does not follow from the experimental data that the ability to conjoin outputs into a single unified format is a task completed by the language faculty. Though Hermer-Vazquez's data shows that humans can in some way combine or at least utilize two distinct sources of data during reorientation, it cannot speak to the mechanism behind that capacity. Even if we accept Hermer-Vazquez's findings that occupying the speech production in general, through verbal shadowing, prevents us combining distinct conceptual representations in to a single LF representation, the experiment does not distinguish whether the LF encoding required to complete the task is performed by the language faculty *per se* or some other downstream more general cognitive faculty that is also occupied during the quite challenging verbal shadowing task.

Carruthers's stated motivation behind his *cognitive functions of language* was to begin to challenge the assumption, pervasive throughout cognitive science, that language serves a purely communicative role in the functioning of the brain, serving merely as an external vessel by which conceptual thought can be transmitted between thinkers. For Carruthers to successfully challenge this assumption we require his account to show clearly that there is good reason to believe that the language faculty in particular is playing an essential important role in the integration of representations from different cognitive domains; the weaker claim that such representations are able somehow to be integrated and can then be expressed in natural language is not enough for Carruthers's conclusion to hold. Yet we are given no reason to characterize the integration process as part of the language faculty rather than as part of some other, downstream, mental faculty.

But to be charitable, however we decide to carve up the LF translation system, speech system, and the abductive reasoning system – and whatever evolutionary story we choose to tell about them – we must still accept that at the core of Carruthers's account of how flexible cognition proceeds there must be some mechanism employing all three of these elements. We cannot see the abductive reasoning faculty as extraneous to Carruthers's account of linguistically aided navigation. Accordingly, I will proceed with the analysis of Carruthers's account as a view concerning the interaction between all three elements, and not worry too much about the question of how we should carve up the language faculty - which elements of the overall system we should characterize as part of the language faculty and which elements we should view as outside of it

The problem of explaining flexibility in modular terms

Carruthers is initially motivated to invoke language as a key element in flexible human cognition as a response to Fodor's problem. Fodor has pointed out that any system built out of an inferentially isolated modular framework has immense difficulty in accounting for the perceived levels of flexibility and creativity witnessed in everyday human cognition (Fodor, 1983; 2001). Here we characterize flexible cognition as cognition that is not bound by the modular boundaries that evolution has established. Carruthers believes that his account of linguistic conjunction of modular outputs can account for flexible human thought without having to give up on a massively modular framework (Carruthers, 2002; 2003).

It is important that any account of cognition we put forward for further investigation be realizable - to be at least *prima facie* compatible with how brains function in the real world. To this end we want the computations that power any proposed system to be tractable in a real-life timescale given the computational limitations of the human brain. Any system that proposes a non-modular system faces serious challenges on this front. A domain-general system, one that is not split up in to specialized modules but that has access to all conceptual representations seemingly must consult a vast database of propositional beliefs as part of any operation. The number of calculations involved in this type of processing becomes astronomical even with relatively few beliefs. A good example comes from belief acquisition. We might want to suggest that when a human acquires a new belief they asses (subconsciously) its consistency with their pre-existing beliefs; but an example from Cherniak shows that if this checking were to be done by a domain-general computation device the suggestion rapidly becomes ridiculous. “Consider how one might check the consistency of a set of beliefs via a truth-table. Even if each line could be checked in the time that it takes a photon of light to travel the diameter of a proton, then even after 20 billion years the truth-table for a set of just 138 beliefs (2138 lines) still wouldn’t have been completed(Cherniak, 1990). It becomes patently clear that though not a logically impossible operation this is not how the human brain deals with consistency of newly acquired beliefs.

This example highlights clearly how easily computational explosion can cripple an account of mental processes. No computation is free, even the simplest take time and computational resources. If the system is set up in such a way that even the most commonplace of operations require a great number of these computations, the system quickly becomes unviable – especially when working with the physical limitations and timeframes of the human brain. But how can a system be structured such that it avoids running into these problems?

Modular encapsulation avoids these problems by making sure each module only has a very small amount of data processing to do in completing its operations and only a small database to consult. Each module is task-specific, designed to complete a particular task and generate outputs of a single format. A system built of these small processing systems is a computationally cheap way of structuring a complex system that responds to a wide variety of stimuli and arguably provides the only chance we have of proposing a tractable mind.

The problem is that this efficiency comes at the expense of flexibility. Modular systems can only deal with the problems they have been set up (either by evolution or design) to face. If some phenomenon (or some feature of a phenomenon) in the world cannot be represented by one of the modules of a system, it cannot be represented by the system in general. This characterization does not seem to fit with our intuitions of how the human brain works - we appear to be able to think about anything. We are left with a dilemma: while a modular structure appears to be our only hope of having a computationally realizable human brain, it struggles to explain one of the key qualities of the human mind – flexibility.

Carruthers wants it both ways, a mind that is both modular and flexible, and believes that language is the key to this. He must show a way in which language overcomes modular boundaries without becoming the kind of domain-general symbol manipulator that is open to the problems of intractability. But does language really avoid the problems associated with domain-general systems? The analogies between Carruthers's account of the language faculty and the kind of domain-independent symbolic manipulator computation devices, that he wants to move away from, are apparent.

Part 3. Challenges to Carruthers's account

The processes that Carruthers calls on the language faulty to perform are notably similar to the logical operations we might expect of a hypothetical domain general symbol manipulator. Further, because of the language faculty's unique place within the wider architecture of the mind, the set of representations it draws on during routine processing is (potentially) the complete set of conceptual representations within the mind. Does this large database not open up the language faculty, as described by Carruthers, to challenges from combinatorial explosion?

Carruthers does offer an interesting response to this potential challenge by clarifying exactly which systematic processing traits do open a system up to computational explosion and shows that the language faculty does not possess these traits. Carruthers shows that combinatorial explosion does not simply arise in all systems with vast input databases but only in those cases where the computational processes of a system requires systematic access to large databases – in essence: computational explosion does not occur wherever a system can access a vast database but only where it does access a vast data base as part of its normal operating procedure (Carruthers, 2003). For example, I might have access to every book in the library but this fact does not slow me down in laying my hands on the book I desire unless I follow a systematic search pattern such as starting at the beginning of the first book in the stacks and working through them alphabetically. A system can operate effectively with a large database as long as the operations over it are effectively guided and controlled somehow. With this clarification in mind we should avoid simply equating domain-general operation with computational intractability. Avoiding combinatorial explosion does not necessarily require a small database but instead requires some form of limit on the amount of information a system routinely accesses.

In the case of conceptual modules this limit is in the form of strictly limited potential input sources, we will call this a case of input-encapsulation. Carruthers also suggests that modules can be process-encapsulated, by which he means that the processing of a module does not systematically require large database searches even if such vast swathes of information are available to the module when needs be; for example the process might have a built in targeted search algorithm that automatically blacklists certain database entries (we shall look at how semantic information might be the key to such a process of limiting access in the next section). The processes themselves form the crucial limitations on the computations the module performs, allowing us to have some degree of flexible cognition at reduced operational cost.

Though process-encapsulation offers a potential get-out, can we be confident that it is how the language faculty is structured? It is possible that the language faculty can simultaneously have access to an incredibly vast database and yet be process-encapsulated in such a way that avoids it systematically consulting vast portions of its database, and thereby avoids the dangers of combinatorial explosion: although the LF interface can access nearly every conceptual representation generated by the conceptual modules, it only ever needs to actually access those that are required for speech production at any one time. An encapsulation process whereby only those representations that are pertinent to the situation are made available to the language faculty to get translated into LF would provide the kind of security against combinatorial explosion Carruthers needs.

We might be able to get this process encapsulation by characterizing word selection during speech production as a process that is guided from the bottom up by the representations generated through perception: for example, when we see a blue wall those representations from the landmark recognition module are activated and get fed into the language faculty, whilst those less pertinent representations from, say, the folk psychology module (how does a blue wall feel, sad?), do not. Rather than seeing the process of speech production as a top-down process (where the language faculty searches through all the representations available to it when trying to construct a sentence), under the bottom up conceptualization we begin to see how the language faculty might be domain-general yet not open to the problems of combinatorial explosion. The actual workings of sentence production are still a matter of ongoing research, but given that in everyday life competent sentence production is a computationally tractable problem, we must assume that this is also true of those sentences that are generated that contain information from two or more distinct conceptual modules. Whatever computationally tractable mechanism accounts for normal speech production, Carruthers can safely claim is also at the base of his syntactic conjunction mechanism. The fact that the language faculty evolved for communication via speech production (and not for domain-general cognition) provides it with a degree of process encapsulation that would not be present in an all-purpose symbol generator.

Even if we can avoid the problem of combinatorial explosion by showing that the language faculty is suitably process-encapsulated, we might worry that Carruthers's account drifts dangerously close to the position, so beloved by the rationalists of old, that language and reasoning are one and the same. Carruthers's account of the processes of the language faculty still bears striking resemblance to a domain-general thinking device - acting like a logical inference machine operating over various symbolic representations. We might worry that Carruthers is ascribing extra-computational capacities to the language faculty that we have no reason to believe it has and that go way beyond those that could plausibly have evolved to meet the relatively simple pressure to communicate.

Carruthers responds to this challenge by saying that language does not perform all the various forms of logical inference that we would expect of a domain-general symbolic manipulator. Instead he suggests that the language faculty's logical processing is limited solely to those that are part of normal grammatical competence, such as conjunction or negation. He argues that in learning the proper syntactical operations of simple linguistic conjunctions such as 'and', we develop the ability to do syntactic conjunction over all of the LF representations generated by the language faculty. For Carruthers, the ability to conjoin linguistic outputs comes part and parcel with learning language and is not a distinct computational capacity of the language faculty. Language then does not require any further computational powers in performing the conjunction than are required during normal speech production.

However, it does not seem to me that simple grammatical conjunction is all that going on in Carruthers's mechanism. I suggest that for Carruthers to obtain the computational benefits he wants from the language faculty's involvement he must accept that something a little more inferentially significant is happening than mere syntactic conjunction.

Let us try and break down clearly exactly what is going on as we generate novel representations through the conjunction mechanism. While it is easy enough to spell out the linguistic representations equivalent to the outputs of the two pre-linguistic modules as:

(i) 'the toy is in the corner with a long wall on the left and a short wall on the right'

and

(ii) ‘the toy is by the blue wall’

It is not quite clear what the product of the conjunction mechanism should look like. Carruthers’s account relies on characterizing the final output, as something akin to

(iii) ‘the toy is in the corner by the blue wall with a long wall on the left and a short wall on the right,’

In which the two sources of information have been totally inferentially integrated, however, a conjunction in accordance with the strict grammatical conjunction rule (as appealed to in Carruthers’s *competence* defence), that uses only the information available from the conceptual representations would surely be more along the lines of:

(iv) ‘the toy is in the corner with a long wall on the left and a short wall on the right **and** the toy is by the blue wall’

I suggest that while (iii) has enough information to specify precisely which corner of the room the toy is hidden in, (iv) does not. We can therefore conclude that the process of getting from (i) and (ii) to (iii), requires some fairly clever, abstract inference beyond that inherent in simple linguistic conjunction. This is highlighted if we look at what extra information is required to use (iv) to successfully locate the toy; we can assume any extra information required for reorientation and contained in (iii) but not in (iv) must have been calculated as part of the computational process that gets from (i) and (ii) to (iii).

To navigate using (iv) requires that we first understand that the representations from the two conceptual modules share common referents – i.e. the toy, and also requires a complete representation of the space with which to check our two facts[2]. Only with reference to a complete representation of the space can we work out whether our description of the toy's location in (iv) makes sense as a definition of one single location in which we should search or if the two separate elements of the description refer to two different corners. On the other hand, the fact that there is one single corner matching that description is already apparent and assumed in (iii), which refers to a single referent (the corner by the blue wall with a long wall on the left and a short wall on the right) as the location of the toy. Working out that there is only one corner which conforms to the description of the toy's location requires a full representation of the space and to infer that the two representations have the same referent, which is exactly the kind of representation Carruthers says that only linguistic conjunction can produce.

It is clear then that extra cognitive steps are required to get from the conceptual representations of the geometry and landmark modules to a linguistic representation rich enough to be used in successful reorientation without the need to refer to any other complete spatial representation. Carruthers's account claims that all of this inferential work is done by the language faculty. However, this does not seem compatible with his assertion that the language faculty furnishes us with representations that can be used in planning reorientation behaviour purely via the process of simple linguistic

[2] We might want to suggest that we use the room itself as the model that we check of our linguistic representation against, however, if this is the case then the linguistic representation is doing nothing that couldn't be achieved more simply by checking (i) and (ii) against the room in a serial fashion. If this were how reorientation proceeds we would expect infants to succeed at the task where adults fail.

conjunction.

Carruthers's account set out to show how we manage advanced navigational feats without reference to a complete, non-linguistic representation of the navigational environment. If the conjunction mechanism does only generate representations such as (iv) that require reference to another complete representation to be usable in navigation then Carruthers account has failed. It seems then that Carruthers must accept that the language faculty cannot generate representations rich enough for successful reorientation by ordinary language conjunction alone; some other logical inference processes must be at work. Should we assume that the language faculty contains the sort of non-linguistic logical inference capacity that is required to do this? I can see no justification in attributing the language faculty with this much reasoning ability, we have no reason to believe that it is such a general-purpose reasoning device. As Robbins succinctly puts it "Language is one thing, reasoning is another"(Robbins, 2002). It seems that Carruthers account of conjunction consigns him to too strong an account of the language faculty's reasoning abilities, that we have no independent reason, evolutionary or evidential[3], to believe that it has.

Finally, Carruthers's account suffers from another problem that has to do with unsubstantiated claims. We should remember that Carruthers is not making claims purely about navigational cognition but instead claiming that the evidence that linguistic conjunction is involved in navigation behaviour provides evidence for the much more wide reaching claim that language is, in

[3] I appreciate that Carruthers's account is put forward as an attempt to explain experimental evidence, and so in some way it is supported or at least in line with this evidence; here I mean rather that there is no independent evidence that supports Carruthers's position that language demonstrates abstract reasoning capacities, beyond the aforementioned evidence showing it is involved in certain areas of cognition.

general, the source of flexible thinking in humans (Carruthers, 2002; 2003). Though the navigation data does provide some support for this overarching claim it is striking that further evidence for this claim is lacking – Carruthers only cites data from two cognitive domains: navigation and number cognition (and it is not clear how much the data from number cognition evidences Carruthers conjunction mechanism). If we are to believe that language plays a fundamental role in cognition, we would expect to see evidence of that interaction much more widely than we actually do. Flexible, cross-domain thought is rife in our daily lives, from planning what we will say to someone to get them to do what we want to do, to understanding a character's behaviour in a movie and therefore the plot; if Carruthers were correct we would expect to see much more experimental evidence of language's involvement in it.

Carruthers does suggest further research avenues and is hopeful that the verbal shadowing and other related experimental paradigms will be transferable to other cognitive domains but in fact since the piece's publication experimental data published has come to challenge Carruthers's claims directly.

One such challenge comes from Rosemary Varley's research with aphasics (Bek, Blades, Siegal, & Varley, 2010). Aphasics are people, who through brain trauma, have lost some or all of their linguistic abilities. In some ways these subjects offer the perfect experimental opportunity to probe the role of language in various areas of cognition – if participants who do not have language can perform some cognitive task to the normal standard then we must conclude that the two elements are disassociated, and that language is not involved with that particular aspect of cognition.

In this vein, Varley re-ran the dual task studies by Hermer-Vazquez testing the navigational abilities of aphasic patients and using linguistically normal participants as a control group. First, she had both sets of participants complete the simple reorientation task used in previous studies without any form of secondary task (single task condition); this task should prove simple for the non-aphasic subjects but, if Carruthers is correct that language is required for successful reorientation under such conditions, we would expect aphasic subjects to have lower success rates. In a second condition, Varley also had subjects complete the reorientation task whilst engaging in verbal shadowing tasks simultaneously (dual task condition), much like in Hermer-Vazquez's experiment, although the verbal shadowing task had to be simplified for those aphasic patients who could not repeat prose. The results show quite clearly that the aphasiac patients despite, lacking normal syntactical abilities still managed to complete both single and dual reorientation tasks in line with the performance of the control group. Interestingly, in both groups performance was only slightly diminished during the verbal shadowing paradigm, a result that stands in contrast to Hermer-Vazquez's original finding that verbal shadowing inhibits successful reorientation. This diminished performance during the dual task condition supports the critique that it was the increase in working memory load from completing verbal shadowing during reorientation that led to normal subjects' lower success rates in Hermer-Vazquez's original study – not the preoccupation of the language faculty.

Crucially for Carruthers, these results show that syntax is not actively involved during reorientation. Varley makes it clear that during initial linguistic trailing her aphasic subjects demonstrated no ability to use syntax to form ordinary linguistic conjunctions when trying to describe verbally spatial locations. Given that the aphasiac participants cannot perform linguistic conjunctions during communication, even under explicit instruction, it seems unlikely that they can utilize the skill subconsciously in the completion of reorientation tasks.

In response, Carruthers could argue that some residual linguistic ability is the source of the aphasics' success; Varley's initial linguistic trialling did reveal that all patients tested had at least some basic understanding of the meaning of key spatial linguistic terms. This suggests that if we do wish to maintain that it is the residual linguistic capacities of the aphasic patients that are responsible for their navigational capacities, the mechanism at play is likely to be one powered by the lexical representations themselves and not syntax

We should take Varley's results with a pinch of salt: As we saw earlier the language faculty is made up of many different subsystems, the interrelatedness of which is not fully understood. Each patient will have a unique profile, with different aspects of language being differently affected. This, combined with the relatively few aphasiac subjects and the intrinsic difficulty of explaining the complexities of the experimental paradigm to patients with severe language impairments, means that the implications of results from experimental work done with aphasics are not quite as stark or reliable as we might hope. Accordingly, we should be hesitant to see Varley's results as a killing blow to Carruthers's view, though evidence against it they certainly are.

Conclusion of investigation into Carruthers's account.

To conclude, I believe that Carruthers's account ascribes too much computational power to the language faculty to constitute a plausible account of how navigational behaviour proceeds. Besides this theoretical challenge, Varley's experimental results from the performance of aphasic patients threaten to undermine the original results which motivated Carruthers's view in the first place, and suggest that Carruthers's claim that syntactic operations are at the root of human reorientation behaviour in particular – and thus flexible cognition generally – is mistaken.

Part 4. A novel account

I would like now to offer an alternative account of the role language plays in navigation. As with the foregoing account from Carruthers, its aim is to explain the correlation data linking possession of lexical items to mature navigation behaviour in humans; further I hope to give an account that does not run into the theoretical problems that dog Carruthers, namely those problems that arise from ascribing too much computational power to the language faculty. The account I am going to put forward tries to firmly ground the role of the language faculty in navigation within its normal communicative functioning. Where Carruthers stresses the computational potential of grammatical syntax in solving problems that fall outside the remit of one particular cognitive module, I will stress the ways in which the linguistic items interact with each other and with our conceptual representations in explaining how we can come to thinking beyond the limits of the conceptual modules.

This account takes its inspiration from the work of Elizabeth Spelke(Spelke, 2011; Spelke & Tsivkin, 2001a), both in drawing on the data provided by her and also trying to flesh out the mechanism in a way that is sympathetic to the intuitions she puts forward in the discussion sections of the experimental work. Spelke herself never gives a holistic account of what she thinks is happening during adult navigation, but I will try and bring to the navigation debate insights from her work on number cognition (which we will also return to at length in the third case study). Spelke focuses on the idea that language is responsible for the development of the numerical concepts in humans, and that these concepts power our more advanced numerical abilities(Spelke & Tsivkin, 2001a). I want to explore a similar account of the linguistic origins of the core concepts that power our navigational abilities.

Carruthers's account stressed the computational power inherent in grammatical speech production as the key factor in explaining the more advanced cognitive abilities of human navigators. In contrast, the account I am going to put forward here sees the structure and features of items of the lexicon as key in explaining how humans can combine elements from different representational repertoires in solving problems.

Before we go into details of the account let us look again at the two distinct representational systems in the brain. The first is the rich conceptual system that we share in part with animals. This is not a single unified system of representation but a heterogeneous collection of representational systems we have been calling conceptual modules. Representations of this class include those from the geometry module, etc. and are rich analogue representations that contain non-symbolic information. Being generated by various, distinct encapsulated modules each with their own distinct representational formats.

On the other hand, we have the linguistic representational system. All of the representations of this sort are entertained by a single faculty – the language faculty – and are in a single unified format. The language faculty is unique to humans and so we must assume that only humans have the representational capacities associated with it. The language faculty's representations, in contrast with the rich analogue conceptual representations, are symbolic (or as Evans puts it: parametric)(Evans, 2015).

In the case of conceptual representations, it is clear what kind of information they contain, for example, representations from the geometry module encode information about the geometric layout of the environment and so on. But it is not quite so apparent what kinds of information lexical items encode. For a start, we might suggest that each lexical item contains syntactic information that determines its proper grammatical usage. But to what degree does a lexical item contain information relating to the meaning of the word? Does the lexical item 'wood' contain any information about the substance wood or just information about its proper grammatical usage?

A good way to investigate this question is to highlight cases where a lexical item has no conceptual representations associated with it and to see how much meaning sentences containing those lexical items appear to have. There are at least two clear types of words that have no semantic associations. First, new words: the hearer of a new word cannot have any associated conceptual representations for them, yet we are able to infer from the semantic context quite a lot of the meaning of a word and approximate a conceptual representation of it (Taylor & Zwaan, 2009). Secondly, functional words: words in any language that appear not to have any conceptual representation attached such as 'the' and 'a'. Such words do still carry with them a substantial amount of meaning information, in this case about the uniqueness of whatever was being described. Given that these smaller words seem to have semantic information I think it is safe to say that lexical items (or perhaps the lexicon in general) contain(s) at least some semantic information, though these thought experiments do not make it clear how this information is stored, we will come back to this question in the final chapter.

If we consider one of language's primary functions as effectively communicating pre-existing conceptual representations to other minds we can see that there is good reason for lexical items to contain at least a small amount of semantic information. First, the semantic information allows us, during sentence production, to generate sentences that make reasonable sense without having to activate and consult all the conceptual representations associated with each word. Also, in much the same way that the syntactic information associated with lexical items means that the sentences we produce are grammatically correct, the corresponding semantic information ensures the sentences we produce make reasonable sense. We very rarely, under normal conditions, make nonsensical but grammatical sentences. For instance, we would be unlikely to make the mistake of saying “before putting on his shoe, John put his foot in his jumper,” instead of “before putting on his shoe, John put his foot in his sock” – despite the fact that ‘jumper’ and ‘sock’ have almost identical syntactic properties. This trait is an upshot of the semantic information of a word being checked against the semantic background of a sentence before utterance (we shall return to the mechanism behind this later).

We must remember that the semantic information encoded in a lexical item is not the same as the information encoded in the associated conceptual representation. The two representations are not in same format or used in the same types of cognition, and furthermore no direct translation can occur between them. Lexical items are only used during linguistic cognition and are not used to represent facts about the world to be used in further inferences in their own right but only facilitate the communication of the conceptual representations. We can see this distance more clearly if we consider story-telling behaviour – when we hear a story for the first time, our understanding of the narrative is delivered through the words in which we hear it told, however experimental evidence shows that after a short while the original linguistic form is forgotten (Bransford & Franks, 1971) and when asked to recount the story we can only do so in our own linguistic form. Only the conceptual core remains, which itself can be expressed, linguistically, in a variety of different ways. If the semantic representational capacities of the two systems were directly corresponding we would expect that the linguistic form of the story would be remembered alongside the conceptual information.

Now that we have established the two systems of representation as distinct in nature we must look at the functional relationship between them. Following Vyvyan Evans's Lexical Concepts Cognitive Models (LCCM) theory (Evans, 2006) I believe the best way to characterize this relationship is in terms of access points between the lexical items and the conceptual representations they are associated with. So for instance the lexical item 'left' might have an access point in the geometry module to a representation of the geometric relationship of X IS LEFT OF Y. These access points facilitate activation of the appropriate representations during speech production and comprehension. When we hear a word, during speech comprehension, the semantic access point instigates the activation of the associated conceptual representation. Conversely when we are trying to put our mental representations into words the access points activate the appropriate word in the lexicon.

Different lexical items will have a differing numbers of access points, from lexical items such as 'an' or 'uhhh' that may well have none to lexical items like 'mother' or 'white' which will likely have myriad conceptual associations and therefore access points. The mapping of these access points throughout the conceptual system develops as we learn the various meanings of words. Interpersonal differences in learning then explain difference in insinuations and connotations attached to words by different people.

Lexical items can have a number of associated concepts, not all of which are appropriate for proper meaning construction at any given moment. For instance, the lexical item 'France' in some context means the nation, and in others might mean the 15 men chosen to represent the nation at rugby. Obviously for one to properly decode meaning efficiently not all these multifarious concepts should be activated on hearing a word. During a conversation about the idea of nationhood in modern Europe, I do not upon hearing the word “France” think of the rugby team – to do so would be distracting and inhibit effective communication. A system is clearly in place that limits the involvement of the conceptual representations to those pertinent to the semantic background of the utterance.

What is more, these various access points can be spread amongst different conceptual modules; clearly not all the various meanings of a word come from the same cognitive domain, for instance the lexical items ‘black’ or ‘white’ might have access points to representations from both the colour perception faculty and social in-group/out-group faculties. With this realization, it seems that words might offer some inroad into the problem of how humans engage in cross-modular thought – words can under the right circumstances lead to the activation of concepts from different modules simultaneously.

During normal speech comprehension the words heard trigger the corresponding lexical items which in turn activate the associated concepts, once these have activated we are doing something akin to experiencing the representations that we would be having had we experienced the event ourselves. We create a mental model of the situation based on the words we hear, as opposed to the things we have experienced. Obviously, the depth and richness of experience from testimony is not as great as that from first-hand experience, and there is therefore an acute phenomenological difference between testimonial and personal experiences (a good storyteller can reduce this difference significantly). These mental models then go on to feed into our action-planning cognition. Just as seeing a green man at the pelican crossing leads me to act in a certain way i.e. crossing the road, so too does hearing my friend say: “green man” if I happen to be looking the other way or distracted. The mechanism by which mental representations become action plans is far beyond the scope of this chapter and a staggeringly diverse problem; suffice to say that once the conceptual representations are activated a distinct causal chain will lead to courses of action regardless of whether they have been activated via lexical items or as a result of experience itself.

Different representations being activated leads to different plans of action and so any new unique combination of activated conceptual representations can potentially cause some novel action-planning cognition. At the heart of language's ability to facilitate novel cognitive behaviour is its ability to activate new combinations of simultaneously-activated conceptual representations that lead to novel action plans and physical behaviour.

Now to get back to the case in hand, navigation. I believe that some of the lexical items associated with navigation actually facilitate reorientation cognition by virtue of their having access points in both conceptual modules utilized in navigation. Importantly the lexical items 'left' and 'right' map onto representations of relationships encoded by both the geometry module and the landmark recognition module. When we experience a relationship of this nature, from either pre-linguistic module, we automatically prepare to encode the experience linguistically, activating the appropriate lexical item. Subsequently whenever this lexical item is activated (say 'left') the conceptual representations it has access points in are also activated, or at least those that are appropriate within the semantic context of the situation do. In practice this means that whenever the geometry module generates a representation of the relationship LEFT OF the lexical item 'left' is activated, which in turn activates loosely the equivalent representations from the object recognition module (note that during navigation situations our concepts of SOCIALISM and CAPITALISM are not activated by the firing of the lexical item 'left' as these concepts are not relevant to the situation that is being prepared for encoding into speech). Language effectively brings to bear in action planning two potentially associated conceptual representations that otherwise might not both have been activated. We know that in the absence of language something inhibits the representations from the landmark recognition module being fired or at least brought to our attention; lexical items having access points in both modules overcomes this inhibitive process and fires the landmark representation, allowing us to reorientate ourselves using both sets of representations.

Language's encoded nexus of associations between lexical items and conceptual representations allows us to attend to certain conceptual representations that might not have been activated by perceptual and other non-linguistic cues, leading to new combinations of activated conceptual representations that must be factored into action planning. In the case of the reorientation task, the representation from the normal geometry module might encourage the action plan: GO TO THE CORNER WITH THE SHORT WALL ON THE LEFT; the activation of this representation will in turn activate the lexical item 'left' by the process which primes lexical items ready for communication (this process of lexical priming will be the focus of the next chapter and elaborated extensively there). The activation of the lexical item 'left' in turn activates the landmark recognition module, which we know is not normally activated during reorientation behaviour. The landmark recognition module in turn will encourage the action plan: GO TO THE CORNER OF THE BLUE WALL. In this situation only one action plan, GO THE CORNER OF THE BLUE WALL WHICH HAS THE SHORT WALL ON THE LEFT satisfies both demands simultaneously and therefore is the plan that is put into action. Only humans can navigate according to this kind of complex action plan because only through the language faculty can both sets of conceptual representations be activated and influence decision making simultaneously. Without language, animals have no capacity to stimulate the activation of semantically linked conceptual representations from the landmark recognition module during reorientation and therefore attend only to the geometric information.

For this associated firing mechanism to take place, the appropriate terminology must be in place, and the semantic information associated with each term sufficiently woven into the association nexus embodied by the lexicon. We must remember the link between the geometry module and landmark recognition module is only manifested in the semantic associations and conceptual access points encoded in the lexical items associated with navigation. Only once these words have been properly learnt and all the various access points developed, do these links become a functioning part of reorientation cognition. The semantic nexus embodied in the lexicon prescribes all the potential links between modules and determines the kinds of cross-domain thinking that can take place.

By learning a language, we learn once-and-for-all how to do the kinds of advanced cognitive behaviours we have been investigating, namely reorientation using both landmark and geometric information. This once-and-for-all developmental account of reorientation cognition fits more closely with the correlation data from Spelke & Hermer(Hermer & Spelke, 1994) than Carruthers's syntax-based account does. Spelke & Hermer's research showed that the developmental threshold that needed to be crossed before children could complete navigational tasks requiring attention to two different sets of representations was not general intelligence or vocabulary size, but specifically mastery of the terms "left" and "right" to the level where children could use them correctly in spontaneous speech. I assume that this ability to competently use a term in spontaneous speech indicates that the term in question is a relatively well-developed lexical item.

While the fact that the key factor in completing the reorientation tasks is linguistic supports the general claim that language is key to reorientation, it is not clear how much support this finding lends to Carruthers's more specific claim that it is the language faculty's syntactic abilities that provide the computational power to complete these tasks. Instead we might suspect that the syntactic ability to conjoin representation would be signalled developmentally by children's mastery of basic grammaticality or conjunction terms like "and" rather than mastery of the terms "left" and "right".

It is important to note that the mechanism described above of patterns of activation determined by access points between lexical items and conceptual representations does not rely on a few special lexical items such as 'left' or 'right', after all if this were so we might only engage in advanced navigation on those occasions where we characterized a situation exactly as 'left' and not with some other lexical description such as 'near' or 'beside'.

This is the case because as well as the access points between lexical items and conceptual representations the associated access mechanism also relies on the semantic associations between words to work. As discussed earlier, when a lexical item is activated it partially activates all the other lexical items that are semantically associated with it; this is the means of generating the semantic background which aids speech comprehension and also leads to the phenomenon of lexical priming. Moreover, in regard to our investigation into language's role in cross-domain thinking, we can see how this associated semantic firing might lead to a leaking over of activation from one domain to another. We might hear a word, which in turn activates an associated lexical item, in line with the semantic background being generated; then the conceptual representation associated with that second lexical item is activated.

So even if the first word did not have an access point to that particular conceptual representation, if its semantic association with a word that does is strong enough it might lead to activating the representation anyway. This bleeding of associated conceptual representations between lexical items means that we do not rely on a number of special lexical items to trigger cross-modular thought, as Carruthers's account suggests; but instead triggers and associations are dispersed throughout linguistic cognition. This mechanism will be addressed in detail during the next chapter.

Dealing with the challenges facing Carruthers: flexibility and computational explosion

So how does this account fare against the challenges Carruthers's account was met with? As with any domain-general thinking mechanism the dangers associated with computational explosion are always looming. Each word in the lexicon has potentially limitless access to conceptual representations, there is no systematic reason it could not have access points to a vast number of conceptual representations that must be consulted on hearing the word. If too many conceptual representations were fired we might assume that the action-planning element of the mind would have too many variables that needed consulting and would suffer computational overload.

In practice this clearly does not happen. The lexical item's semantic information allows only those access points to conceptual representations that are appropriate to the current usage of a lexical item to fire and are therefore factored in to action planning etc. Just as the syntactic information of a sentence requires agreement between all of the words in that sentence, providing a background grammatical structure, the semantic information associated with each word in a sentence generates a background of semantic information that helps us deduce what a given lexical item might mean in that context, only those access points to conceptual representations that are appropriate to this meaning context are activated during speech comprehension. The semantic information associated with lexical items functions as a limit on how many of the many potential associated representations are activated, allowing only those that are likely to be relevant to the meaning context to go on to be used in further reasoning behaviour.

There is also a second limiting factor on the number of conceptual representations that a given lexical item will fire. The mechanism depends on the nature of lexical items, in particular their semantic information and the mapping of its access points to conceptual representations. The set of access points of a given lexical item is learnt as part of the process of learning the words of a language. Learning a word then instils a culturally agreed-upon limit to the amount of semantic information associated with any given lexical item; its meaning and therefore its set of access points is delimited by the language group. Word meanings evolve in response to a need for communication, this means that they tend not to have too many access points to representations in the same cognitive domain, as this would lead to serious ambiguity in a language. This external requirement for effective communication offers another practical limit on the number of conceptual representations consulted as part of normal linguistic cognition, limiting the dangers from computational explosion.

Another significant advantage of this account over Carruthers's is that it does not credit the language faculty with any computational powers that go beyond those used in everyday communication. The operations it performs are not quasi-logical inferences and it does not ascribe language the power of generating novel forms of representation. Despite the fact that at this early stage the details of the account have yet to be spelt out we can see how we are moving towards a picture of cognition where normal language processing can lead to enhanced and adaptable cognitive behaviour. This will become a guiding principle of this thesis, that goes on to illustrate how purely communicative mechanisms of the language faculty can go on to have tangible effects on cognition downstream.

Response to Varley's data

What about the results from Varley (Bek et al., 2010), that stands in opposition to the evidence from dual task studies? I believe the current account does not stand and fall with the dual tasks studies, in fact it makes no predictions about whether verbal shadowing should prevent navigational abilities at all. The account maintains that although language is involved in facilitating cross-modular cognition, it is not in online active linguistic cognition that this cross-modular thought occurs. Hence, we do not have to be actively engaged in linguistic cognition to complete navigational tasks and therefore verbal shadowing should not hinder our ability to do so. All that is required to facilitate cross-modular thought (and thereby adult navigation) is for experiential data to activate various lexical items, potentially in preparation to express them linguistically later, and that these lexical items in turn activate the conceptual representations prescribed by the make-up of their conceptual access points and in-line with the semantic background. Note that this requires no active involvement of speech production's syntactical abilities.

Accordingly, even Varley's agrammatical subjects who have lost syntax comprehension are still complete the reorientation task. Classically aphasic patients' communications are limited to disjointed nouns or noun phrases. Though these lexical items can no longer be combined syntactically during speech production, the access points and semantic information that allows them to be used in even the most basic forms of communication of thoughts may remain intact and so the process of associated activation can still take place. Because these patients learnt these lexical associations before becoming their brain trauma, the neural pathways (the access points between lexical items and conceptual representations) required to facilitate cross-modular thought are already in place. And because the mechanism requires no online use of grammatical or linguistic skills these patients are able to behave much like patients who still have a full set of linguistic capacities.

This idea that the language faculty is constantly encoding experience in such a way as to later communicate it, facilitating cross-modular thought, will be explored in later chapters in great depth.

Conclusion

Despite positing no specialized representational machinery, I am confident that the access point account put forward here provides a feasible way of explaining the experimental observations linking language to navigation in human navigators. It shows how language can be seen as being responsible for our ability to utilize simultaneously representations from the two different pre-existing conceptual modules associated with navigation in non-human animals and human infants in reorientation.

The preceding investigation into navigation leaves open the question of whether activation of specific lexical items is required for cross-domain thought or whether some looser pattern of activation is sufficient. Hermer-Vazquez's data points to the association between possession of certain terms and success at reorientation tasks. However, I suspect that a mechanism that focuses on a few key terms to explain the myriad subtle and varied cases of cross-domain cognition will run in to difficulties. For every special term, which has the capacity to activate the necessary mental representation it seems that there is the possibility of their being another term that is semantically appropriate but does not have an essential access point that means cross-modular thought does not proceed simply for the sake of word choice. It seems intuitively unlikely that the choice of the word 'left' might allow us to solve a reorientation problem but use of the word 'beside' might lead us to fail the same problem. However, this may well be the case but the data from reorientation throws a little light on this question.

In the next chapter I will focus on how semantic background is built up via activation between associated lexical items and how this might alleviate the problems associated with endowing a few lexical items, such as 'left' and 'right' with special importance in certain cognitive behaviours.

Case study 2.

"Don't do that, it's f**king gross": An investigation into the roots and transmission of moral disgust and its relationship to obscene language

Caveat – this chapter contains swear words, quite a lot of them. As will be discussed later, swear words have an immitigable negative psychological impact on the reader or hearer, even when used in the anodyne setting of academic writing, leaving them repelled or revolted. Please try not to let the repeated usage of swear words throughout this piece impact negatively on your appraisal of the work contained.

Introduction

This second case study is quite distinct from the last, and it is the only case study we look at that is not investigated by Carruthers or others who work on the effects of language on cognition. Accordingly, it takes quite a different turn from the chapters on navigation and number, which follow the pattern of comparing attempts at explaining certain experimental results by positing differing accounts of how the language faculty in general can affect cognition.

This chapter instead proposes another potential mechanism by which language affects cognition, namely by facilitating the expansion of the remit of our pre-linguistic disgust response; but instead of describing a mechanism based in language functioning in general, it focuses on one particular linguistic behaviour, swearing, which exhibits unusual and interesting effects on cognition.

The first port of call for this investigation will be a brief look at the human disgust response, detailing its physiological characteristics and its evolutionary past. We will look at how disgust evolved to meet the challenges posed by infection and illness, and find out why we find so many potential disease vectors disgusting. However, this is only half the story, it will become clear that this disease-avoidance explanation cannot help us answer the riddle of why we also find morally outrageous behaviour disgusting.

This observation is the starting point of an investigation into the deeply entwined relationship of morality and disgust. This investigation will bring to the fore the fundamental question I want to answer in this chapter: how do normative acts come to take on moral significance and become issues of disgust?

I believe that the answer to this question comes, in part, from language, particularly obscene or taboo swear words, . We shall look at some of the unique characteristics of swear words and subsequently try to explain these within the framework of the account of cognitive linguistics put forward in the preceding chapter. I intend to show how the complex relationship between disgust and swear words is the key to answering our question. I will proceed by sketching out a mechanism for how our reflexive swearing at times of outrage comes to tarnish certain behaviour with disgust-triggering offensiveness.

Before we begin to look at the relationship between the two elements of the proposal we should look at the two distinct elements, the disgust response and swear words, individually.

Part 1. The disgust response and mores

The briefest investigation into the emotion of disgust is enough to highlight its slightly paradoxical nature. On the one hand it seems primitive, basic and uncontrollable - ultimately animal. No amount of the higher rationality that humans are so proud of can suppress or prevent a disgust response; yet it turns out that humans are actually the only animals that display the behaviour in its full sense (Rozin, Haidt, & McCauley, 2008). And it is clear with only the most cursory glance at social history that what is considered disgusting varies significantly between populations and individuals.

Given the heterogeneous set of things that trigger the disgust response - disgust elicitors - why do we continue to refer to it as a single, unified psychological phenomenon? In short: because, despite the variety of disgust elicitors, the response itself is remarkably stable and homogenous across populations and individuals.

The disgust response is characterized in terms of revulsion and avoidance. The clearest physiological elements of the disgust response are oral: a distinctive facial expression in which the nose becomes wrinkled, closing the nasal passage stopping further inhalation of bad odours, and mouth gapping to encourage discharge of offending material from the mouth. This can be followed by the gag response in an attempt to expel offending articles of food from the digestive system.

This facial expression has the ability to trigger further disgust reactions in those witnessing it. This ability to directly induce the disgust response in others through an involuntary facial expression has been referred to by Kelly as *semantic signalling* (Kelly, 2011) and has important ramifications for the social role of disgust.

Other physiological elements of the disgust response include nausea and a lowered heart rate (this is in contrast to fear and outrage which increase heart rate). In very extreme cases nausea leads to vomiting, which might be considered as an attempt to undo mistakes and reject offensive objects that may have already been ingested.

These physiological responses are accompanied by a very strong psychological response in which the disgusted party tries to remove themselves from the offending object and rejects the disgust elicitor. When we are disgusted by something we cannot help but try to move ourselves away from it and remove any part of our body from contact with it. Anything associated with the object, or that has touched the object, also becomes repulsive.

The degree to which we are disgusted varies with the nature of the experience, meaning that perhaps not all these effects are triggered. We are able to have mild disgust reactions, where a mere hint of the gape face in the form of lip twisting up, might just flicker across our face, to full-blown repulsion responses. Though the scale of the reaction might change, we never exhibit other responses alongside the disgust reaction that contradict it. For example: our disgust face doesn't occur alongside a desire to touch or get closer to the disgust elicitor.

Overall the disgust response is very stable, that is to say that different cultures do not exhibit disgust in idiosyncratic, culturally-defined ways. We can see this clearly in Ekman's facial recognition studies that show that disgust is recognisable in others by people across massive cultural divides. Yet on the other hand the stimuli that can trigger a disgust response in any given individual vary massively both intra- and inter-culturally (Ekman & Friesen, 1971; 1986). At this juncture let us run through and attempt to categorise the various stimuli that might be considered offensive and disgusting.

Disgust elicitors

The most basic, and (potentially) universal, disgust elicitors are bad-tasting food stuffs; in fact, the word "disgust", etymologically speaking, means "bad taste". Any food stuff that is too bitter or sour can set off a disgust response; these foul foodstuffs are the most universal of disgust elicitors, occurring in all populations, though, as we shall see shortly, individual food stuffs can come to be culturally accepted despite contradicting the general rules of distaste. This response likely evolved to meet the dangers associated with humans' evolutionary niche as omnivorous scavengers. Haidt *et al.* point out that while being an omnivore opens up to humans vast amounts of potential food stuffs and alleviates dependence on one single food source, it also puts us at risk of falling ill if we chose to eat something that had gone bad or is simply indigestible (Haidt, Rozin, Mccauley, & Imada, 1997). While some animals are genetically pre-disposed to recognise certain things as foodstuffs, humans, and other omnivores, must learn what can, and what cannot, be eaten. The disgust response helps us to avoid consumption of things that are likely to cause us illness or discomfort such as rancid meat and bitter, unripe fruit. Once we have eaten something disgustingly bitter or rancid the disgust response acts to promptly expel it from our mouth and prevents us smelling it by blocking the nostrils with an upturned lip. After this initial oral response, we might also try to remove the offending stuff from us, throwing it aside or walking away. Subsequently we then tend to avoid contact with the offending foodstuff and seemingly similar foodstuffs in the future. This learnt avoidance depends on a strong associative process of one-shot learning(Garcia, Hankins, & Rusiniak, 1974), that is to say, we are apt to find a potential foodstuff disgusting even after a single distaste-experience. This makes evolutionary good sense; when it comes to survival it is better to be safe than sorry, and it is not surprising that such a trait might have been selected for.

But personal experience is not the only way we come to find things disgusting. Witnessing a disgust response in someone else often sets off a disgust response in ourselves, we exhibit a mild disgust response in response to witnessing the disgust response in others yet we also seem to know that the thing that set it off in them is disgusting(Goldman & Sripada, 2005; Kelly, 2011). This sharing of disgust elicitors through semantic signalling helps us learn what is, and is not, to be eaten without our having to eat potentially toxic things. It means that, in short, if we witness someone being disgusted at a food stuff, we know not to eat it; without having to go through the experience ourselves – which might ultimately prove dangerous.

In this way bad-taste disgust elicitors can be spread throughout a culture, without individual members all having to make the same mistakes. The process guides and shapes societies' particular elaborate food cultures. The rules governing these cultures do not necessarily follow the simple distaste reaction in finding only things that are especially bitter or rancid unacceptable foodstuffs. Nonetheless the sharing of the food rules utilises the same mechanism as witnessed in distaste. For example, the taste of cat meat is no more likely to set off a distaste reaction than the taste of beef but in many cultures eating it would be seen as disgusting, and cat meat is treated as if it was truly distasteful on a purely gustatory level. It is indicative of how strong these food conventions are that many cultures have food stuffs as part of their normal food culture, that to outsiders might seem disgusting and contradict distaste rules, such as (rotten) fish sauce in Chinese cooking, blue cheese (rancid) in French culture or American's drinking whisky sours (sour).

Disgust therefore cannot be considered simply as guarding us against foodstuffs that present a potential danger of illness. Otherwise eating human flesh or slugs should not be particularly disgusting as they do not pose any extra danger of immediate infection than their less disgusting counter parts beef and whelks. There must be some other element involved in making something disgusting.

It seems then that disgust must also trigger in response to something psychologically distinct from bad taste. Haidt *et al.* characterize the quality something has that makes it trigger the disgust response as *offensiveness* - it seems that offensiveness goes beyond bad taste. For instance, food that has been walked over by a cockroach is not disgusting because the taste has changed but because of an association with cockroaches which are offensive themselves.

There are other non-food disgust elicitors

The above examples indicate that foodstuffs are not the only disgust elicitors, in the above example the cockroach is perceived as disgusting and not because it is likely to taste bad. What kind of things, other than distasteful foods might elicit a disgust response? The most common way of studying disgust in a cross-cultural way is by simply asking people from different communities to list the things that they find disgusting. This self-report methodology has the advantages of being able to collect relatively large samples quickly and easily, and this way we get a good picture of the full spectrum of disgust elicitors. Besides inappropriate food stuffs, when asked about what disgusts them, subjects frequently mention: obscene sexual acts, open or infected wounds, body deformations and mutations, almost all bodily fluids and corpses – especially those visibly decaying (Valerie Curtis & Biran, 2001; Haidt, Rozin, Mccauley, & Imada, 1997). The plethora of variations on these themes given by subjects from different cultures illustrates the amount of variation between cultures in what is thought of as disgusting: different cultures find slightly different sexual acts taboo and have different ways of dealing with corpses that are considered appropriate (and therefore not disgusting).

However, what unites these various elicitors is that they can all be seen as increasing fitness by guarding against risk of infection, parasites and illness (for experimental support of this claim see (Val Curtis, Aunger, & Rabie, 2004)). The disgust response firstly acts to expel indigestible or potentially dangerous food stuffs and secondly affects our behaviour to prevent us coming into contact with potential disease vectors. We are repelled by disgusting things and attempt to distance ourselves from them – this massively lessens the likelihood of infection. If the evolutionary pressure of the threat of infection was enough to change our physiology in the form of adaptations specifically tuned to prevent infection (hydrochloric acid in the stomach, constant shedding of gut epithelium, enzymes in saliva), then it is not unreasonable to suggest that the same pressure may have altered our behavioural traits too, in this case in the form of altering our disgust response to fire in cases of potential infection, as any behavioural pattern that prevents infection was likely to be selected for (especially during pre-medicine times, when any serious illness was likely to severely inhibit chances to produce fertile offspring). All disgust elicitors that can loosely be seen as related to avoidance of disease and infection I shall call visceral disgust elicitors, as they are related to bodily health.

Further evidence for this theory of disgust as a health preservation mechanism comes from a study by Curtis and Biran (Valerie Curtis & Biran, 2001): Curtis and Biran notice that the disgust elicitors most commonly mentioned in their surveys map closely onto a list of disease vectors associated with the most dangerous infectious diseases. They point out that all bodily fluids pose a very high risk of infection of very serious diseases (chlorella from faeces, whooping cough from phlegm etc.) with the exception of tears, which are not associated with any serious infectious diseases. They note that this fact is reflected in their studies of disgust elicitors across cultures – where despite frequent mentions of all other bodily fluids from members of all sampled cultures, not a single subject listed tears as disgusting.

Contagion

One of the most important features of disgust is just how contagious the quality of offensiveness is. This is illustrated by the earlier example of a cockroach crawling over a plate of food, we can see clearly that the offensiveness of the contaminated food stuff is changed even though the plate of food has not been altered in such a way that would affect the taste, the contagion effect is not limited to events that change the physical properties of the original thing, offensiveness is an invisible property an object has and can be spread invisibly by the merest contact or even conceptual association. This fact might help explain why there is such a breadth of things that are considered disgusting: it seems almost anything has the capacity to be infected with offensiveness and so become disgusting. Through contagion, when something is associated with something disgusting it readily becomes disgusting in and of itself, even if we know that the new thing cannot make us ill or does not share other properties of the original object. Evidence for this comes from studies carried out by Nemeroff & Rozin that probed people's sensitivity to offensiveness. They noted that the reluctance of subjects to put on a jumper that had been laundered (and therefore posed no risk of infection) but previously worn by a stranger increased massively if the subjects were told that the stranger had lost a leg or had committed a murder, and increased so much so as to make the jumper totally disgusting if they were told that it had once been worn by history's worst moral monster: Adolf Hitler (Nemeroff & Rozin, 1994; 2000). This shows that something can become disgusting just by virtue of being conceptually associated with something disgusting, even if we know that it in no way poses a risk to our health. Disgust is so contagious that often even a single associating experience is enough to render something disgusting. We see this in the one-shot food learning mechanism, that means people are unlikely to want to eat again something that they previously ate prior to getting ill, even if later they find out that it was not the thing that caused the illness at all.

Moral Disgust

The above example illustrates that the explanation of disgust evolving as a way of preventing infectious disease only explains so much of the workings of the human disgust response. We have already briefly touched on two examples that do not quite fit with this explanation: firstly, that of eating cat or human meat (there is no immediate risk of disease associated with eating either of these foodstuffs) and secondly the disgustingness of a jumper purportedly worn by Adolf Hitler.

In fact when quizzed about what they found disgusting, only about 25% of participants' responses fell into the category of visceral disgust (Haidt, Rozin, Mccauley, & Imada, 1997) that are associated with risk of infectious disease (sample taken from both American and Japanese university students). The remainder of responses given described moral transgressions, which on the face of it pose no immediate risk of infection. Examples of moral disgust elicitors included: lawyers who chase ambulances, people who abandon elderly relatives, people who embezzle money from pension funds, betrayal, insulting behaviour, men who beat women, cruelty to horses (examples taken from (Haidt, Rozin, Mccauley, & Imada, 1997)and (Valerie Curtis & Biran, 2001).

It is notable that the degree to which moral disgust elicitors vary from culture to culture appears greater than the degree to which visceral disgust elicitors vary across cultures(Haidt, Rozin, Mccauley, & Imada, 1997). This is clear in Haidt's study in which, despite the fact that the percentage of responses that involved moral disgust elicitors was similar between the Japanese and the American groups, the focus of the content of the responses differed significantly. This was to such a degree that it seems unlikely that any American presented with the list of Japanese responses would even register that the list was of reported disgust elicitors. This contrasts with the visceral disgust elicitors, which seem much more homogenous across cultures, with only slight variation. Haidt's studies show that Americans' ideas of morally disgusting acts focused on senseless violence, dehumanizing acts and infringements of personal liberties, whereas Japanese responses included failing to meet expected standards, being spoken too harshly and not finding one's name on a board naming people who passed an entrance exam (public humiliation). There appears to be almost no overlap in these two samples, and for Western readers it is difficult to see how the Japanese examples can be seen as disgusting in the same way that the visceral disgust elicitors are.

One unifying thing about these moral disgust elicitors is that they can all be characterized as acts of transgression of societal norms. However, it is obvious that not all social norm breaking could appropriately be met with disgust.

Some social norms can be broken without triggering the disgust reaction in witnesses, for instance think of someone crossing the road not at a traffic light or of someone wearing socks and sandals (or any slightly eccentric dress code). These transgressions are unlikely to trigger in us revulsion or disgust; more likely they will perplex, vex or annoy us. On the other hand some societal norms seem imbued with real moral significance. Take for instance the norm in liberal Western society that we should not cause harm to other people – (under normal circumstances) any transgression of this is met with horror, dismay and disgust.

I propose a terminological distinction that will make the coming investigation easier. I will call those rules governing proper societal behaviour, the transgression of which does not warrant disgust and which are not imbued with any significant moral meaning, “norms”; and those rules which are imbued with important moral significance and the breaking of which is met with disgust “mores” (singular: “*mōs*”). To clarify this distinction, think of the difference in response we might have witnessing someone jaywalk versus seeing a mother smoking with her baby in her arms. Though the *don’t-cross-the-road-dangerously* societal code has been in place a lot longer than the *don’t-expose-children-to-cigarette-smoke* code, it does not have the same moral weight. By my terminological definitions, the first is an example of a norm and the second of a *mōs*.

This terminological clarification brings to light an important question: Why are morality and disgust so closely linked? It is clear that the idea of moral disgust elicitors do not fit with the characterization of disgust as an infection-avoidance mechanism – avoiding people who perform these morally disgusting actions is unlikely to decrease our risk of infectious disease; after all, moral corruption is not infectious in the same way that bodily disease is. It is difficult to see immediately what evolutionary fitness benefits accrue from our responding to certain moral transgressions with disgust, that could have led to the co-opting of the disgust response from the visceral to the moral realm.

In *Yuck!,* Kelly offers an account that establishes the importance of following mores in successful cooperation when living in large social groups (though he does not share this exact terminology) and suggests the evolutionary pressure to live in larger groups led to the adaptation of the pre-existing disgust response to serve social purposes(Kelly, 2011). He argues that as we lived in larger and larger groups more coordination and collaboration was necessary for survival. Wasting time and resources trying to cooperate with people that were not going to return the favour could be costly in survival terms. Therefore, he argues it became important for us to have a way to identify fruitful co-operators and thereby to avoid interaction with those people, with whom cooperation might be difficult and unfruitful, namely people from different cultures. Kelly suggests that the disgust mechanism was co-opted to fulfil these new social roles. By responding to transgressions of societal norms with repulsion and disgust we were able to ensure that we were not going to attempt to cooperate with those who did not share our social norms. Kelly argues then that we are evolutionarily biased to find people that do not share the outward signs of abiding by our shared social norms disgusting. Avoiding contact with outsiders – xenophobia – Kelly argues was essential for group survival, and we ensured this bias by co-opting the disgust system to respond not only to visceral disgust elicitors that might cause infection but also to moral transgressions.

However, xenophobia cannot directly account for why we find the act of breaking social mores disgusting; and it seems unlikely that breaking a *mōs* is disgusting because it indicates we are from a different social group. It is not clear in Kelly's account why breaking a *mōs* sets off the disgust response but breaking another, less morally significant norm does not – surely the breaking of a norm, such as a fashion code, is just as indicative of belonging to a different cultural group as breaking a moral code governing proper behaviour. In fact given that conforming to certain norms is a significant outward expression of group membership (and therefore of suitability for cooperation), fashion codes that determine our external appearance seem like the ideal norms to become imbued with special significance.

It seems much more obvious that the breaking of some moral codes is disgusting in-and-of-itself and not because doing so signifies outgroup membership, but this raises the question why are some social norms moralized and relevant to the disgust response and others not. What is it about the breaking of *mōs* that means they are disgusting and how do they get to become disgust elicitors?

Is moral disgust "disgust-*veritas*"?

An important part of this chapter will be the answering of the question: Is the use of the term "disgust" to label our response to the breaking of mores a reflection of our true physiological response to the acts? Or in other words: are we genuinely disgusted by so called moral disgust elicitors or is the use of the term "disgust" in labelling our response to them purely metaphorical? This question is important because if we cannot establish that moral disgust is disgust-*veritas* then very simply the answer to the question we set out to answer – "how do social norms becomes the kind of things that can set of a disgust reaction?" – is simple: they don't.

If use of the term “disgust” to label our response to moral transgressions is metaphorical then we are claiming that the emotion we feel when presented with a moral disgust elicitor is physiologically distinct from the response we might feel when presented with a visceral disgust elicitor. This is slightly odd given the ease with which the two sets of elicitors are set side by side when subjects are asked what disgusts them. The two sets of things are clearly associated with the concept of disgust in the minds of the respondents. So why might we suspect that the use of the term “disgust” in the realm of morality is purely metaphorical?

Nabi argues that the kinds of things that we describe as disgusting in the moral realm (mōs transgressions) are actually more akin, in their psychological effect, to acts that cause outrage or annoyance (Nabi, 2002). Traditional psychology expects the public transgression of a societal code to be met with outrage and not disgust and she argues this is what respondents feel when they see the transgressions they later report as disgusting. To explain this discrepancy Nabi suggests that the public usage of the word “disgust” must have become divorced from the stricter, scientific term, as used traditionally by psychologists. She conducted studies probing subjects’ understanding of the meaning of the term “disgust”. She claims that her findings show that the term “disgust”, as used in common parlance, also refers to behavioural responses that the psychological community would in fact characterize as anger or outrage. In the lay sense then the term “disgust” might have taken on a wider meaning to encompass outrageous acts to emphasize just how serious the transgression is deemed. We can see why humans might want to do this, for instance describing a politician’s actions as disgusting might be a good way to rhetorically emphasise disapproval of them and to cast serious aspersions as to their character, without ever really meaning that their actions were actually physiologically disgusting.

Nabi therefore claims that we should pay heed to the fact that when subjects use the term “disgust” in a lay conversational setting (such as the settings of the questionnaires probing what they find disgusting) they are not necessarily referring to the physiological response the psychologist calls “disgust” but their answers may also be referring to emotional responses that in a strictly scientific sense might be thought of as outrage. The upshot of this for our current investigation is that we can no longer be confident that just because, when quizzed on disgust elicitors, subjects mention moral acts alongside visceral acts that these two types of disgust are in fact physiologically congruent. We then have no way of telling from their own accounts whether the subjects are using the term “disgusting” to label the physiological response of disgust or of outrage (or something different again).

However, Nabi’s studies do not illustrate conclusively that the disgust we feel at moral elicitors is not the same as the disgust we feel at visceral disgust elicitors, merely that verbal self-reporting isn’t an accurate way for us to identify assuredly disgust elicitors. For the current investigation to proceed we must find some other way of establishing the fact that moral disgust is disgust-*veritas*. For this let us look back to the disgust response itself. As discussed earlier, the set of behavioural and physiological traits associated with the disgust response are stable across the population and well documented. Chapman *et al.* (Chapman, Kim, Susskind, & Anderson, 2009) use this fact to establish whether patients witnessing moral transgressions experience disgust-*veritas* by measuring the movement of the muscles associated with the archetypal gape face. By digitally measuring facial responses in subjects to distasteful and disgusting liquids compared to controls of neutral and sweet tasting liquids Chapman *et al.* built up a detailed picture of the muscle movements associated with the true disgust responses. They then exposed the subjects to photographs containing images of morally taboo behaviours (alongside equally negative but purely sad photographs as a control) and measured facial responses again. The results found that subjects had physiological responses identical to those associated with a proper disgust response to the images of moral transgressions. This was not the case for the sad or upsetting images which were met with an entirely different physiological response. This finding indicates that disgust at moral transgressions is physiologically identical to disgust at visceral disgust elicitors and therefore that the description of moral transgressions as "disgusting" by patients is not merely metaphorical.

In a follow-up study Chapman *et al.* had subjects play a version of the Ultimatum Game, whereby subjects are given an offer of a share of a pool of money by either an experimenter or another test subject. If they accept the offer then both parties receive the money, split as per the offer made; however, if they reject the offer then neither party receives any money. It is therefore always in the subject's best, financial, interest to accept any money offered – an unjustly small share of the money is still worth more than nothing. Chapman *et al.,* following Rozin's analysis of moral disgust in Western society (Rozin, 2008), reasoned that unfairness is a key component of morally disgusting behaviour (at least for his Western test subjects) and therefore that if moral disgust is disgust-*veritas* then receiving a clearly unfair offer should be met with a disgust response. Instead of relying on measurement of facial movements, results were obtained through self-reported non-verbal accounts: after offers had been rejected or accepted subjects were asked which of a series photographs, illustrating the canonical emotion facial expressions, best matched their own emotional response. By trading on the fact that the basic emotions are universally recognisable in this way, Chapmen *et al.* avoided the challenges arising from Nabi's analysis of the term "disgust" as used in common parlance. The results show that subjects predominately select the traditional gape face (associated with disgust) as best describing their emotional response to an unfair offer. Chapman *et al*. conclude that the subjects genuinely did feel disgusted at the person presenting an unfair offer. It is interesting to note subjects showed a high tendency to reject offers they deemed as unfair, as rejection or aversion is a key element to the behavioural response we have to disgust elicitors. A genuine disgust response in subjects might explain the rejection of offers despite it being economically irrational to do so, as disgust is known to override more rational considerations (Rozin, Millman, & Nemeroff, 1986). Despite these uncertainties surrounding the relationship between disgust and outrage I conclude that there is enough evidence from Chapman *et al.*'s studies to conclude that moral disgust is disgust-*veritas*.

Chapman's results do not rule out the possibility that outrage or anger may also be associated with the normal response to transgression of social norms, just as Nabi has suggested, and the relationship between outrage and disgust is something that we shall explore later in this chapter. Given that our ordinary language term, "disgust", appears to map onto both outrage and disgust responses we might expect that the relationship between them runs deep.

From norms to mores

This conclusion leaves our original quandary intact; we are still looking for a mechanism detailing how disgust might come to be transferred from the visceral to the moral realm and how some social norms come to be transmuted into mores while others do not.

The fact that there is such variety in what counts as morally disgusting between cultures gives us some clues about the nature of the mechanism that renders certain normative transgressions disgusting to us and others not. I believe the mechanism is active on a societal and not a genetic level, in so far as we do not appear to be predisposed to find any particular behaviours disgusting and others not. The same cannot be said for the visceral disgust elicitors which appear to be much more constant across societies and are therefore more likely to be genetically determined, at least as far as distaste disgust elicitors.

Further evidence that the process of moralization operates on a societal level – and therefore that what becomes moralized is socially, rather than genetically determined – comes from Rozin's study of the cigarette smoking behaviour in the U.S.A. His research shows that even within a lifetime smoking has gone from being an act without any moral implications to a being a highly moralized issue (Rozin & Singh, 1999). Rozin's research involved probing people who grew up during a time when smoking had no moral connotations about their current responses to the morality of smoking. He shows that even people who grew up and became active in society during a time when smoking had no moral implications still conformed to a modern interpretation of smoking as a morally laden issue. The fact that the norms surrounding smoking can become moralized so fast again implies that the change is brought about by societal or cultural processes.

Rozin mentions a number of possible ways in which this process of moralization happens. These include abstract rational reflection, particularly striking personal experience and education. For instance we might become vegetarian and find the eating of meat a morally laden issue after visiting a slaughter house, reflecting on the sanctity of life or by being brought up that way by vegetarian parents. All of these mechanisms might describe how for an individual a norm might become a *mōs*.

I would like to discuss another particular mechanism that I feel is particularly important. It is, in a sense, analogous to the case of the gape face being a semantic signal that triggers the imperative and unquestionable transferral of food norms, as it is a mechanism by which norms become mores in a similarly imperative fashion, without the need for personal experience or consideration of the issue. This capacity for imperative transfer of moral norms between members of a culture leads to greater cultural homogeneity than the other mechanisms outlined by Rozin can ensure, which tend to work with varying degrees on different individuals.

Part 2: Language in general and swearing in particular

I suggest that the adaptation of the pre-existing disgust response to operate over normative behaviour developed out of disgust cognition's interaction with language. In particular, I propose that it arises from our innate tendency to swear when outraged and the interaction of this reflexive swearing mechanism with disgust's capacity to come to be associated with a wide variety of stimuli, across different modalities.

In order to elaborate this theory, a fairly thorough analysis of the phenomenon of swearing is first required, especially with regards to how swearing behaviour differs from ordinary language use. I will eventually elaborate this difference in terms of the associated access account of cognitive semantics developed in the previous chapter. Once we have an understanding of the phenomenon of swearing firmly in place we will be able to look at just how it contributes to the process of moralization of social norms.

Hearing swear words

Loosely defined, swear words (or taboo words – following Jay (Jay, 2009b), I will use the terms interchangeably) are exceptionally offensive lexical items. Swear words are unusual both in their effects on us and in the ways we wield them. We predominantly swear to achieve certain elaborate social ends, often with little recourse to the swear words' literal meanings and without intending to communicate the concepts associated with the terms. Swear words play an interesting and controversial role within society, variously being accused of being dangerous to young children, explicitly legislated against, and rarely protected under free-speech acts. Alongside these unusual social roles and quirks they have unusual cognitive qualities to match: swear words are powerfully repellent and offensive to us in a way that other words are not, and to such a degree that, much like stray animals and muddy feet, we might not allow them in the house.

Swear words have a unique way of striking us, they are hard to ignore and once heard they have a distinct psychological and emotional impact on us. Pinker illustrates just how distracting and attention grabbing they are with a foul-mouthed version of the well-known Stroop test, a test in which a set of coloured words are displayed and the subjects have to read off the colours the words are printed in, ignoring the meanings of the words themselves. This is infamously more difficult to do if the words are the names of different colours; we cannot help but read out the colour names instead of naming the colours of the printed words. Pinker's even more devilish version shows that if the words are swear words there is comparable difficulty in seeing past the words and reading off the colours of the ink they are printed in; it is clear that swear words grab our attention and distract us from the cognitive task in hand.

Pinker describes this phenomenon as follows: “Once a [swear] word is seen or heard, we are incapable of treating it as a squiggle or noise; we reflexively look it up in memory and respond to its meaning, including its connotation”. We cannot overlook it and carry on with the task in hand, its full meaning is mandatorily brought to conscious attention. This is clearly not the case with words in ordinary language, where the full conceptual meaning of a word need not be consulted for normal speech production to continue, we do not have to think about the nation of France every time the radio commentator says the name of the team during the rugby match.

Later we shall describe this immitigable response in terms of the associated access account, outlined in the previous chapter, but for now let us look at the kinds of meanings swear words have that we are forced to be aware of.

Swear words tend to refer to visceral disgust elicitors (Jay, 2009b), for instance, the words “shit” and “piss” are names of excretory products associated with disease transmission. It is not quite so immediately obvious why the word “fuck” might be considered to refer to a disgust elicitor; in fact, it might at first seem counter intuitive for humans to be slightly disgusted by sex, as surely a drive to have sex increases our gene’s chances of survival, but given the serious potential that sexual relations carry for infection (which can often lead to infertility) it is not surprising that the disgust reaction fires in response to the idea of sex, especially in the unhygienic, animal fashion that the word “fuck” brings to mind. Further, Rozin has argued that many of the things that we think of as disgusting remind us of our animal nature (Rozin, Haidt, & McCauley, 1999) and as the term “fuck” connotes the sheer animal act of copulation and does not call to mind the higher romantic conceptions of “making love”, for example, it seems to fit with this characterisation. Swear words are the names of disgust elicitors stripped of any euphemism, they are the words that refer to the visceral disgust elicitors directly, without recourse to any metaphorical or euphemistic conceptual stand-ins.

However, swear words are not always the words for obvious visceral disgust elicitors, there are exceptions. For instance, in the English language, the word "nigger" is often cited as the most offensive and disgusting word, and society-wide taboo still tightly controls its use. Just as other swear words such as "shit" and "fuck" are disgusting because they are associated with strong visceral disgust elicitors, I would argue that this taboo word is disgusting because of its association with a very powerful moral disgust elicitor – slavery. As we saw before, amongst Westerners, impingement on freedom and unfair treatment are significant moral disgust elicitors; it may well be that the word "nigger" is so offensive and disgusting because it is the product, and therefore is associated with, a system that, like no other, broke these moral codes.

There are exceptions to the characterisation of swear words as words that refer to disgust elicitors. Notably, French-Canadian swear words are almost exclusively to do with religious artefacts, e.g. "Tabernacle". These words are still treated as disgusting and unacceptable within most social contexts, just as with the more scatological swear words found in English. These exceptions raise the interesting question of how words get to become swear words when they are not associated with explicitly disgusting things, a question sadly we do not have space to go into here. What is important for the arguments that follow is that swear words are disgusting to us, regardless of how this comes about

As well as (mostly) referring to disgust elicitors, swear words are themselves disgust elicitors. Evidence for this claim can be seen in the way we treat them within society, as harmful and contaminating, and our physiological response of repulsion to them. When we hear them we are struck by a strong negative emotional impact(Dewaele, 2004; Jay, 2009a). This impact, I argue, is akin to the emotional impact felt when we come into contact with any other mild disgust elicitor. Our reaction to an offensive swear word shares all the characteristic traits of a mild disgust response: we are repulsed, and offended and wish to distance ourselves from anything associated with the swear word (person or referent). Further: in the studies of what kinds of things people find disgusting that we looked at earlier responses included “offensive language”, “rude words” and “swearing” (Valerie Curtis & Biran, 2001; Haidt, Rozin, Mccauley, & Imada, 1997). It seems that not only are swear words linguistic descriptions of disgust elicitors, the words themselves are disgust elicitors.

That being said, the offensiveness, and therefore the disgustingness of swear words can vary from context to context. When we are with our friends we use swear words frequently without causing the slightest discomfort in our listeners; and swear words are most offensive and therefore most disgusting when they are said loudly, aggressively and outside of a convivial, humorous context (Beers Fägersten, 2007; N. Wang, 2013). In these relaxed contexts it appears some of the disgusting potential of the swear words is muted, perhaps this is because we feel relaxed and not at risk (and therefore not wary of infection) during these safe environments. These times of comfortable swearing has many important socializing effects, including increasing group bonding and facilitating discussion of very personal issues(N. Wang, 2013); and might contribute to the sharing of socially stipulated disgust elicitors and moral or hygiene standards.

Saying swear words

However, despite the massive impact of swearing on hearers, swear words are often uttered with no intention of referencing the things they mean. In times of stress, outrage or pain other mammals whimper or howl, while humans yell, swear, cuss, or exclaim. On one level these speech acts fulfil the same communicative results as howling in non-human animals, including: raising alarm and letting nearby animals know you are in pain and need help or scaring off other animals. However, in addition to these results swearing also confers extra semantic information to those listening that is often incidental to the speaker's purpose.

When we swear in exclamation, we are not trying to express the meaning of the swear words, it is not the same as normal considered language use but an almost automatic response to outrage or danger. Jay describes these swearing acts as non-propositional (Jay & Janschewitz, 2008); van lanker 1987)[4]. Swearing at these times is an automatic vocal response, and not part of our usual communicative linguistic behaviour. Accordingly, when we swear responsively at times of high emotion, we do not utilize the same semantically-rich linguistic faculties that we do during ordinary communicative language use.

When we swear in this non-propositional way very different areas of the brain are activated than those normally associated with speech production. In particular, non-propositional swearing appears to be accompanied by activation of the amygdala – an area of the brain otherwise associated with emotion cognition. Further evidence for the disconnect between our swearing

[4] Interestingly we do not immediately have the negative psychological impact that normally goes along with the hearing of the words. I believe we are not disgusted by the swear words we utter when angry because when we are angry we are unable to be disgusted - anger and outrage suppress the disgust response, though this claim needs further research.

response and normal propositional language use comes from aphasic patients who often maintain the ability to swear coherently in frustration at their situation despite having lost the rest of their linguistic abilities(Van Lancker & Cummings, 1999). Similarly, the uncontrollable swearing of Tourette's syndrome patients highlights the difference between swearing and ordinary propositional speech and the fact that Tourette's patients' Coprolalia symptoms are more pronounced during times of stress (Van Lancker & Cummings, 1999) is indicative of swearing's role in response to outrage and emotional intensity.

Obviously at other times we do use swear words communicatively, with their semantic meaning intended; for instance, when we make a dirty joke that relies on specific meanings of a swear word or when we are reflecting on a swear word's etymology in an academic sense. At these times we utilize the semantic meanings associated with the term just as we would with any other lexical term. Swear words live a dual life: firstly, as ordinary lexical items deployed at will for communicative purposes and secondly as exclamations of pain or outrage, reflex-like and without intentional semantic meaning.

But just because often swear words are used without the intention of communicating the literal meanings of the words does not mean that they aren't understood by hearers in these terms. A heard swear word still has the same negative psychological effects that we described earlier on the hearer, regardless of the reasons and semantic intentions behind its utterance. The negative impact of swear words is in fact at its highest when they are said explosively, viciously and in outrage (Beers Fägersten, 2007), exactly like they are in the non-propositional swearing behaviours we have just outlined. It seems then these acts of swearing in outrage or pain are the ones most likely to trigger disgust reactions in hearers.

There appears then to be a unique and interesting discrepancy with swear words: Though they are easy to say, or rather hard not to say, under certain circumstances; they are hard and unpleasant to hear. The ease with which we say them is not well matched to the impact they have on the hearer.

Swearing in terms of lexical access points

With this understanding of the relationship between swear words and disgust elicitors in place I would like to look at the role swearing has in the turning of social norms into social mores. In short I suggest that it is the discrepancy between the ease with which we swear at times of norm transgressions and the strong negative psychological effects hearing swear words have that provides the crack through which disgust gets into the normative world.

To see how this mechanism might function I would first like to look at the phenomenon of swearing in terms of associated access points outlined in the last chapter. Under this account, we see the mind as having two distinct levels of representational faculty: firstly, the heterogeneous representations from the various conceptual modules in the mind and secondly, the homogenous unified set of linguistic representations of the lexicon.

The conceptual representations that are explicitly important in this scenario are those that are generated by all the various mental faculties that come to trigger the disgust response, for instance our conceptual representation of faeces, deformity or putridity. It is not necessary at this juncture to assess exactly the form of the representations the disgust response works with or its functioning in more detail, we just need to know that the disgust response fires in response to certain conceptual representations activated in turn by perceptual information.

And on the linguistic side of the coin: I suggest that the linguistic representations of swear words are of the same form and structure as any other lexical item stored in the lexicon. They are connected with other, semantically associated, lexical items via a set of lexical access points, and to conceptual representations via a set of conceptual access points, just as other lexical items are. Given this general similarity to the other items in the lexicon, how do we account for the unique characteristics of swearing that we looked at in the previous section, namely the immitigable nature of their negative effects on hearers?

Normally words only activate the conceptual representations associated with them that are relevant to the speech, as determined by the semantic background generated by the speech, and only if the activation of the lexical item is strong enough i.e. it reaches a certain activation threshold. The lexical items are connected in such a way as to allow speech comprehension to proceed without the conceptual representations associated with the terms being activated in order for speech to be comprehended. An example: my conceptual representation NATION OF FRANCE will not fire if either the word "France" is only mentioned in passing during speech or if the conversation is actually about rugby and the conceptual representation that is more appropriate to proper speech comprehension is FRENCH NATIONAL RUGBY TEAM.

I suggest that in the case of swearing, swear words function like ordinary lexical items – building up the semantic background by priming associated lexical items and then only firing the conceptual representations appropriate to the context as determined by the pattern of lexical items that are activated. The difference in the case of swearing is that the firing of the conceptual representations associated with the swear words (normally a disgust elicitor) is almost assured by hearing the swear words. This is because each associated access point has a different threshold of activation that has to be met before the conceptual representation is fired, and in the case of swear words this threshold is exceptionally low, and so fires almost every time the word is heard.

This suggestion can explain why swear words leap out of a page at us, why they stand out so boldly when dropped into normal speech and why subtle variations on them make such effective branding campaigns (think: FCUK). The question we are left with is: What makes the threshold so low? Briefly, I suspect that it is a mixture of social cues that these are special terms, conditioning during childhood and memories of punishment associated with saying them during childhood (Jay *et al*., 2006). The way we bring our children up with swear words and the efforts we make as a society to protect vulnerable people from their effects may account for why we maintain such sensitivity to them even into adulthood and after much exposure.

Swear words as disgust elicitors

When we hear a swear word we are initially disgusted because hearing it automatically triggers the representations associated with the swear words which, as discussed earlier, are, mostly, representations of disgust elicitors. So, hearing a swear word activates a disgust elicitor representation which in turn triggers the disgust reaction. This mechanism works because the disgust reaction triggers in response to the activation of a representation of a disgust elicitor, regardless of how that representation came to be activated. This is the unique power of language: it can activate, through testimony, representations of non-experienced objects or events. Language triggers the disgust response to fire in response to a conceptual representation of something offensive by activating that representation.

However, I believe that the offensiveness of swear words goes beyond the mandatory firing of conceptual representations of other disgust elicitors. I suggest that with time the lexical items of the swear words are themselves the representations that trigger the disgust response directly without having to activate the conceptual representations associated with the lexical items.

If each time we hear a swear word uttered, we automatically activate the disgust-eliciting representation associated with it, the swear word (lexical item) will come to become associated with the disgust response via traditional conditioning. With exposure, I suggest that the lexical item of the swear word becomes so associated with the conceptual representation that it comes to be a disgust elicitor as well. Remember disgust is very contagious, and something can readily become disgusting simply by being associated frequently with something that is already disgusting.

The disgust response mechanism clearly has the potential to fire in response to a large variety of stimuli, and there is no reason to believe that it would not respond to lexical representations as well as the more traditional conceptual representations associated with disease vectors. As an established example of the breadth of the form of potential elicitors, remember the way the disgust response fires in response to seeing the gape face in others: in this example representations from the facial recognition module have become offensive, despite this having no direct potential to transmit disease. I do not think it is contentious to suggest that linguistic representations of disgust elicitors in the form of swear words might also become disgust elicitors despite no direct relationship to disease risks.

This claim is backed up by the self-reporting studies we looked at earlier that detailed what people found disgusting. Subjects frequently cited obscene language alongside, and separately, to the disgust elicitors those rude words and obscene language refer to. However, as noted with the moral disgust elicitors it is not clear whether these self-reporting studies are an accurate portrayal of the set of disgust elicitors[5].

Part 3: Tying the leads together – the role of swearing in moralization of norms

I said earlier that I believed language has a large role to play in answering the question of how disgust became transferred from the visceral to the moral. This question mirrors the more focussed question: how do social norms become mores? I will here begin to sketch the mechanism by which this comes about, first in general terms, then later in the explicit terms of the associated access account of cognitive semantics.

This story starts with an emotion other than disgust: outrage. Our usual reaction to witnessing the breaking of societal norms is not disgust (this only happens in already moralized cases) but outrage. Think about a

[5] It would be fantastic if some empirical studies were done that looked into the offensiveness of swear words by measuring the physiological traits of the disgust response in patients. Until this is done I will continue to proceed under the assumption that after a certain amount of exposure and associative formations the lexical items of swear words are disgust elicitors in and of themselves, i.e. they do more than mandatorily activate their associated, disgust eliciting ,conceptual representations as in this case it is still the conceptual representations that cause the disgust response to fire rather than the swear words themselves.

A British person watching someone push in a long queue ahead of them, it is unlikely that they feel disgusted by this behaviour, but more likely they would feel cross or outraged. If the breaking of the social norm is extreme enough, their anger might even cause them to swear, it has been suggested that such acts of swearing are a means of venting rage and avoiding physical conflict (Jay, 2009b; Jay, King, & Duncan, 2006; N. Wang, 2013). Swearing in this sort of context is reflexive, we often do not think about what we are saying, and it has reportedly a cathartic quality for the swearer, reducing anger.

However, for anyone hearing the outburst, including the swearer themselves, the effect is quite different. By swearing about social acts we begin to tarnish such acts as disgusting in the eyes (or rather ears) of any witnesses. The act becomes associated with the swear word and so begins to become disgusting too. This is, in essence, the core of the mechanism I am suggesting, that the association of swear words and outrageous acts can come to render those kinds of acts as disgusting to anyone witnessing the outraged swearing outburst. Two further qualities of the contagiousness of disgust lead me to believe that the scenario sketched above is feasible.

Firstly, the fact that such little exposure is needed to render something disgusting: for example food walked over quickly by a cockroach becomes disgusting even though exposure was passing. Contagion is so strong in humans because the disgust system is set up to create new disgust elicitors after even a single experience (one-shot learning) to ensure that we do not eat food that has made us sick previously. With this in mind, we can see how the temporary association between the swear word and the normative transgression, established during the transitory speech act of outraged swearing could be enough to render the transgression disgusting. After all, swear words are most disgusting in exactly the types of context this scenario is embedded in, when they are used forcefully and angrily (Beers Fägersten, 2007). Accordingly the disgust response is liable to be relatively strong in these scenarios, and therefore we are more likely to be susceptible to contagious associations.

The second quality of disgust that supports my theory is that the rendering of some new thing as a disgust elicitor through contagious association with an existing disgust elicitor can happen across modalities. This is illustrated by the fact that witnessing the gape face in someone makes whatever they are disgusted at disgusting to us too. In this case disgust triggered by a representation from facial recognition faculties has caused a representation from object recognition faculties to become associated with the disgust reaction and a disgust elicitor in its own right. Disgust can be triggered by verbal testimony, visual experience or taste, and new disgust elicitors set up in this way continue to set off disgust even if they are subsequently encountered via a different modality. For someone who found hotdogs disgusting after a particularly bad case of food poisoning, the sight of hotdogs might set off the same disgust reaction as the smell of them or a hearing a story about someone consuming hotdogs. The process of new disgust elicitors being established by contagious contact with an existing disgust elicitor is clearly not limited to representations from the same representational capacity or from one single sensory modality.

Given that we know that disgust is transferred easily in a single experience and across modalities I do not believe that it is outlandish to suggest that it can be transferred from the swear words (which we have seen are certifiable disgust elicitors) to transgressions of normative acts (which we know to be the kind of things that can become disgust elicitors). These factors only indicate that such a transferral is plausible but they in no way describe how it might come about.

A more detailed account of the mechanism

I will now describe how this process might happen in the framework of the associated access account. First let us look at what must be in place for this mechanism to operate: firstly, we need the lexical items for the swear words to be in and of themselves disgust elicitors. Secondly, we need a set of conceptual representations of social norms (presumably generated by a specialized norm-regulating mechanism) that have access in points in the appropriate lexical items. This norm-regulating mechanism must also be able to trigger outrage and swearing at times of perceived, serious norm-breaking. And finally, we need a disgust mechanism that has the potential to acquire new disgust elicitors by association with old ones (via contagion).

I believe the preceding investigation has established that all these pieces of the jigsaw puzzle are present in normal humans, so let us now see how they all fit together. In the forthcoming exegesis I will draw on the example, first fleshed out by Rozin, of how smoking in social situations has become a morally-laden issue. I choose the example of smoking because, at the time of writing, the view that smoking in public is morally wrong is just on the cusp of becoming widespread, so that we both have the intuitions that it is a moral issue but can also imagine a world in which it is not a moral issue, a world that for many of us is within living memory. Hopefully, this actively changing example will grant us insight into the progression of disgust elicitors becoming shared by society.

The following passage have particularly *story-time* overtones, I have chosen to write it up this way because I feel that these vignettes are apt to stir more realistic responses when presented in the everyday language we might actually encounter them in.

Imagine a cab driver lighting a cigarette while ferrying a family with young children around. The father outraged yells “Fuck, man! What are you doing?” The father is outraged because he is witnessing what he believes is a disgraceful transgression of a social norm, that is putting his children at risk. In this scenario we can presume that the swearing was a non-propositional speech act, it was involuntary and the father had no intention of expressing to the driver the semantic information he associates with the lexical item ‘fuck’. The other passenger in the car, say the mother of the child, comprehends the speech in the usual fashion: the words heard build up a semantic background so that she can understand that the father is angry about the driver’s behaviour, and that he did not mean to express the concept of copulation by saying the word “fuck”. She understands the intended communicative purpose of the exclamation knowing full well that the father does not intend to communicate the concept of ANIMAL-LIKE COPULATION.

Nonetheless her lexical item ‘fuck’ is activated during speech comprehension and due to the strong emotional effects of swear words, she has a mild disgust reaction. So even though she does not actively think about, or fire the conceptual representation ANIMAL-LIKE COPULATION, the disgust response still fires in response to the lexical item ‘fuck’.

At the same time, her cognitive mechanism that recognizes and represents social norms (and their transgressions) also comes to fire in response to the transgression. She registers that the outburst of rage from her partner was in response to this transgression, the disgust reaction she felt (from hearing the swear word) was caused then (indirectly) by the act. The transgression of the social norm will become associated with the disgust response from that point forward. In this case, the conceptual representation for the transgression DON'T SMOKE AROUND CHILDREN will become a mild disgust elicitor in its own right by having been associated with a disgust reaction. I suggest that the one-shot learning mechanism, characteristic of the disgust response, allows norm transgressions to become moralized relatively quickly with very few such incidents. And once something has become associated with the disgust response it is difficult for it to become un-disgusting, things tend to become disgust elicitors for good[6]. This moral association with social norms becomes established, remembered and embellished by future exposure to them.

We should note that this mechanism does not require the conceptual representation of the transgression to develop an access point to the lexical item 'fuck' to work. All that is necessary for the mechanism is that the word "fuck" activates the disgust reaction, which is extremely sensitive to disgust contagion, even across modular boundaries.

This observation begins to answer a question left open in the previous chapter about whether simultaneous firing of two cognitive faculties, as brought about by general lexical activation can be enough to generate new cognitive behaviours. Or if in fact, relatively few lexical items have access points to more than one conceptual representational capacity and that only the activation of these special items leads to interesting, novel cognitive behaviour in humans. This later type of account is typified in Carruthers's account of navigation, which places special importance on the key lexical items 'left' and 'right' to drive the mechanism.

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[6]This might be why people tend to become more conservative as they get older, after a whole life lived vast swathes of social norms have probably been transmuted into mores and taken on serious moral connotations.

I think the case of swearing shows that activation of various cognitive faculties can be triggered by almost any words, we do not need particular terms to have direct access points in two distinct mental capacities for this to work. Though the mechanism relies on a few special terms (swear words), it is not their unique pattern of access points in many mental faculties that facilitates the novel forms of cognition we are interested in but rather their ability to generally activate a particular cognitive faculty – in this case disgust. If we look at the case in point the word "fuck" does not need to have associated access points that simultaneously activate both conceptual representations of social norm transgression and of disgust elicitors when the word is heard for the mechanism to happen. All words that have the ability to activate distinct mental capacities in whatever way have the ability to prompt original and new cognitive behaviour and new action plans.

Further, I suggest that as the actual activation patterns a sentence triggers in our conceptual faculties is dependent on the semantic context determined by the relationships between lexical items, and not just by each word individually, we should see the interesting effects of language on cognition not as dependent on a few important lexical items with dispersed conceptual access points but as a product of the complex nexus of semantic associations stored as part of the lexicon. We will return to this suggestion in further detail during the final chapter.

Even at this interim stage it seems clear that we should conclude that language's ability to trigger new cognitive behaviour is likely much richer, subtler and invariably more complex than Carruthers's more rigid account of syntactic conjunction might suggest. The kind of mechanism Carruthers cites in his navigation example can only occur in those few cases in which we have lexical items with association points in conceptual representations from two distinct, but overlapping faculties, the relatively small number of such cases (as a percentage of the overall lexicon) sets an upper limit on the potential acts of cross modular thought that we can engage in. And so, it seems unlikely that this mechanism can account for the very flexible (a cross-modular) behaviour we normally like to credit humans minds with, the mechanism I have put forward above shows that such flexible thinking, as facilitated by language, can occur without the special terms and overlapping faculty remits, that Carruthers account relies on.

Difference to ordinary language learning

It is important to notice how clearly the above mechanism differs from the way we ordinarily learn new things (in this case the moral importance of certain social norms) via language. Normally when we are presented with new information linguistically, we are at liberty to evaluate the statements and see if we agree with them before we take on them on board. We are able to judge for ourselves whether we believe them, and whether we will incorporate them into our problem solving and action planning behaviour. This is equally true of learning, via linguistic instruction, the moral codes that might come to guide our behaviour in society. Just because someone tells us, “eating vegetables is morally wrong because it removes potential food for the animals,” it does not mean that we necessarily will come to hold the same views or even agree; we are at liberty to reject this moral code and not live by it. However, if we are presented with a moral judgement through the swearing mechanism detailed above, we are not able to reflect on it in the same way; our response is determined reflexively by the swear word triggering a disgust response. Experiments have shown that no amount of rationalization can supress the disgust response: subjects still find eating a brown object that resembles faeces disgusting no matter how confident they are that it is in fact chocolate (Rozin et al., 1986). The same thing occurs on hearing a swear word uttered in response to a social transgression. We cannot help but become disgusted at hearing the swear word and therefore come to begin to find the act disgusting in itself, even if quizzed outside of the situation we might not describe the action as particularly disgusting.

Our immitigable disgust reactions mean that we cannot help but come to associate the immoral act and disgust, we cannot but accept the judgement given to us by others in society. In much the same way as semantic signalling via the gape face allows for the mandatory exchange of food preferences throughout society, swearing facilitates mandatory exchange of moral codes throughout society.

This is not to say that we necessarily come to hold any old moral codes after a single swearing experience; the mechanism can only work if we are already aware of the social norm that is being transgressed and represent its transgression conceptually alongside the other social norms in the mental faculty dedicated to representing these rules. It is this pre-existing conceptual representation that then becomes associated with the disgust response. Hence, if we do not hold the view that such-and-such a behaviour is socially unacceptable already, it cannot come to be moralized through this swearing mechanism.

Part 4: Some objections

Love and marriage, horse and carriage – outrage and disgust

Earlier we came across the objection that the use of the term “disgusting” to describe a morally taboo action was sheer metaphor, and that actually the emotional response to seeing immoral actions was more akin to outrage or anger than proper disgust. It is interesting to show that, while the experimental data shows that moral disgust is disgust *veritas*, outrage does play an important role within this proposed mechanism. The fact that both responses are part of the same overall mechanism might explain the reasons for the objection being raised in the first place. Hopefully the above mechanism shows that both outrage and disgust are genuine reactions to transgression of certain norms.

Head-banging problem

A serious worry: if swearing at times of high intensity has the ability to render the activity that accompanies the swearing disgusting why do we not find things like stubbing our toe or banging our head disgusting? Whenever we do these things we are apt to swear reflexively in response, just as we might during times of normative indignation. Surely all the necessary components are there to make the mechanism work. Disgust-eliciting swear words, acts for the words to become associated with, etc. Yet it is clearly preposterous to think that these accidental injuries might take on serious moral connotations.

One potential response to this objection is to suggest there is a limit on the kinds of things that are eligible to become disgust elicitors. In short, the disgust response system is such that representations of other types of action are not the kind of thing that the disgust system can trigger in response to. I argue that we have to have the conceptual representations of the transgressions of social norms firmly in place before they are eligible to become disgust elicitors. Representations of other kinds of behaviours, including accidents, are not represented in a conceptual form that is appropriate to become a disgust elicitor. Though there is, currently, no experimental work to support such a suggestion, it does neatly answer the head banging problem but leaves open the question: why might disgust be particular relevant to moral issues and why might the disgust response evolved such an affinity for representations of social codes? I believe we have already come across the answer to this question in Kelly's assessment of the evolutionary fitness arising from finding normative transgressions as disgusting.

Conclusion

A little word on the intended scope of this theory: I am not trying to suggest that the swearing mechanism detailed above is the only way things become disgusting, this is clearly not the case, many food stuffs become disgusting via the process of semantic signalling or even first hand experience of getting ill after eating a certain foodstuff. Further, I am also not trying to suggest that this process is the only way norms can be transmuted into mores, and therefore brought under the remit of the disgust response. Rozin highlights a number of different ways by which this process of moralization can come about including rational contemplation of an issue say after reading a book, after particularly powerful affective experiences, say visiting a slaughterhouse, or simply via instruction during childhood.

The swearing mechanism I have put forward might seem a little far-fetched but I believe that the fairly thorough investigations into disgust and swearing provide ample bedrock for the theory. That having been said, though this investigation can provide an excellent reason to believe in the mechanism put forward, it cannot hope to prove it. For that we need experimental work. In this particular area of study it seems to me that experimental work can be quite fruitful. The universal stability of the disgust reaction makes it quite easy to measure the legitimacy of any proposed disgust elicitor, this could be utilized in the first instance by checking whether swear words are genuine disgust elicitors. As this claim is a cornerstone of the overall thesis, it could well stand empirical backing.

My aim in this chapter was merely to highlight the way in which a very special type of linguistic cognition (swearing) has a role to play in cognition more widely and to try and spell this out in terms of the account of language functioning, that through various case studies, I am trying to develop in this thesis. My goal is to show that through lexical items' ability to interact with the full gamut of our conceptual representational capacities in various different and interesting ways, lexical items can come to instigate cognitive behavioural patterns that could not be achieved in the absence of the human language faculty. In this case study we have seen how language can help to co-opt and redistribute the cognitive capacities behind even our most primitive emotional responses and allow them to be utilized to meet different evolutionary demands, without the need to evolve new representational faculties.

Case study 3.
Learning to count: language and conceptual development

This final case study deals with another cognitive domain cited by Carruthers in *The cognitive functions of language,* in support of his overall account of language as a cross-modular thinking device: number cognition. However, despite Carruthers's equivocation over language's role in navigation and number cognition, we shall see that they are actually very different. By comparing the different mechanisms behind language's role in number and navigation cognition we will be able to see just how varied the effects of language on cognition are. We will see that as well as increasing our cognitive capacities and making us more flexible thinkers, language is fundamental to the development of other, non-linguistic conceptual representations, making it all the more clear that we should not see language's role in cognition as consistent or uniform across all domains.

We have a unique human capacity to represent large numbers exactly, which has made possible all sorts of uniquely human achievements from escaping the earth's gravity on board spaceships to founding economics systems that span the world. We also have a unique human ability to produce linguistic representations of almost anything. It is not clear to what degree our ability to represent numbers accurately is due to our ability to represent them linguistically.

There are a variety of types of number that we can represent: from the positive whole numbers, known as the integers, that are the numeric correlate of the sizes of sets of real objects; to the fractions that represent the relationships between the sizes of two sets; to the negative numbers which appear not to be represented in the real world at all. Though we have the capacity to produce mental representations of all these types of numbers, their gradual discovery (or invention?) took thousands of years. It seems obvious that the most primitive type of number representations are the integers (though even this assumption has been challenged by developmental psychologists (Gallistel & Gelman, 2000)) and arguably all of the other number representations we use in the more advanced mathematical processes are developed from these representations. Accordingly, this chapter will focus on our ability to come to mentally represent the full spectrum of whole numbers accurately.

From the outset, there seem to be three possible general ways to characterize language's relationship to our number representations: (i) that linguistic representations have nothing to do with our conceptual representations of number beyond allowing us to express them. (ii) that our linguistic representations of number are our accurate representations of large integers and hence are utilized during numerical cognition. Or, (iii) that our linguistic representations of number are instrumental in our developing conceptual representations of number, but are not themselves necessarily utilized during numerical cognition. In this chapter I will be looking at accounts that fall into all three categories, before finally developing an account that credits language with a key role in the development of our concepts of number by framing the mechanisms behind it in terms of the associated access account of language.

Part 1. The pre-linguistic representations of number

To claim that our linguistic representations of number simply allow us to express our distinct conceptual representations of number is to pre-suppose that our pre-linguistic capacities at representing number are able to explain all of the mathematical behaviour witnessed in humans. This hypothesis is easy to test, for if our lexical number representations – LNRs do nothing other than allow us to express the products of our numerical cognition then there should be evidence that we can do mathematical tasks without recourse to language or that non-linguistic humans perform normally on tasks probing mathematical abilities.

It seems that we require an investigation into the pre-linguistic numerical capacities of humans and what the form of the mental representations that underpin them is. One potential way of investigating what human pre-linguistic representations look like is by investigating the representational capacities of animals, as much of the cognitive machinery in human minds is inherited from and shared with other animals. This side-by-side comparison can only get us so far, as we cannot preclude the possibility that we may possess some other mental faculty, beside language, that sets our numerical skills apart from the other animals.

It is obvious that animals must be able to discriminate between quantities to survive, stealth predators must work out whether there are too many members of a prey species around to make a successful hunt impossible, and Western scrub jays have been shown to respond to variation in the perishability of cached foodstuff by returning to caches in an order that means the least food is wasted; displaying some ability to represent quantity of time (Clayton, Emery, & Dickinson, 2006). To remember and respond to quantity in the world like this, implies that these animals are capable of representing numerical value in some form or other.

The extent of this ability has been probed experimentally; in one famous experiment, by Platt and Johnson, rats are trained to press a lever, lever-A, a number of times before pressing lever-B to receive a small amount of food. If lever-A is pressed an insufficient number of times before lever-B is pressed, then the rat must endure a short time-out sequence before having to begin again. There was no reprimand or negative feedback for pressing lever-A too many times. After an initial learning period, the rats tended toward pressing the correct number of times more and more accurately. They learnt how many times lever-A needed pressing and eventually began to respond selectively to the varying number of presses specified in each trial. However, no matter how experienced the rats became their responses remained only approximately correct and always erring on the side of caution, always pressing too many times rather than too few. The rats' behaviour followed this pattern regardless of the number of presses though larger target numbers yielded larger average errors (Platt & Johnson, 1971). Many variations on the experiment provide evidence that the rats really are responding to numerosity and not some other feature. For instance, Mechner & Guevrekian set up an experiment that controlled for duration simply by varying the hunger levels of the rats working on the assumption that hungry rats will press faster (Mechner & Guevrekian, 1962). This increase in pressing rate (and therefore decrease in duration of the task) had no effect on the rats' ability to press the lever the correct number of times. Experiments have also been run that require rats to combine and enumerate stimuli of different modalities including tasks that involved enumerating sets of both noises and lights (Meck & Church, 1983) which show that the rats' responses to numerosity are not modally bound and therefore that the numeric information they represent is not tied to the nature of the experience, for instance it is not stored as a visual memory of the array, but in abstracted numerical form. Taken together these studies are clear evidence that rats are able to represent numerosity, somewhat inaccurately. These results have been replicated with myriad different animals from chimpanzees to fish (for a full description of these experiments see(Dehaene, 2011)) with quantitative rather than qualitative differences found between species; pigeons, it seems, can more accurately respond to higher numerosities than rats. The pattern of inaccuracy animals display conforms to two laws:

> The Magnitude Effect
>
> Performance for discriminating numerosities separated by an equal amount declines as the quantities increase. For instance, it is harder to tell 10 from 12 than to tell 2 from 4, even though the difference between the pairs is the same.
>
> The Distance Effect
>
> Performance for discriminating two numerosities declines as the distance between the two decreases. For instance, it is harder to tell 3 from 4 than to tell 3 from 8.
>
> (taken from Dahaene 2011, quoted in Laurence & Margolis, 2005, p.218)

To explain these results, Gallistel & Gelman posit the existence of the accumulator, a cognitive system for representing quantity and magnitude (Gallistel, 1990b; Gallistel & Gelman, 2000), found evidence for in both humans and non-human animals. The accumulator does not represent discrete representations of cardinal values but continuous representations of quantity or magnitude. It functions across modalities, and is used in keeping time and in judging quantity. Gallistel & Gelman give the analogy of the measuring cup that is gradually filled, the level of the cup is equivalent to the final representation of the quantity, representations from the accumulator can be stored and compared to allow for discrimination between quantities. The accumulator is inaccurate, its representations do not represent exact numerical values but quantities, its ability to produce precise representations declines in line with the distance and magnitude effects. Witnessed behaviour that follows these laws can be presumed to be the product of the accumulator.

The accumulator in humans

Humans clearly can represent numbers accurately; further, we have no more difficulty discerning the number 18 and 19 than 4 and 5 and so it appears that we are not bound by whatever causes the magnitude and distance effects seen in animals' ability to represent number. Could this be because our accumulator is more developed or refined than the one witnessed in animals and can generate accurate representations of the integers?

One way to check this is to look at the mathematical behaviour of infants that have yet to learn to count linguistically. We presume that before children have learnt to use the count terms they must be using whatever pre-linguistic numeric representational capacities humans are endowed with to discern different numbers. Spelke and Xu conducted experiments to investigate infants' ability to represent number by probing their ability to discriminate between sets of different sizes (Xu & Spelke, 2000). These experiments work by habituating the subjects to seeing an array of either 8 or 16 dots (the actual arrays are controlled so as discrimination cannot be done on the basis of area of the set or size of the individual objects in it). When presented with an array of novel numerosity number (i.e. showing the 8 array to infants who were habituated to seeing the 16 array and *vice versa*) the infants exhibited extended looking time behaviour indicating that they could discriminate between the two sets. The tests were repeated with arrays of closer or larger numerosities numbers leading to the discovery that the ratio infants can respond to lies between 1:2 and 2:3. Being surprised by the novel array demonstrates that infants have the ability to approximately represent numerosity, and therefore to be surprised when a different numerosity is displayed. Though this evidence shows that infants do have an accumulator module the findings show it clearly does not have the capacity to represent exact number. We cannot conclude from this however that an accumulator in adults does not produce accurate representations of number, this finding might equally be explained by the fact that the accumulator in infants has not yet reached maturity. Just because a system is innate that does not necessarily mean that we are born with it functioning fully (Samuels, 2002a); many systems that we are born with develop over time.

Perhaps over time the accumulator's representations become more refined and accurate. To test this, Whalen, Gallistel and Gelman set up an experiment that tested adult subjects' accumulator performance, in which subjects respond to a displayed numeral by tapping a lever the equivalent number of times (Whalen, Gallistel, & Gelman, 1999). This experimental paradigm inhibited adults' capacity to count out the correct number taps using our verbal linguistic capacities by having them tap at a rate that far exceeded our best estimates of the rate of sub-vocal counting. The results show that in such situations adults generate the same sort of approximate representations used by non-human animals; the inaccuracy of these representations display the same magnitude and distance effects as seen in rats.

It appears then that we do not fare any better at non-linguistically representing number than animals. It clearly cannot be the pre-linguistic representations of number from the accumulator that allow us to represent exact number and thereby perform advanced mathematical thought.

It appears that claims about number words simply mapping on to our pre-linguistic representations of number are false, as we clearly do not have accurate pre-linguistic representations of large integers.

The addition of language

Gallistel and Gelman interpret the evidence from adults as showing that the accumulator actually represents the entirety of the set of real numbers not just the integers inaccurately (Gallistel & Gelman, 2000), claiming that its representations are not discrete and inaccurate, but continuous and precise. For them the perceived inaccuracy of the system, comes from problems in recalling and utilizing the exact representations not that the representations themselves are inaccurate. Limitations on memory, or representational capacity mean that we cannot use the truly fine-grained representations of number the accumulator generates.

They suggest that the addition of language to the system overcomes these shortcomings and allows us to utilize the exact representations of the accumulator to represent the integers. If the accumulator does represent the entirety of the reals a small subset of its potential representations must be representations of the integers. The number words allow us to pick out these representations. The nature of the number words as discrete allow us to pick out the integers from the infinite number of representations of real numbers, as Gallistel and Gelman claim that they are the numbers that a discrete symbolic system, such as language, can represent. By learning to count, infants simply map the number words onto the pre-existing representations of the integers. Language, by being a discrete representational format overcomes the inherent difficulty we have in recalling exact quantities represented by the accumulator.

Laurence and Margolis (Laurence & Margolis, 2005) identify two fundamental ways to challenge Gallistel and Gelman's account of how we learn to represent large exact integers: firstly, by challenging the assumption that the accumulator does innately represent the entirety of the reals and amongst them exact integers. And secondly by challenging the assumption that language mapping onto the representations from the accumulator will assuredly pick out the integers.

Firstly, the data from animal and human behaviour provide no desiderata on why we should believe Gallistel and Gelman's account of a hyper-accurate representational system hampered by memory recall issues, over the much more simplistic account that sees the accumulator as only being able to represent approximate quantity. There is nothing in the witnessed behaviour of the rats pressing levers that demonstrates that we should attribute them with the capacity to represent the difference between 19.000005 and 19.000006, especially when the much simpler explanation that they cannot represent the difference fits the data just as well. Of course, Gallistel and Gelman are perfectly entitled to say that we simply have not developed experimental paradigms delicate enough to sense such discriminatory ability yet, but it does seem hard to envision an experiment that would make their claims about the representations of the accumulator falsifiable and so it seems that the onus of proof lies with them. All existing evidence indicates the fact that humans have only approximate pre-linguistic representations of number, not hyper-accurate ones.

Secondly, Laurence and Margolis challenge Gallistel and Gelman's assumptions about language only representing discrete number by pointing out that language is not limited to representing only discrete quantity but can in fact represent approximate quantity through linguistic quantifiers (such as “some”, “lots”, “truck-loads”, etc.) - which evidence has shown are linguistically prior to the number words(E. V. Clark & Nikitina, 2009). Language can also readily represent irrational numbers through names such as “pi” and “the square root of two”. If there is no reason to assume that language will naturally pick out the integers rather than any other numbers, then there is no reason to follow Gallistel and Gelman in thinking that the interaction between language and the accumulator will lead to the number words getting mapped directly onto the integer representations. Nothing in the accumulator indicates that the representations of integers are of special importance and require particular mapping to the LNRs. We might just as well learn that the word “one” maps onto the accumulator’s representation of 1.1, “two” to 1.2, “three” to 1.3 and so on.

In conclusion, it seems that the language faculty cannot provide a simple mapping between our pre-linguistic representations of the integers and the number words, primarily because we do not appear to have pre-linguistic representation of the integers.

For the remainder of this chapter I will be referring to the mental faculty that generates approximate representations of quantity and magnitude, above referred to as the accumulator, as the Approximate Number System (ANS) partially to distinguish it from Gallistel and Gelman’s account and also so as not to make any implicit claims about the mechanisms behind its representational capacities.

Part 2. Language and the other set of numerical representations

So perhaps the linguistic numerical representations do more than just express our pre-linguistic capacities. We might even be tempted to say that our linguistic numerical representations are our sole representations of numbers. It is hard to tease apart our representations of quantity from the lexical representations of them, the quality of numerosity in some way feels more tied to the number word or symbol we use to refer to them, than say colours do, it does not feel like we can conceptualize numbers distinct from the number words or symbols we use to represent them.

This intuition is supported by evidence from people growing up in numerate and linguistic societies but who have no access to language (from being deaf and not part of a formal signing linguistic community) that appear not to develop fully developed number representations (accurate representations of large numbers) and cannot complete exact numerical tasks despite having to deal with numerical problems on a daily basis (Spaepen, Coppola, & Spelke, 2011).

In line with these intuitions Spelke has put forward accounts of number cognition that credit language with an unrivalled place in our number cognition. She claims that representations of exact large numerosities are formulated by and can only be entertained by language(Spelke & Tsivkin, 2001a)[7], and that we have no other dedicated mental faculty that represents

[7] This view is in line with Carruthers' account of the cognitive-conception of language and is actively endorsed by him in *the cognitive functions of language* (Carruthers,2002); however, at times, Carruthers strong position on the role language in cognition lead him to make claims that go beyond those that Spelke explicitly makes, for this reason this current section will deal with Spelke's view explicitly but we should tacitly assume that the same position is held by Carruthers. In a later section we will look at the details of Carruthers synthesis of Spelke's view on number cognition into his own overall account of the cognitive conception of language.

number. She therefore seems to be claiming that the representations that we utilize when doing advanced numerical calculations or even when we consider large exact numerosities are linguistic representations and that these LNRs contain all the information necessary for a number concept. Under this type of account, the integers are only ever mentally represented in a linguistic format and cannot be cognitively entertained in another way, though she does suppose that there are mental faculties that utilize representations generated by the language faculty in their more domain-general cognitive roles.

Before we look at the mechanism behind language's representation of number or assess this account, let us look at the structure of the cognitive architecture of the brain that this accounts presupposes.

The account posits two pre-linguistic faculties that produce representations that contain some numerical information. The first is the ANS, that we looked at in the last section. Additionally, the account relies on a conceptual system that keeps track of small numbers of distinct objects. This object tracking system can keep tags on the locations of up to three or four numerically distinct objects in the visual array. Though not explicitly representing number, the ability to represent distinct objects in the visual array and to compare with sets of previous representations in the working memory does allow us to perform seemingly numerical tasks. For instance, Wynn has shown that infants of only five months display increased looking time, and by hypothesis are surprised by, the sight of two distinct objects moving behind a screen which is then lifted to reveal 3 objects. This finding she argues shows that infants represent the mathematical fact that 1+1=2 and this explains why a display of 1+1=3 is surprising to them (Wynn, 1992a).

Importantly for this account, the object tracing system generates exact and individual representations of quantifiable things that make up the set of objects; the number of these representations correlates exactly with the cardinal value of the number of things within a set. It does appear then to facilitate exact enumeration in a way that the ANS cannot. However, like the ANS the system operates within a distinct set of performance limits. Most significantly the maximum number of objects tracked has been shown to be three in infants, maturing to four in adults, and the object tracking module does not represent objects after they have been obscured from view for an extended period of time.

The object tracking system cannot really be said to be explicitly representing the quantity of a set of objects as it does not represent the number of the objects in the set but instead tracks them all as individuals, it cannot therefore, alone be the root of our more advanced enumeration skill. The representations of the object tracking system are not fully-fledged number concepts; and infants cannot use their representation of sets of two or three objects from the object tracking system in numerical tasks just as adults use their more developed number concepts of two and three. In this sense, we might describe it as proto-numerical, as it does not create representations of numerosity, but rather a set of representations of objects that can go on to be enumerated precisely and exactly.

Neither of these two pre-linguistic cognitive faculties by themselves furnishes us with large exact representations of number, which we are taking to be the hallmark of adult human numerical cognition.

Both of these systems have a long evolutionary history and are not only found in humans, but are present in our closest evolutionary ancestors; for Spelke what sets us apart from the other species with whom we share these pre-linguistic mental capacities, is the evolution of the language faculty in humans. She argues that it is the workings of the language faculty that give rise to our more advanced numerical abilities; specifically, she sees language as a domain general combinatorial system that can conjoin the representations delivered from the two pre-linguistic systems to form our proper numerical concepts.

Through this process of conjoining distinct representations, we end up with representations that overcome the limits of each pre-linguistic system, number concepts that are both exact, like the representations from the object tracking system and unbound in terms of size, like the representations from the ANS. The representations that are produced by this conjunction are linguistic in format.

The case of number is a key case study in Spelke's wider theory about language as the means of conceptual development. This theory claims that language is what makes humans such flexible thinkers, not bound by the limits set by encapsulation of the cognitive (Spelke, 2003). Language allows us to cognize together different bits of information from different mental faculties that otherwise would be informationally isolated. By conjoining these various bits of information, language allows us to represent things that we are not able to solely with the suite of cognitive capacities inherited from our pre-linguistic ancestors. Accordingly, only the language faculty has the capacity to represent the large integers accurately, and we must therefore conclude that Spelke believes that our linguistic representations of number are the number representations we use to perform numerical cognition – the LNRs are our number concepts (Spelke, 2001).

We saw another case study for this type of account in the chapter about navigation. Though there are immediate similarities I believe the form of the conjunction described in each case is subtly different, and as such I will attempt to assess Spelke's claims about the formation of linguistic number representations afresh and on its own terms and highlight where Spelke makes assumptions based on her view that the two cases exemplify twinned mechanisms.

To support his claim about the role and importance of language in number cognition Spelke cites three main sources of evidence that the language faculty is utilized during mathematical cognition; firstly evidence from Aphasics, evidence from literate people brought up in innumerate societies and finally evidence from bilinguals. Each case is important here because they allow us to investigate the disconnect between approximate mathematical abilities, and the exact mathematical abilities and in each case, probe the role of linguistic representations of number.

Evidence from aphasia

There are a number of recorded cases of aphasic patients who lost their ability to use exact numerical concepts but did not lose their ability to perform approximate numerical tasks when their language faculties were damaged. For example Dehaene and Cohen present evidence from a patient who failed to identify errors in mathematical statements that required an accurate grasp of number, such as "7+3=11", but could identify errors when the mistakes were large enough so as to only rely on approximate representations of number, such as "7+3=17" (Dehaene & Cohen, 1991). This evidence seems to show that there are two distinct systems of calculation in the normal human brain:

one linguistic and exact, and another non-linguistic and approximate. The loss of the language faculty appears to only affect the former.

If the language faculty was responsible for the formation of our exact representations of number, but once formed it played no active role in numerical cognition, then we might expect the aphasic subjects to still be able to perform exact numerical cognition so long as the damage happened after the process of forming the LNRs was completed. However, Dehaene's patient clearly has trouble with precise mathematical tasks, despite previously being capable of them and therefore at least once was in possession of fully formed LNRs.

This case, therefore, implies that language is actively involved in number cognition and that some linguistic activity is required each time we need to represent an exact numerical quantity. From the fact that the symbolic representations of number still cause the patient to bring to mind approximate numerical representations we can conclude that the lexical items for the number words themselves are not entirely damaged but that they no longer contain or access the extra information about exact quantity that the conjunction mechanism endows them with.

This strongly seems to support Spelke's claims about the ongoing involvement of language in numerical cognition, however the trouble with any data from aphasic subjects is that we cannot know for certain that whatever damage caused the loss of language abilities did not also do secondary damage to some other system that might hypothetically have been responsible for those cognitive capacities. In this case it might have been that some separate mechanism that is responsible for cognitively representing large exact numbers might have been damaged alongside the language system when the brain trauma occurred. It is impossible to rule out such a possibility without many more similar cases being studied. However, the number of aphasic patients from which to gather evidence is very small. Even more challenging to Spelke's claims are the findings from some other aphasic patients who exhibit relatively unimpaired numerical skills (Varley, Klessinger, Romanowski, & Siegal, 2005).

These counterexamples might lead us to conclude, contra our previous conjecture, that once the number concepts have been initially formed and have become items in the lexicon they can be utilized by some other general-purpose computational device that drives our numerical abilities. In this case, the role of the language faculty is to generate the number representations in the first place; but is not necessarily involved in the numerical cognition that follows. In the case of the aphasic patient who has lost the ability to construct or decipher sentences we might suggest that though they have suffered damage to the speech production and comprehension subsystems of the language faculty their lexicon has survived relatively undamaged and thus any representations in it can go on to be used in cognitive faculties downstream, just as they might in the case of non-aphasics.

However, Spelke does not clarify her position on whether the language faculty is actively involved in number cognition beyond just the initial formation of the representations; or if its role is purely developmental. Therefore, the counterexample of numerate aphasics may not necessarily be contradictory to the account. Either way the data from aphasics is so sparse and apparently contradictory that it is not on its own strong enough to convincingly support Spelke's position on language.

Evidence from literate people brought up in innumerate cultures

The Pirahã language, spoken by an isolated Amazonian tribe, lacks terms for exact numbers or quantities. The three words they do have for quantity: "hói" "hoí" and "baágiso" have each been shown to refer to a variety of overlapping numerosities (Gordon, 2004), and it has even been argued that these number-like terms do not even encode approximate numerical quantities at all but actually encode comparative quantities – such as "more" or "less" rather than "few", "some" or "many" (Frank, Everett, Fedorenko, & Gibson, 2008). Whatever the case, it is clear that this language lacks the resources to represent large-scale numbers accurately and speakers of the Pirahã language display unusual cognitive shortcomings in the cognitive representations of number. In matching tasks that require subjects to match the number of items in a set of objects with another set of objects, Pirahã speakers are able to match the set size precisely when the initial set is visible, but fail when they have to match the numerosity of a set that has been obscured from vision, this implies that they have no mental structure that can represent the numerosity once the set has been occluded that can then be used to contrast with their constructed set. It appears then that language is the cognitive tool that allows for the storing of representation of exact number (Frank et al., 2008; Spaepen et al., 2011).

It has been argued that success in the initial one-to-one matching task shows that members of the Pirahã are able to represent the exact numerosity of the set (Frank et al., 2008) even if they are unable to recall that information later. The ability to store and recall these representations is required to complete more difficult tasks where the initial set of objects are obscured before being matched but not for the direct matching trials. This explanation equates completion of the initial one-to-one matching task with representing the numerical value of a set, however it seems clear that a simple process of serially matching each item in turn would suffice to successfully complete the task without ever having to rely on mentally representing the cardinal value of the set as a whole. If this interpretation is correct then it seems that members of the Pirahã might be entirely unable to represent accurate quantities of sets even when they are presented with them. A finding that confirmed this potential would go a long way toward confirming the suspicion that numerical language is essential for accurately representing large exact number at all.

However, it is very difficult in this kind of situation to determine to what degree numerical language, or lack thereof, is responsible for any particular behavioural finding rather than a societal factor. After all, all native speakers of Pirahã come from one very homogenous social group and so it is entirely possible that, for example, the lack of mental number representations in the population is due to a shortcoming in the Pirahã education system and not necessarily due to limitations of their language – we can conceive of another tribe whose language also contains no words for exact representations of number but who, through rigorous training, teach their youngsters to represent number exactly, and so we should be hesitant about claims linking the Pirahã's lack of number words and their inability to represent exact numerosity

Bilingual training studies

The final piece of evidence in support of the account comes from Spelke and Tsivkin (Spelke & Tsivkin, 2001b; 2001a), who set up an experiment whereby Russian-English bilinguals were taught a series of different skills and then tested in those skills in both the language they were taught in, and the untaught language. The tasks probed the impact of training in a particular language in one of four sets of skills: (1) approximate number skills (approximating cube roots), (2) exact numerical skills, and finally recalling historical and geographical facts that contained both (3) numerical and (4) non-numerical information. The results of the experiments show that while there was no performance cost when performing the approximate numbers tasks in the language they were not taught in, performance on the exact numerical skills was greatly affected by performing the skill in the untaught language.

The studies also show that ability to recall facts that contained numerical information was more efficient when the fact was recalled in the language that it was taught in, but training language had no effect when recalling facts that contained no numerical information.

These findings appear to demonstrate that language is the format of thought about exact number; the extra time required to give answers in a second language represents the cognitive effort required to translate the exact number information from the language it is mentally represented in to the language required for the communication in the experiment. This translation also appears to have been required even when recalling facts that contain numerical information in a language that is different from the language those facts were learnt and stored in, whereas with the approximate and non-numerical thought it appears bi-lingual speakers can simply perform the cognitive processes pre-linguistically and can easily output the information in whichever language is required.

These findings are backed up by anecdotal evidence from bilinguals who claim that, despite total fluency with a second language, they still perform counting or enumeration tasks in their first language, even if the first language is never used for anything else.

All three sources of evidence seem to speak to the involvement of language in number cognition but they do almost nothing to clarify the exact nature of this relationship. In fact, the internal tensions in the aphasic and Pirahã evidence show that further clarification of Spelke's account is necessary before we can see whether or not the evidence supports it.

Clarifications of Carruthers's account

It may seem obvious that up to now we have not looked at exactly how Spelke's conjunction mechanism is supposed to work, only at what it is supposed to produce. We can use Carruthers account of the cognitive functions of language (which actually cites Spelke's work on number as evidence for it) to flesh out the mechanism Spelke hints at, in a little more detail.

For Carruthers, the language faculty occupies a unique and important place within the wider mental architecture. While other modules, both perceptual and conceptual, draw their inputs from a relatively confined number of sources (for computational economy), the language faculty can take the outputs of almost any other module as its inputs – for it to be a tool for communicating the full gamut of our mental representation it must have access to all these representations (which are the outputs of the other mental modules).

Before the language faculty can conjoin the information from these various cognitive faculties into a single linguistic representation the language faculty must first parse all the conceptual representations from the various cognitive faculties, each originally in their own unique representational format, into a unified linguistic format. This linguistic form is referred to by Carruthers as logical form (LF). Having the various pre-linguistic representations in LF is what allows representations to be cognized together or conjoined using ordinary linguistic processes. The LF representations can be activated without our being consciously aware of them and so we can parse things into LF without actively thinking about forming a sentence about them. This is critical for Spelke's account as it explains why we do not have to consciously entertain sentences about numbers to form our linguistic numerical representations.

Following Spelke and Carruthers's assertion that the case of number follows the same sort of mechanism as navigation we can now sketch out the mechanism behind the formation of number concepts in more detail: imagine that the representations from the small and large pre-linguistic proto-numeric systems are both activated in response to perceived quantity or because we are actively trying to think numerically. The language faculty parses both the distinct representations into LF; once they are in this single format, the speech production subsystem can conjoin the two distinct representations into one single unified representation using a syntactical conjunction. This linguistic representation is then for Spelke, our true representation of a number. Still in LF it can then be used as the input of other cognitive faculties downstream from the language faculty (Carruthers posits a general action-planning faculty as one potential LF consumer) and thus our numeric representations get brought into our wider cognition.

As mentioned above Spelke makes it clear that she sees the examples of navigation and number as two sides of the same coin, frequently addressing both sets of data in the same paper to explain her overall position that language is the mechanism of "conceptual development" (Spelke, 2011; Spelke & Tsivkin, 2001a). While both case studies have an amount of experimental backing, it seems that the mechanism from navigation is relatively robust and spelled out in great detail, while the mechanism for number is somewhat underdeveloped in Spelke's own writing and a certain weakness in the account become clear when we question how far the similarities with the navigation case run and how many assumptions we make about the mechanism behind number simply because Spelke constantly presents it alongside the navigation example.

To start, it seems obvious that when we navigate we must generate fresh representations each time. Each situation in which we are disorientated is likely to be different from the last (or else we might not have become disorientated). And the mechanism behind navigation allows for us to be responsive to this changing environment by allowing for the generations of appropriate novel representations each time, each tailored to aiding reorientation given both the spatial and landmark information available to us in a given situation. In each novel situation the two different representational pre-linguistic faculties will contribute something different, representing their remitted information about the space in which we find ourselves. From these context-relevant pre-linguistic ingredients the language faculty is able to generate a novel representation that contains information that is relevant exclusively to the problem of reorientation in the given situation.

However, this requirement of constantly refreshed and novel representations seems to be totally superfluous in the case of number cognition. Each time we think of the number three it is unnecessary for us to generate a novel and situationally appropriate representation of that number. In fact, we normally see number as a quality that persists throughout any situation, constant over any variation in texture, appearance or even modality. The number two, it intuitively seems, has never changed and never will change, therefore our representation of it once formed seems never to need to be updated. The idea of the impossibility of changing our representation of a number is even used to generate the tension in the denouement of Orwell's *1984* when the regime tries to get our semi-subversive hero to alter his beliefs about the number two such that he believes 2+2=5 (Orwell, 1990). In fact, it seems potentially risky to have a system that represents number, which generates fresh representations from the old ingredients each time, for instance, if our ANS is playing up one day then all of our mathematical judgements, which happen downstream of its representations, will be affected too.

However, if we are to follow Spelke and Carruthers in saying that the case of number and the case of navigation follow the same overarching mechanism, it seems like Spelke's account suggests that every time we use the representation of a number we do construct it afresh from the two distinct representations of the activatated pre-linguistic numerical faculties, if this is the case we must use the language production faculty every time we represent number – and currently there is no conclusive evidence that this is the case (the evidence Spelke seems to rely on infers that language is a necessary tool in developing number concepts but it does not speak to the constant involvement of language), and perhaps a little evidence that it is not in the form of numerate aphasic patients.

Further, other accounts of mathematical cognition take for granted the fact our number concepts are persisting mental representations and do not get created from constituent parts over and over again. This is not a conclusive argument that shows that Spelke's mechanism is false but it does illustrate that the assumption of a twinned mechanism between the number and navigation cases puts the Spelke account at odds with the perceived wisdom of all other accounts that presume we generate at some point in development, by whatever means, a fixed and stable mental representation of number.

Spelke and Carruthers' assumption that number and navigation follow the same mechanism would be vindicated by experiments that show that occupying the linguistic elements of the brain inhibited people's ability to represent exact number at all, just as evidence for the linguistic conjunction thesis in navigation is supported by the Hermer-Vazquez's verbal shadowing experiments (Hermer-Vazquez et al., 1999). But such evidence does not appear to be forthcoming.

It seems that to rehabilitate Spelke's ideas about language's role in number cognition we must distance it from the claims that it follows the same basic structure as the account of navigation both Spelke and Carruthers support. Instead of assuming that the number concepts get formulated on a constant basis we might want to see the process of linguistic conjunction as the process by which we develop more stable, enduring linguistic representations of number.

The representations of number that are generated by the conjunction process might, instead of just being used once, be stored so that they might be called upon later without the need to generate them again from fresh. Linguistic representations are stored in the lexicon and there is no doubt that 'two' is an object in our lexicon; we use it on a daily basis in contexts where we do not need to activate our corresponding number concept, for instance in sentences such as "Take the two-four-two to Finsbury Park," we use the lexical item 'two' without using the conceptual representation of the number two.

However, we must remember that Spelke is not just claiming that we have linguistic representations of number – this much is obvious – but moreover that these linguistic representations are the representations of number we use to represent large exact numbers in our wider numeric cognition. So is the lexical item 'two' the conjunction of our pre-linguistic numerical representations and if so do we do mental arithmetic with it?

The problem is that it is clearly not the case that the lexical item 'two' is exactly equivalent to the syntactic conjunction of the two pre-linguistic outputs; further it is unclear how such a lexical item might be able to be utilized in the full and rich numerical cognition that characterizes human interaction with quantity. Though the process of conjunction seems to make sense in the navigation case, it is not quite clear what representations of number such a process would generate would be like or how they might function in number cognition.

Spelke's written accounts do attempt to answer the question of what do the LNRs produced by the conjunction look like. However, there is a lack of explicit examples from Spelke and the two sketches give slightly contradictory pictures of what is supposed to be going on.

In the first case, Spelke describes what happens when a child is presented with a visual array containing two things. She suggests that after a while with exposure the child will come to realize that the word 'two' (already in her lexicon, learnt by rote) maps onto both representations from the ANS and the object tracking faculty, and eventually that this child will come to conjoin both sets of representations around this single linguistic anchor (Spelke & Tsivkin, 2001a).

However, Laurence and Margolis show that if we follow her lead that the conjunction of the two representations occurs through a syntactic operation akin to linguistic conjunction, it is not clear what the resulting representation of the two will look like. Spelke characterises the output of the object tracking system when confronted with a visual array containing two things as (i) 'an object x and an object y such that $x \neq y$'. She then follows Gallistel and Gelman in describing the output of the ANS as (ii) '-------' (representing a blur on the number line) (Spelke & Tsivkin, 2001a). Laurence and Margolis then conclude that the product of the strict logical conjunction of these two representations would then be something like (iii) 'an object x and an object y such that $x \neq y$ and ------' [formatting adapted to be consistent with this thesis] (Laurence & Margolis, 2005).

It is very difficult to see how such a representation could be said to represent exactly the number two, and to represent it to such a degree that this representation could be the basis of our mathematical thought; or how this representation could be tied to the lexical item 'two' such that it comes to mean "two". It seems obvious that such a representation simply is not going to be able to fulfil the role of a fully-fledged number concept.

Perhaps though this is just a very uncharitable reading of the Spelke account; the nonsensical nature of this conjunction may arise because our English language characterizations of the initial representations are so far off the mark. It is very difficult to see what the LF translation of an attention marker would be (in the case of the object tracking system) or of what an approximate quantity (in the case of the ANS) would look like. If we somehow had better access to the LF form of these representations the final linguistic product might seem more sensible. This problem did not arise in the case of the navigation example where the English language is equipped to deliver descriptions of the kinds of features of an environment each of the pre-linguistic faculties represented. Perhaps it is only fair to abandon any criticism of Spelke's conjunction that relies on accessing the validity of the product of a strict conjunction when we cannot confidently know what the inputs are likely to be.

More importantly, the conjunction detailed above appears to work only in those cases where both pre-linguistic faculties fire when shown the same visual array containing number information. If one of the faculties does not generate a representation then there is no conjunction to be performed. Problematically for Spelke, experiments seem to show that we do not use the ANS when representing small sets, and instead entirely rely on the object tracking system when dealing with small numerosities. It has been shown that infants fail to discriminate between visual arrays of 2 versus 4 dots but succeed in discriminating between 4 versus 8 dot visual arrays, even though the ratio of dots being distinguished is the same in both cases(Xu & Spelke, 2000). These findings make it clear that the system simply does not operate over smaller numbers and infants rely exclusively on the object tracking system to make numerical judgements. Further evidence of the reliance on this system comes from Feigenson *et al.'s* findings that infants consistently choose offerings of 3 cookies over 2 cookies when offered the choice despite the fact that this ratio of 2:3 is above the threshold of what is discriminable by their ANS at this age of development (Feigenson, Carey, & Hauser, 2002).

These findings do not necessarily demonstrate that the ANS is unable to, or does not represent small sets: The lack of reliance on the ANS when dealing with small numerosities might be due to a mechanism of suppressing the representations from the ANS which at this size are too vague to be relied on. The behaviour of ignoring one set of representations that might prove unreliable is similar to the behaviour witnessed in rats when navigating after disorientation, which, though capable of navigating using landmark information, ignore this information in favour of navigating solely by geometric information. It is not clear whether a similar mechanism is happening in human infants when confronted with small visual arrays or not; but in the name of giving Spelke's account the most charitable reading we will presume that the ANS does fire in the case of small numbers but its output is not utilized during certain tasks because it is suppressed by some other mechanism. It is then not unreasonable to suggest that the ANS representations are generated for these small sets and do go on to be taken up by the language faculty and conjoined with the information from the object tracking system, even though in the absence of language the representations would have been suppressed and not utilized in numerical cognition.

Even if we grant the possibility of the ANS generating representations of small quantities, the conjunction detailed above can only ever operate in those few cases where the representations from the two distinct pre-linguistic systems overlap, at best this can be the case of 1, 2, 3 and potentially 4. And so Spelke must give a different account of what is happening in cases where the number in question is one which is not explicitly represented by the object tracking system.

One thing we might notice in the above sketch of a conjoined representation is just how much work the object tracking system representation is doing in describing the features of what we expect from a fully-fledged representation of a number. It highlights that there are distinct individuals, not just a measure of stuff (think of the distinction between count nouns and mass nouns), and that there is an exact number of these individuals. Perhaps then we might want to argue that instead of the object tracking system producing accurate representations of the cardinality of sets it provides us with more general information about form and information required in the construction of our robust number concepts. Concepts of integers differ in many important ways from the representations from the ANS of approximate quantity: number concepts represent an exact quantity and that this quantity differs from the previous integer by exactly one and that each member of the set being represented is a distinct single unit; all these qualities seem to be exemplified in the representations from the object tracking system, and so perhaps what the object tracking system provides is an understanding of these qualities that is combined with our approximate representations of quantity to generate accurate large-scale number representations.

If this is the case we have to give up on the idea that the conjunction of the two pre-linguistic representations is a syntactic operation, where representations are simply stuck together. Instead we should begin to view the conjunction as a process of cognitive development, where we generate a new form of representation in which information gleaned from one cognitive faculty is brought to bear on the information generated by another.

Laurence and Margolis characterise this suggestion as like trying to combine the concepts RED and EXACT to produce the concept of EXACT RED, a concept in which they claim that the EXACT element is doing no work and renders the concept no more meaningful that the pre-existing representation RED. This seems a little unfair: while it is true that the concept of EXACT RED is nonsensical, and does not map on to anything in experience, it does not necessarily mean the same is true of EXACTLY SEVEN. EXACTLY SEVEN is clearly sensible and maps directly onto something we can experience, it seems in this case the idea of exactitude does add something to the vague representation of seven that we get from ANS (Laurence & Margolis, 2005, pg. 231).

There is another problem with the idea of EXACTLY SEVEN: it is not clear that there is any way for the child developing these concepts to know exactly what EXACTLY SEVEN is supposed to apply to if we have no way of representing a set of exactly seven things in the first place.

Laurence and Margolis argue that adding the concept EXACT to an approximate numerical representation, such as those generated by the ANS, does not give us the integers as there is no way to know which is the next representation from the ANS that should be represented by a number word. There is nothing in the notion of EXACT that guides which representation from the ANS it should be conjoined with to generate the number concept EXACTLY SEVEN.

However, we must remember that for Spelke's account to be correct we do not have to assume that the language faculty has the cognitive capacity to do the mathematical calculations, in her picture of the mind this can be handled by some other cognitive faculty further downstream of the language faculty that utilizes the LNRs produced by the language faculty. No, all that we need of Spelke's account is that the LNRs can contain and represent all the information pertaining to number that we want our fully-fledged number concepts to do. I do not believe this can be the case. Even if we grant the possibility that the combination of the pre-linguistic representations could generate exact representations of large numbers, it still appears that this representation does not contain all the information that might be relevant to complicated mathematical tasks that we might have to do in the course of normal numerical life. Spelke's mechanism at best provides a LNR that accurately represents the cardinal value of a number but it does not have the means to store other information about the number. The LNR produced by Spelke's system of six does not tell us that six is a multiple of two and three or that the sum of its factors is itself (thus making it a perfect number), or that it is the 6^{th} ordinal number. All of these facts might be part of the semantic information contained within our fully developed concept of six and should be stored as part of it, we should not have to work them out each time from the basic representation of exact quantity generated by the conjunction. For Spelke's account, which posits no other conceptual device that can store or generate concepts of number, all this extra information pertaining to each number must be stored as part of the linguistic concept, but it is not clear that items stored in the lexicon contain this much conceptual information; it is far in excess of what is necessary for efficient speech production and comprehension. In the case of the lexical item 'six' it seems that the necessary semantic information to facilitate rapid comprehension of sentences containing it might at best stretch to indicating that it is a number word and should be used in appropriate syntactic contexts, some indication of the associated cardinal value and which integers it precedes or follows. This information allows for an understanding of sentences that have numeric content, and allows us for example to respond quickly to sentences such as "He had six wives," with shock and "You've won six pounds on the lottery," with dismay. The LNR for six certainly does not contain the information that six is a perfect number or that it was of special significance in the Babylonian calendar, so this information must be stored somewhere else.

Language is not a domain-general conceptual faculty and the types of mental representation it can store are limited to lexical items that are developed to be used in speech production to aid the transfer of conceptual representations, but not conceptual representations themselves. It seems that Spelke's account is flawed fundamentally because the tools language has for representing conceptual information are insufficient for representing fully all the information we want our number concepts to contain, so there must be some other form of number representation at play in adult humans.

That lexical items cannot contain this richness of information is not really a problem for an account that sees language as essential for developing the true number representations but that does not claim that these representations are linguistic themselves. It is down this route that I would like to turn this current investigation.

Part 3. Lexical priming and the developmental role of language

The preceding investigations indicate that language's role in number cognition is most likely one of facilitating the formation of non-linguistic conceptual number representations, as the accounts that suggest that linguistic representations of number are our number concepts or simply map onto our pre-existing number concepts both appear to be unsustainable.

We will therefore proceed assuming that we do have non-linguistic conceptual representations of number as well as the lexical number representations, or number words. The nature of these non-linguistic concepts will be addressed at length further on in this chapter but for now I would like to focus on the relationship between language and these non-linguistic number concepts.

We now turn to the work of Susan Carey who proposes a form of bootstrap mechanism to explain how we use language to develop our numerical concepts (Carey, 2004; 2009). This account faces a number of problems but by framing it in the language of the associated access account we have been developing over the previous chapters, I believe we will be able to overcome them. Within this framework, we will clarify the format and the relationships of the lexical numerical representations; and will show that by clarifying these relationships we can shore up Carey's bootstrapping account. Particular attention will be paid to the role of lexical priming, which is one of the key mechanism within the associated access account's picture of language, but that gets no mention in Carey's exegesis of the development of number concepts.

The secondary aim of the section is to show that language's involvement in the development of number concepts, or how children come to give meaning to number words is not simplistic or straightforward, that it plays subtly different roles at different stages that is not captured in descriptions such as "conjoining" or "facilitating cross modular thought". None of roles ascribed to language in this mechanism require it to have any cognitive capacities that go beyond everyday language learning and production. It is not by ascribing to the language faculty new capacities or powers that I hope to show the importance of language in number cognition but by clarifying how, at each stage, normal linguistic processes help the child overcome the challenges posed by trying to develop robust concepts of large numbers.

To begin with I think it is important to frame the developmental mystery we are trying to explain. Children clearly have some grasp of number words and can display counting behaviour (sounding off the number words in order) from an early age, though it is clear that these words do not always mean the same things as they do for adults. Some behavioural studies make it look like infants treat number words that are beyond their ability to enumerate as general quantifiers such as "some", "many" or "lots" (E. V. Clark & Nikitina, 2009). The question is then, how do children get from knowing the number words to knowing what the number words mean? One simple solution would be that it is very much like knowing anything: we have pre-linguistic representations that we simply must learn to map onto our words. The trouble with this is that, as we have seen in the previous sections of this chapter, none of our number-like pre-linguistic representations can be described as number concepts proper, that is none of them can provide accurate representations of large quantities. So then, the story of how we come to map the number words to our representations of exact quantities mirrors the story of how we develop these representations.

Carey's, and linked accounts, fundamentally claim that our ability to create ordered symbolic structures that are devoid of content, beyond their internal relationships, allows us to develop new concepts that go beyond our pre-linguistic conceptual repertoire. Carey refers to this process of learning the meaning of a word that we have no conceptual representation for as bootstrapping, to capture the idea that by doing so we achieve something seemingly impossible.

In the case of number, the count list (the ordered set of number words) provides a set of placeholders. Each term in the count list is defined completely by its relationship with the other count terms; they have no meaning outside of the system they are learnt in. And at this stage, children have no knowledge of what the terms of the count list mean or signify to other members of the language group. The number words come gradually to acquire meaning for the child by processes of induction, supposition and analogical reasoning. As they develop meaning we can see that the child is developing their concepts of number.

Laurence and Margolis provide a good breakdown of the overall process of development of the number concepts and the inductive reasoning the child must make at each step (Margolis & Laurence, 2008). At the end of this process the child's number words map on to large accurate number representations and the child understands that each number differs from its predecessor by exactly one. We will look at how the child achieves the crucial induction in each stage in turn as well as looking at what particular role language plays at each juncture.

1. Learning the meanings of the small number words: Children must first develop robust conceptual representations of the first small number words and have these mapped onto the appropriate lexical items in their count list. This set of knowledge is the basis for the inductions that follow. How we develop

these small number representations is an interesting question in itself, and various alternatives have been proposed.

2. Working out the cardinality principle: In the second stage of learning infants must learn that the final word in a count gives the cardinal value of a set, this is known as the cardinality principle. This is a fairly abstract realization and requires the child to have a rigidly established count list and to be able to consistently label objects with number words in a one-to-one pattern; once they can do this they are able to work out the cardinality principle. This stage begins to tie together the notions of numerical value of a set and the number words that will be capitalized on to make the crucial final induction.

3. Working out the successor function: Under the bootstrapping account, the final feat that a child must achieve before being credited with having mastered advanced counting is grasping the successor function, the realization that every number in the count sequence refers to a cardinal value one greater than the one it follows. This realization gets at the very structure of the integers and confers on the child the ability to generate accurate large scale number concepts for any given number word in their count list.

Concurrent to these stages of development, children must also learn by rote the count list, that is the ordered set of number words. To begin with it is clear that children attach no meaning to these terms, they are empty placeholders. We learn them just like we learn the rhyme “eenie, meeny, miny, mo” or the days of the week. The human brain clearly has quite a capacity for remembering verbal lists, and the importance of this skill and the lexical systems that underpin it will be examined later. It is just important to bear in mind that this learning process happens alongside the learning of the meaning of numbers though it itself deals with no numerical information.

Step one: small sets

Laurence and Margolis's breakdown makes it clear that to begin the process of learning what the large number words mean, we must have in place an understanding of the small number words. This conclusion is evidenced by studies from Karen Wynn that show that children learn the proper meanings of the first few number words before they learn to enumerate generally (Wynn, 1992b).

Wynn's work has shown that after approximately a year and half of knowing by rote the count list but without appearing to know that any particular word on that list applies to a particular number or quantity, children come to learn that the word "one" applies to an individual object and, when asked to, can pick one and only one object from a pile. These behaviours seem to imply that a child has a fairly robust understanding of the use of the word "one" and accordingly must have a fairly robust concept of ONE. However, they treat all other number words as meaning something like "more than one" and respond to requests to pass any number of objects other than one by handing over a random number of objects but always more than one. For English speakers, this stage happens at roughly between 2 and 2.5 years of age.

Children at the next stage in development know that, as well as "one" meaning one, the word "two" applies to sets that contain exactly two objects, and can correctly identify sets that contain two objects. It takes another 6 – 9 months for one-knowers to become two-knowers. At this stage all other words in the count come to mean approximately MORE THAN TWO. After another six months or so children similarly come to learn the meaning of the word "three".

While some children then proceed to learn the meaning of the word “four” in this piecemeal fashion most children appear to make a crucial development at this stage and come to realize that all items on their count list have cardinality value and can correctly use the count routine to enumerate and give sets of any value on their count list. Wynn calls children at this stage Cardinal-Knowers. This stage is marked by an interesting behavioural change: up until this stage children asked for a certain number of objects that is beyond the number concepts they know just grab a random number of things; but once they become Cardinal-Knowers they endeavour to give the right number by embarking on a counting routine to get to the right number of things. Though they might still get the wrong number through errors in counting, they appear to appreciate that the right number can be ascertained by counting to it (Wynn, 1990; 1992b).

Wynn’s exegesis gives us a time frame and a developmental trajectory for describing how children learn the first few number terms but it does not tell us anything about how children come to learn the first few count terms in this piecemeal fashion. It has been variously suggested that we develop them from the representations of the ANS, from the object tracking representations, analogy to the linguistic quantifiers or from a dedicated number module. Though commentators stress the fact that it does not matter for the final stage of the bootstrap how they are learnt so long as they are in place (Rips, Asmuth, & Bloomfield, 2006), to complete our investigation into how much language is involved with the development of our number concepts we should look at all the possible alternatives.

Could the small number system be the root of our initial number concepts? This seems unlikely because, as we saw before, it does not contain any representations with numeric content. The representations it generates are of individuals, that it can individuate up to four individuals simultaneously does not in any way show that it generates a representation of set size. In fact, to count the representations of individuals the object tracking system generates we would need another system that represents set size, which is exactly what we are looking for. It may be key in explaining how children can physically come to count things, providing the mechanism by which they individuate them, and which thereby facilitates subsequently enumeration, but it cannot, alone, be the source of our initial number representations.

We might instead claim that it is the ANS that furnishes the child with the first few number concepts that are necessary to proceed with the bootstrap: it is the most numerate of our pre-linguistic systems and people have long assumed a developmental continuity between the representations of the ANS and our more developed representations of the integers (but see (Rips, Bloomfield, & Asmuth, 2008) for a lengthy critique of this assumption). However, we have already looked at the difficulties of building a system that assumes that the ANS produces representations of small numbers, namely that it appears that it does not function over small numbers or at best its output is masked, plausibly because they are too inaccurate to be useful. Further to this there is evidence from Le Corre that children do not in fact map their pre-linguistic representations from the ANS onto the number words until about six months after they have grasped the successor function and completed the bootstrap process (Le Corre & Carey, 2007). Given that we do not map these representations onto our number words until we have already developed the number concepts, these representations cannot be the source of the meanings of the first few number words we need to ground the initial stages of the bootstrapping process.

A more promising suggestion comes from Carey following work done by Bloom and Wynn (Bloom & Wynn, 1997) who propose that initially our understanding of how number words function is from analogy to quantifiers found in natural language. While growing up children are surrounded by number words and quantifiers, presented within very similar syntactic contexts, and there is evidence that to begin with they view them as interchangeable elements of language.

Firstly, children learn the meaning of the term “one”, roughly as synonym of “a” and in line with the singular/plural distinction in language. At this stage, they misinterpret all other words in the count list as being a general plural marker.

What about languages without singular/plural distinction? There is evidence that speakers of languages that do not have plurals become one-learners six months later than English speakers. This demonstrates that it is difficult to grasp the meaning of “one” without the singular/plural distinction being firmly understood and utilized, and speaks to the importance of the syntactical information about quantifiers in the learning of the first few numbers. Though Chinese and Japanese speakers take longer to get to this stage, their progress at learning the numbers from here on seems to proceed at the same rate as for English-speaking children, becoming two-knowers then three-knowers and then cardinal-knowers roughly six months later than English speakers (Sarnecka, Kamenskaya, Yamana, Ogura, & Yudovina, 2007).

This pattern of misinterpreting the meanings of the number words as general quantifiers continues through the one-, two- and three-knower stages. Until they grasp the cardinality principle children treat the number words that they have not learnt yet as having general quantificational meanings, even if the exact number they apply to is not known. This implies that children understand that the number words refer to numerosity even if they do not know what particular numerosity applies; to do this, the number words at this stage must have some usage conditions specified as syntactic information as part of the lexical item.

The syntactic information that is attached to the number terms at this stage is very important, it provides information about the kind of things the number words can range over and allows children to make inductions about the difference between number words. This analogy between number words and quantifiers allows learners to realize that the number words pick out the quality of quantity.

Once they have understood that the first few number words function like quantifiers and therefore range over numeric information, infants are in a position to start mapping them onto our pre-existing representations pertaining to quantity. The child now has in place the cognitive faculties to label and enumerate small sets of things.

An alternative account is given by Carey, who instead suggests that the representations we map our number words onto are representations of sets of things, stored in long term memory. These sets of things were presumably once individuated using the small object tracking system and the remembered representations of them might contain representations of the indexing tags from the object tracking system. These stored representations are probably just abstracted sets: [a], [b,c], [d,e,f] etc. though she suggests that they might be of actual remembered sets of things such as [mum,dad].

These representations of sets are clearly not number concepts proper. Set size is not represented, only sets of different sizes; it is only when they are mapped to number words appropriately that we come to see how these representations of sets are analogous to abstract quantity. These representations of sets mapped to the first few number words become the first few representations of number. These number representations do not seem like the adult representations of number. As discussed above there is more to our number concepts than a description of the quantity with which it is syntactically appropriate to use the term. These primitive number concepts develop as children become more familiar with the counting routine but we will see that even at this stage they suffice to facilitate the induction that follows.

Alternatively, Laurence and Margolis suggest a system based on a specific number module (Laurence & Margolis, 2005; Margolis & Laurence, 2008) that is a weighted network rigged in such a way that a different number of nodes are activated in response to different numerosities. This small number module has its numerical content by virtue of responding consistently and distinctly to different numerosities, it is numerical in that it is "reliably connected" ((Margolis & Laurence, 2008), p.937) to the perceivable quantities in the world.

It might be argued that this system negates the need for the bootstrap by making number concepts innate: if children need to have concepts of number to learn the concepts of number, what is there left to do? I would argue that the richness of the representations of number generated by Laurence and Margolis's number module is modest and that, though these number concepts respond exactly to different numbers, they do not provide children with any of the richer understanding of numbers that are required to become an advanced counter. In this sense, they function exactly as the representations of sets of different size, which Carey favours, do; and it is only when they are mapped to the correct number words that they come to have a meaning in the wider context of counting and the integers.

Fundamentally these two proposals offer the same thing to the aspiring number learner: They generate representations of sets of exact size, for sets of between one and four objects. It is important to realize that having these representations does not qualify the child as an advanced counter, as the triggering of these representations does not allow the child to discern the numerical relationship between the two sets nor does it allow them to enumerate in order, that is to say, having these representations does not automatically make them cardinal-knowers. These systems just have to provide the representations of quantity that we can map the first few number words to. For ease of reference I shall call whatever system it is that generates these accurate small representations of set size the *small set system*.

At this stage then, aspiring counters have in place two important things: firstly, similarities between quantifiers and number words, and secondly the mapping between the number words (with their syntactic information) onto the first few accurate representations of set size (from the small set system). The syntactic information from the analogy to quantifiers specifies that the number words all pick out different quantities, where what these quantities are is contributed by the appropriate mapping (or access point establishment) to the representations of set size from the number module.

Infants who have learnt the first few number terms then have lexical representations of the first four numbers with the access points to the appropriate representations of set size from the small set system and syntactic information, stored as part of the lexical item, determining under what numerical conditions it is grammatically appropriate to use them.

These representations are beginning to look a lot like the number words entertained by adults, and this is reflected in the similarities in the way in which children use them: infants use the first few number words in the system properly, to refer to sets of exact quantity. However, the other number words still behave in a mysterious ways or as generic plural markers; this is quite distinct to more advanced number learners who realize that even if they do not know what numerosity is associated with a number word they still treat them as referring to a single, unknown, number.

Step two: cardinality

At this stage, children are in a position to make the inductive inference that generates them the cardinality principle (that the last term given in a count gives the cardinal value of the set). By now, children are practised at reeling off the count list in order when prompted and can assign members of the set to be counted a number word in an exact one-to-one correspondence. This comes through practice at the counting routine, aided by parental guidance. With this one-to-one counting routine and the first few number words endowed with numerical meaning, children are in a position to come to realize that the last word given in a counting routine gives the cardinal value of the set of things being enumerated. For instance, a child will come to realize that a counting routine that ends on three will always happen when the set of things being enumerated contains exactly three things, the same is true for the word "two" and sets of two things. The cardinality principle can be worked out from only the modest number of number concepts at the child's disposal and eventually goes on to aid the child in developing concepts of the rest of the numbers on their count list.

It may simply appear as coincidence to start with, but the solidity of the counting routine ensures that the same result is given enough for the child to come to grasp the robustness of the cardinality principle. Familiarity with the practice of verbal counting ensures that the count list always follows the same order and that its terms are given in a one-to-one correspondence with the objects of the set.

Step three: the bootstrap and the successor function

Once children have in place the first few number concepts accurately mapped onto the first number words, and the child is beginning to grasp the cardinality principle, the child is on the brink of becoming an advanced counter. All that is needed is a process that allows children to acquire the meanings of words for large numbers. This is done by a piece of inductive reasoning from the meanings of the words for small numbers already at their disposal. This final stage of the bootstrap concludes with children working out the successor principle, that the next word on a count list applies to a number one more than its predecessor.

If they recognize the analogy between the relationship between a number word and its successor in the count list and the representations of set size associated with each term, Carey suggests that children will be able to make the crucial induction: “if “x” is followed by “y” in the counting sequence, adding a[n] individual to a set with a cardinal value X results in a set with the cardinal value Y” ((Carey, 2009), pg.327). From here the child simply has to realize that a single individual is the equivalent of one to get them to the successor function.

Remember that grasping the successor function is presumed to indicate that a child has become an advanced counter and can enumerate any number in their count list. Whether they have mapped appropriate numerical concepts to each lexical item in their count list is irrelevant, the point is that with the successor function in place they have the capacity to give meaning to large number words. This is something that is impossible with only the pre-linguistic numeric capacities.

Children are now in a position to work out from their concept FOUR and the successor principle that the lexical item 'five' means five by adding one to their representation of four, this can be repeated for 'six' and 'seven' and so on. This appears to be a rather piecemeal system of learning and it is unlikely to explain how all number words come to be given meaning - it seems unlikely that we generate our conceptual representation of 132 by working out that it is one more than 131. We shall look at the alternative pathways to forming number concepts that are opened up after this crucial induction takes place in the next section.

By this mechanism children start to learn the meanings of number words and it provides us with one firm way in which we formulate the conceptual representations of large number that are necessary for mathematical thought. It is important to bear in mind that these conceptual large number representations are not purely linguistic, the lexical number representations in the lexicon provide just a focus point to which the conceptual representations are mapped, this relationship is the same for other concepts with associated lexical items. The key difference in the case of number is that these conceptual representations are not the product of some pre-linguistic conceptual module, that we can just map to a word, as is the case with say the concept RED, but are the unique product of socially guided, conceptual construction. It is therefore impossible for us to entertain these concepts without previously constructing them. Carey's bootstrapping process shows how we use language to do this.

The conceptual representations, not the lexical representations of number are the representations that we use to complete numerical cognition and we can utilize them without activating the corresponding lexical numerical representations; this is a key point of difference with the view of Spelke that we looked at in the last section.

The diabolic counters: an argument against Carey's bootstrap

Rips et al. contest that this inductive process cannot be the way in which children learn to count, arguing that the number in the counting sequence that comes immediately after any given number is not well defined and so the child cannot be ensured of getting from the initial stages (knowing the small numbers) to a fully-fledged understanding of the integers (Rips et al., 2006). They argue that the induction does not guarantee that learners will generate the integers as normally understood because no part of the induction defines what numeral comes next in a count list.

They illustrate this problem with a devious example. They ask us to imagine twins who have acquired, through whatever method, a solid understanding of the first three count terms and the cardinal principle. Then they both make the crucial induction that whatever item comes next on their count list is exactly one more than the predecessor, and they both learn to count up to nine like any normal child – at this stage they clearly have conceptual representations of the integers up to nine that we would comfortably call normal. But while one of the twins, Fran, learns the normal counting system, one of the twins, Jan, is led astray by a diabolic parent who teaches her that the number that follows nine is zero. Accordingly, the child then continues to use what she knows about the numbers to work out the number that follows 'zero' is 'one'. If Jan was asked to count out a set of 11 cookies, she would conclude by counting the

10th cookie as “zero” and the 11th as “one”; if she was tasked with counting out 21 cookies the concluding verbal response would be the same – “one”.

She thereby comes to have a cyclical number system where the lexical item ‘one’ comes to apply to sets that contain 1, 11, 21… objects, and the lexical item ‘two’ would map onto 2, 12, 22 etc. In mathematics this system of counting is called Mod_{10}.

It is not just that Jan is simply using the words in an unusual way but that her concepts of number are not normal. Using the cardinal principle, she would conclude that any count list that ends in the word “one” would have one object, and so her conceptual representation ONE would mirror this. Her concept of ONE would be a representations of sets with quantities of 1, 11, 21 and so forth; it is clearly possible to have conceptual representations of certain sets of numbers, for instance our concept of PRIME NUMBER is a concept that contains lots of different numerosities, much like Jan’s concept ONE.

Jan’s cyclical naming system seems a little implausible but remember, we often learn, and are correct in learning, cyclical naming patterns in many other cases; the days of the week and the months of the year both follow a pattern that is analogous to Jan’s peculiar counting routine; there is clearly nothing intrinsic in the child’s ability to create ordered lists that precludes the possibility of learning a Mod_{10} counting system.

Rips *et al.*’s key argument is that there is nothing in the workings of the bootstrap as described above that precludes learning such a numbering system. They argue that Jan’s number system is entirely consistent with Carey’s induction “if “x” is followed by “y” in the counting sequence, adding a[n] individual to a set with a cardinal value X results in a set with the cardinal value Y" and embodies it just as well as the normal integers do. This striking conclusion, they believe is due to the fact that there is nothing in the inductive conclusion that accurately defines what the next thing in the counting sequence should be. They claim, "The bootstrap is undermined because it presupposed a system of numerals that tracks them."(Rips et al., 2006) It is important to note that this counterexample does not speak to the falsity of the bootstrap induction but merely claims that the conclusion of the bootstrap is under-determined and cannot, by itself, get us to the natural numbers.

However, Rips *et al*. want their diabolic counters to show that we should not credit the induction with being the way in which we learn the proper number concepts, arguing that if the induction cannot be guaranteed to get learners to the proper concepts of numbers then it cannot be the system that young learners use. This conclusion is a little hasty.

Rips *et al*. are right in that their devious counterexample does show us that the bootstrap is not enough to get us to the natural numbers – but it does not show that we must give up on it entirely, it might equally well lead us to the conclusion that some other mechanism acts in tandem to support it, to ensure children do not use induction to generate incorrect number concepts.

In fact elsewhere in their paper, Rips *et al*. suggest that something must restrict the concept of next number to ensure that young learners end up learning the *correct* numeral system (Rips et al., 2006). They themselves suggest that the only thing that can get learners to the right answer is a set of axioms that aggressively and accurately define the natural numbers, akin to those known as the Dedekind-Peano axioms that mathematically define what we mean by the term, "natural numbers". They go on to argue that if we do ascribe to the young brain these axioms then the bootstrap is superfluous as the axioms already define the natural numbers, the very thing the bootstrap is supposed to get us, and so we should give up on it.

Ascribing this level of knowledge to young brains is excessive, children can get to be numerate without ever representing the Dedekind-Peano axioms either consciously or subconsciously. It is only with investigation that we develop these broad understandings of the abstract relationships that define the natural numbers.

In insisting the infant mind must grasp the Dedekind-Peano axioms to be able to represent natural numbers, Rips et al. are conflating our concept of NATURAL NUMBER with our concepts of the natural numbers themselves; the former is a highly conceptualized mathematical notion, the latter are invisible parts of everyday cognition. We do not need an understanding of what the natural numbers are to be able to use accurate numerical representations; we do not need representations of the axioms that define natural number, we just need number concepts that comply with them. If these can be attained via another process that does not require representation of the Dedekind-Peano axioms we must still accept that children have learnt to count.

So what alternative might explain a child's ability to come to have an appropriate understanding of what the next term in a count list should be. I suggest it is another feature of the symbolic structure of the count list, overlooked in both Carey and Rips's sparse accounts of the functions of language required for the induction.

Understanding how the count list works is key to understanding how children learn numbers concepts, but is a much neglected element of inductive accounts of number learning. That children can learn the number list is taken for granted as a relatively unimportant pre-requisite for learning number concepts and not treated as part of the process in general. If we look at how we are able to learn and produce the count list I believe we will gather some insight into its role in the wider picture of learning number concepts in general.

Let us then look at exactly what learning a list by rote involves and how far it gets us in the proper learning of the number words. When we learn by rote a serially ordered verbal list, such as “Monday, Tuesday, Wednesday, Thursday, Friday”, or “eenie, meeny, miny, mo” each item in the list results in a separate lexical item stored in the lexicon. As discussed earlier they can, to begin with, have no semantic content themselves (or even syntactic content in the case of the nonsense words, “eenie”, “meeny” etc.). These lists exist purely as a set of relationships between these lexical items – that ‘meeny’ follows ‘eenie’ and precedes ‘miny’ etc. These lists may be cyclical as in the case of the weekdays, where ‘Monday’ follows ‘Sunday’ in much the same way as ‘Wednesday’ follows ‘Tuesday’ or they may be linear, as with the count list.

The relationships between the terms must be stored somewhere. We do not store lexical items in one part of the brain and then a conceptual description of their relationships elsewhere; the information pertaining to the order of the list is stored in the lexicon, as a function of the access points between associated lexical items in the list(Hoey, 2005). These connections between lexical items facilitate speech production via the process of lexical priming.

When we speak a word aloud, we prime or activate the words that we are likely to use next during speech production. For instance, if we were talking about British car manufacturers and I say the word “Rolls”, my language faculty automatically primes (partially activates ready for inclusion in a sentence) the lexical item ‘Royce’, so that when I come to form sentences I do not have to choose amongst all potential lexical items that might follow 'Rolls' but only select from those that are appropriate to the current context, so as to maintain fast communication. These primings are context-dependent and allow us to deal with the complicated linguistic problem of polysemy. For instance: 'Royce' is much more likely to be activated after the lexical item 'Rolls' is activated in scenarios where one is talking about cars than in one in which the conversation is about favourite sandwiches. By priming lexical items we can communicate effectively despite the incredible number of words that have multiple meanings, ensuring that we rarely get confused by which meaning of the word, say "Rolls", was intended. Effectively lexical priming makes it such that saying one word makes another, related, word more likely to be said than other non-related words. This effect is compounded if a number of lexical items are activated in an order that builds up a rich lexical context: such a rich lexical context can limit the choice of which lexical item will follow hugely, potentially even to just one.

Lexical priming allows us to be able to form sensible sentences quickly without having to choose from the thousands of possible words (Hoey, 2005). Further lexical priming allows us to understand people quickly from the context of the conversation. For instance, when hearing someone else, possibly from Sheffield, talking about sandwich preferences and they say "breadcakes" my lexical item for 'breadcake' will slightly prime my lexical item for 'roll' so that when I hear the word 'rolls' I know they mean the bread variety not the car variety by virtue of the semantic context that has been built up via the previous lexical item activations. This priming is facilitated by the nexus of connections between lexical items, that effectively embody their semantic content. Each lexical item is associated via a series of access points with semantically linked terms, such that when the lexical item is activated, it primes those lexical items it is semantically linked to making them more likely to be activated during subsequent speech production or comprehension.

The process of lexical priming is well established and has historically been used to probe the background mental states, biases or perceived contexts of patients using association. The mechanism underlies the "say the first word that comes to your mind when I say…" type of psychological studies; though these studies may or may not be efficient at diagnosing psychological disorder, they trade on the fact that when we hear or say a word we activate those words that are semantically linked to it.

When we learn empty symbolic systems, such as the count list, what we are learning is these activation links and their appropriate activation weightings. When we learn an empty list of placeholders, such as the count list, we are setting up these activations for the lexical items in the list, that have no access points to conceptual representations and therefore the only context that might trigger them is the internal linguistic prompt of the previous member of the list being spoken. And so, we end up with lexical items that can only easily be triggered by other words and in a set and stable order. In these cases of placeholder lexical items, the lexical primings take on an even larger role. When we do not know the meanings of the number terms, i.e. when there are no conceptual number representations associated with the words, then there is nothing else that can trigger the number words other than the lexical priming via the previous number terms. That makes it is unlikely for a child to say the wrong number word after having said the preceding number terms consistently; there might be errors occasionally but the system is very strong once the count list has been firmly established.

Understanding that this mechanism underlies our verbal counting habits allows us to see why the case of Jan's Mod_{10} system seems so counter intuitive to us non- Mod_{10}; it is hard for those of us who have a firmly established standard count list to conceive of saying zero after saying “four, five, six, seven, eight, nine” when engaged in a counting task, it is uncomfortable and manifestly counter-intuitive.

If Jan had in place a proper set of count terms with appropriately weighted relations then it would be seemingly impossible for her to learn a Mod_{10} system as she would be very unlikely to repeatedly say “zero” after “nine” when lexical priming is leading her to say “ten”.

I agree that if her diabolic parent had taught her exclusively and consistently that the word that follows “nine” is “zero” then she would inevitably learn the Mod_{10} system, not the standard system. However, this realization only highlights that what determines the number system we learn is determined by the count list we are working from, Jan’s situation brings home the importance of language and lexical priming in supporting the successor function to ensure we learn the proper, culturally endorsed, counting system. If we have correctly learnt the proper integer count list, then it seems that the induction process cannot help but get us to a proper understanding of the integers.

Mapping more information to the bootstrapped concepts

Earlier we briefly mentioned that, though the successor function provides learners with the tools to generate accurate representations of large numbers on their count list, it seemed unlikely that all of our conceptual representations of number are generated one by one, through application of the successor function.

After becoming advanced counters our number concepts do not cease to develop. One suggestion is that after a while we learn to map our representations of large quantity from the ANS onto our number words. Though these representations of quantity do not form the seed of our initial representations of number, there is a great deal of evidence that shows after a while we do learn to map the approximate representations from the ANS to the number words, as shown by our ability to give an estimate of the quantity of objects in a visual array that is presented to us in such conditions that we do not have a chance to count verbally using the number words. For this to work our number words must be associated somehow with our approximate representations of number activated during the task. The representation from the ANS obviously has an access point to the verbal representations. However, these representations still do not have the ability to become our accurate conceptual representations of numbers.

Rips *et al.* suggest that a lot of the processes behind the development of our number concepts are processes of rational reflection (Rips et al., 2008). They show how we come to build up accurate number representations through the processes of learning and through reflection on the numbers we have already developed representations for. For instance, we might come to understand that seventy is the quantity equivalent to ten lots of seven as we learn our ten times table. Beyond just learning the remainder of the cardinal values of number concepts, there is conceptual information attached to certain number concepts that is distinct from their cardinal value that must be learnt to if we are to have fully fledged numerical concepts. We learn this information as we learn other non-numeric conceptual matters. For instance, learning the prime numbers or the perfect numbers does not simply come about through familiarity with the counting routine and cardinal values attached to its terms. Learning the prime or perfect numbers requires a reflective inquiry or teaching about the number concepts we already have in place and the system of mathematics that they are a part of. Over time, all of this information gets incorporated into our conceptual representation of a number in much the same way our concepts of non-mathematical things grow and develop over time.

There are two distinct types of mechanism at play in the examples given above of the broadening of our number concepts, that can be distinguished by looking at what each entails in terms of the associated access account of lexical representations. On the one hand the representations of the ANS, a separate cognitive faculty, are mapped onto a lexical numerical item which opens up an access point between the lexical item and a conceptual faculty. This broadens the applicability and meaning of the lexical item by allowing it to be used to communicate conceptual representations that were previously inexpressible. However, the number concept associated with the lexical numerical representation is unchanged.

And on the other hand, the process of the conceptual representations of the numbers themselves, developing through learning and rational reflection, does not open up access points between the conceptual faculties and the lexical numerical representations; it merely increases the amount of information the conceptual representation contains.

One process develops the breadth of the lexical number representations by mapping it to new representational faculties, the other increases the amount of information incorporated in the conceptual representations of number. However, the perceptible effect of both is an increase in competence and understanding of mathematical concepts.

Further indication of the partial independence of the lexical number representations and the number concepts behind them comes from the observation that in everyday use we often find ourselves using the lexical number representations without calling to mind an exact representation of the integer it is associated with. For instance, when we are dealing with words for very large numbers we often seem unable to grasp the actual magnitude of the quantity associated with the term despite linguistic familiarity with it. Imagine hearing someone report the size of a crowds as “twenty-five thousand, four hundred and thirty three people”, it is very hard to understand, in terms of exact quantity, what this means.

In this case, despite the fact that a lexical item is fully formed and therefore comprehendible when heard in speech, it seems that we have not yet tied it to a conceptual representation of a number or to a representation of approximate quantity from the ANS. Nonetheless, the lexical item can still function in a conversational setting. These empty lexical number representations pose an issue for communication and we have developed many techniques of approximating, rounding up, visual aids and metaphor to help communicate larger integers that people have not generated rich conceptual representations for.

Similarly, when we remember telephone numbers, we appear to only remember the lexical representation of the number not the numerical concept of the associated integer - I do not call to mind my conceptual representation of the number seven billion, eight hundred and seventeen million, nine hundred and sixty-seven thousand, three hundred and eighty-eight when I try and remember my phone number but just the lexical items, with a little help from lexical priming and verbal memory loops. This shows that the lexical number representations can have a cognitive life all of their own and we can utilize them without thinking of the numerical concepts associated with them; conversely we can use the conceptual representations of numbers during mathematical thought without thinking of the names of the numbers at all. The associated access account of cognitive semantics details how we can use the semantic information associated with lexical items to facilitate linguistic communication, without having to activate the conceptual representations associated with the lexical items. This is the case for lexical number representations that we can utilize in speech even if we have not gone on to formulate conceptual representations of the number they will eventually come to stand for. This is just as true of our learning the first few count terms as children to our eventually getting our heads around pi or the square root of minus one later in our education.

Conclusion

Although it seemed at the outset that the case of number might have been similar to the navigation case study – with language involved in the integration of knowledge from two distinct pre-linguistic cognitive faculties, Carruthers's assumption that the two case were distinct instantiations of the same mechanism was clearly mistaken. It appears that very different mechanisms are at play in navigation, where language plays an active online role in problem solving; and number, where language is critical for development of conceptual representations.

Further, language's role, even within number cognition is varied; many of the mechanisms that play a part in the wider picture of how children develop number concepts fall outside of the bootstrap's remit. For a start, we have seen the importance of learning by rote and the lexical priming mechanism in learning the first few count terms and also in making sure that number learners cannot help but learn the proper integer count list. Further, after the bootstrap has been concluded we saw how lexical number representations act as a focal point of the broadening concepts of numbers by forming various access points between the number words and the corresponding representations of the ANS and our more conceptual representations of number.

Tying the threads together
A conclusion and a taxonomy

In the introduction, we came across Carruthers's dissection of the functions of language into either communicative or cognitive. This distinction was made with the intention of highlighting the possibility of a more cognitively important role of language within wider cognition than is normally assumed within the field of cognitive science. Clearly, I too believe that the role of language in cognition is often understated within the study of cognition, and share Carruthers's intentions of highlighting a more cognitively active account of language. However, I feel that Carruthers's distinction between cognitive and communicative conceptions of language actually leads us away from the correct view of language's role in cognition and towards Carruthers's own view of the architecture of cognition, which he expounds in *The cognitive functions of language*, after highlighting the distinction.

In the first section of this chapter I will look at how Carruthers's dichotomy leads towards his own strong, cognitive conception of language, by showing how actually the cognitive repercussions of language's functions are by-products of the normal communicative mechanisms of language, rather than the product of some other, more computational, capacities of language. Further, such an account of language, which runs together, what Carruthers's terms, cognitive and communicative elements of language, does not fit into Carruthers's distinction happily, and so by following the lines of thought proposed by the distinction we might overlook it as a possibility. I fear that Carruthers is trying to tease language's roles in cognition apart in a place that does not make sense.

I will also try to make it clear that Carruthers's distinction assumes a naïve view of the communicative functions of language, which makes it seem like his computational account of language's role in cognition is the only viable way of establishing the importance of language's function within cognition and explaining the evidence for language's involvement in various cognitive domains.

If we give up on a naïve view of communicative language it becomes easier to see the interesting cognitive effects of language on thought as simply upshots of its communicative functions. The second section of this chapter then will flesh out the sketches of language function that we began to develop over the course of the investigations into the case studies that make up the previous chapters.

The third section of this chapter will then attempt to build a taxonomy of the roles of language in cognition starting from a more mature view of language's functions. We will draw lines of similarity between the mechanisms we looked at in the foregoing case studies and draw from them some more general conclusions about the means by which language plays a role in the wider picture of cognition; thereby hoping to explain humanity's long-held intuition that language is one of the key factors in our advanced cognitive capacities. At the same time, we will also touch upon a few other mechanisms suggested by other commentators on the interaction of language and thought and see how they fit with our account of language. The basic taxonomy I present splits the mechanisms of interaction between language and thought between (a) those where language has a subtle, implicit and wide ranging effect, but in ways which are not consciously aware of, and so seem to us like normal cognitive behaviour; and (b) those where we use language consciously, as a cognitive tool for expanding our capacities by exploiting some of the mechanisms that evolved to meet the demands of effective communication.

Part 1. Carruthers and the misleading dichotomy

Carruthers's motivation in *The cognitive functions of language* (Carruthers, 2002) is to evidence and support the general claim that language has a greater role to play in cognition than merely expressing the thoughts that the suite of pre-linguistic conceptual modules generate. He proposes a taxonomy which splits language's functions into either communicative functions, those which are used during normal linguistic communication, and cognitive functions, more controversial functions through which language plays a role in wider cognition. By producing this taxonomy he hopes to draw us away from the view that is prevalent in cognitive science that language is purely communicative, merely a tool for transmitting thoughts generated by pre-linguistic modules between thinkers.

I am sympathetic to Carruthers's cause, and believe that any attempt to highlight the potential importance of language within cognition is worthwhile. By giving a label to, and legitimizing, the non-trivial cognitive functions of language Carruthers helps us bring into line with the modularist point of view the intuitions we all have about the deeply interrelated nature of language and thought. However, the dichotomy Carruthers suggests leads us towards viewing the cognitive role of language as quite distinct from the communicative roles it performs.

But what are the cognitive functions language performs that Carruthers believes need bringing to light? By reminding ourselves what Carruthers is arguing for we might be able to see why he puts forward the distinction he does. Carruthers puts forward an account that sees language's role in wider cognition in its role as a cross-modular, domain-general faculty that allows us to generate novel representations, which contain information from two distinct conceptual modules.

These complex linguistic representations cannot be entertained by the pre-linguistic conceptual modules and allow us to perform flexible online cognition that is not bound by the encapsulated limits of the cognitive modules. The potential mechanisms behind this thought are exemplified in his account of reorientation behaviour in humans, which we looked at in the first case study. For Carruthers, language's main cognitive capacity is to combine information from distinct pre-linguistic representational faculties into one unified linguistic representation that can be used during problem-solving cognitive behaviour by first translating the conceptual representations into a symbolic linguistic format and then conjoining the representations.

Carruthers's argument makes massive claims about the scope of language's involvement in cognition, viewing it as a key cross-modular thinking device. Its apparent domain generality (language is domain-general in so far as it can represent seemingly anything) and computational potential leads Carruthers to suggest that language is behind vast swathes of our more complex cognitive behaviour, especially those that appear to utilize information from two distinct conceptual representational faculties simultaneously, which covers a lot of our cognitive behaviour. Yet Carruthers cites evidence from only two distinct cognitive domains to support his general theory of language – navigation and number and in both cases, we have found Carruthers's account of language's role unpalatable.

In both case studies explored by Carruthers, the fundamental issue was a lack of evidence that the language faculty does function in the way he suggests. For instance, in the case of navigation we saw that into order to generate a representation which could be used for reorientation from the two distinct pre-linguistic conceptual representations, the language faculty would have to perform quite complicated inductions, beyond the scope of the syntactic conjunction he suggests. There is just no reason to suppose that language has such complicated and advanced computational capacities, and such a suggestion goes against the general wisdom of developing a cognitive architecture that does not rely on domain-general symbol manipulators. Such domain general symbol manipulators have been shown to face insurmountable problems from computational intractability.

We must conclude that language does not function as Carruthers suggests, it is not in fact like a domain-general computer, able to take inputs from any module and combine their representations in logical inferences. So why might Carruthers posit such an extreme view of the computational power of language? I think that part of the reason why he is drawn to such a picture (besides it being consistent with many of our intuitions about the importance of language in thought) is due to his assuming a naïve view of how the communicative side of language works, which leads him to neglect the potential for interesting cognitive behaviour that a language faculty that adapted solely to meet communicative ends might generate.

Despite positing communicative functions as one half of his dichotomy, Carruthers at no point goes into how they actually work. By failing to do so, he effectively negatively defines the communicative role of language by describing the raft of mechanisms that cause interesting effects on cognition as part of the cognitive roles of language and labelling everything we are left with as communicative. By removing all interesting linguistic behaviour from the communicative side, we are left with a view of the communicative functions of language is that is oversimplified and unelaborated.

It seems that Carruthers implicitly sees the communicative functions of language as simple translational mechanisms from conceptual representations to linguistic representations, seeing language *qua* communication as purely a vessel for thought. Such a view is sometimes called a Pure Translation view of language (A. Clark, 2006). Carruthers sees sentence production as translation first from conceptual representations into LF, a format of representation that contains all the information from the conceptual representations in a syntactic form, and then, if the thoughts are going to be expressed verbally, from LF into natural language. The process of speech comprehension then becomes simply the reversal of this process. In *The cognitive functions of language* Carruthers admits that this story is oversimplified but states that he does not see how it will lead to any problems for his account, as it is the view assumed by both sides of the debate: "How, then, does the sentence get assembled? I have to confess that I don't have a complete answer to this question in my pocket at the moment! But then this need be no particular embarrassment" (Carruthers, 2002), p.669). Though Carruthers is right to say that he is not alone in being without an answer to the problem of sentence production, by not having a story Carruthers assumes an overly simplistic picture of the process. And by doing so Carruthers implicitly acknowledges the possibility of linguistic versions of conceptual representations, containing all the same information.

The Pure Translation view is obviously an overly simplistic view but one that we assume on an everyday basis. It is a shorthand way of viewing the functioning of the language faculty that has snuck into cognitive science as the default position.

It is unclear in his writing if Carruthers does hold a Pure Translational view of language's role within cognition but if we follow the dichotomy he provides, we are led to assuming it. Further I believe this assumption leads Carruthers towards overly complex accounts of language's involvement in thought that require positing extraneous mechanisms and functional capacities within language to make up for the dearth of interesting interactions between language and thought left by assuming an overly simplistic view of communicative language.

If we do not subscribe to a purely translational view of language functioning then we might be able to show that language does play an important role in cognition, without having to credit it with explicitly domain-general computational powers as Carruthers does. We must remember that to assume that language evolved for communication, and therefore to see communication as its primary function, is not necessarily to endorse a purely translational role.

So, what is wrong with a pure translation view? We do not have to push very hard before the pure translation view begins to give way under pressure. In fact we, probably, have all come across its shortcomings as a description of language faculty's functioning in our everyday life. Intuitively then it seems that when we fail to put our ideas into words or when we are unclear what somebody means by a statement it seems that an exact translation of thought to words is impossible.

The Pure Translation view seems to require that, to be able to express our thoughts we have to have corresponding linguistic representations of them, which capture the same information about the world. This is clearly impossible – we would need too many words, far more than the language faculty could store or process. For instance, think about how many different colours we are able to perceive, yet languages have relatively few colour words – in some cases as few as two, yet communication still proceeds effectively so it cannot be the case that Pure Translation is required for effective communication. It appears we cannot represent all the colour representation we might possibly entertain linguistically. We might argue that we can linguistically represent all colour tones either through analogical description: a certain hue might linguistically be captured as: "old-pine-cones-that-have-been-drying-by-a-fire-in-a-barn-for-the-winter-brown", or via a formal method where we analyse the make-up of the colour scientifically. But even these attempts do not get us exactly to our colour representations. The embellished linguistic description does not specify whether the pine cones were from one or other species which might lead to a difference in final dried hue; and the formal process is only as fine-grained as our analysis; It does not seem possible that we will be able to describe each of the colour representations that humans are able to pick out. It seems that just as we can have no single, perfect translation between sentences from one language into another, we cannot have pure translation between concepts and words.

Evans characterizes the difference between conceptual representations and linguistic representations as the difference between parametric and analogue representations (Evans, 2015). He says that we should think of linguistic representations as parametric, in that the information they contain is highly abstracted from the richness of experience and purely schematic. Whereas, our conceptual representations can contain an incredibly rich amount of analogue information (obviously, some mental representations are likely to be far simpler than this). These analogue representations are simulations of some of the information in world. Linguistic representations should not be seen as representations of information in the world but as a representational format that is a means of communicating our conceptual representations to other speakers; they cannot hope to contain all the information the conceptual representations contain. The fundamental difference in the type of representation each system generates means that it is fundamentally impossible to translate exactly the information stored in one form into the other, yet somehow communication continues.

The preceding arguments against Pure Translation merely trade on intuitions gathered from the experiencing the difficulty of expressing our thoughts and cannot possibly hope to do justice to the problem as a whole. However these intuitions are supported by the conclusion of the three preceding chapters that the relationship between lexical items and conceptual representations is complex and leads to interesting cognitive effects. We should then reject Pure Translation exactly because these, and linked investigations, illustrate that the complexity of language system leads to cognitive behaviours that the Pure Translation view cannot explain. The complexity of the system as a whole will be brought to light further as we begin to produce our taxonomy of the various different mechanisms of interaction between language and thought, and this complexity is the ultimate argument against Pure Translation.

By assuming a Pure Translation view Carruthers neglects to investigate the possibility that the nature of the mechanisms language evolved to meet communicative needs might themselves be the source of rich and interesting cognitive behaviours; the very kinds of behaviours that Carruthers tries so hard to attribute to language via ascribing it other, more elaborate computational functions, distinct from its communication functions.

We have seen how Carruthers, in constructing his taxonomy leads us to believe that only what the terms cognitive functions of language can go on to have further roles in our wider cognition by performing explicit computational tasks and that the communicative functions of language are without further downstream cognitive effects. So, in his attempt to draw our attention to the cognitive, computational role of language he actually draws us away from seeing the vast cognitive impact that the normal, *communicative* functions of language produce downstream. As we saw in the foregoing case studies, these functions can explain the behavioural data that Carruthers cites in support of his vastly overpowered computational version of the language faculty.

I believe therefore that we should distance ourselves from Carruthers's distinction; his characterisations of both the computational and communicative sides of language fail to do justice to how language truly interacts with thought. The first does not accurately represent the functional capacities of language, and overstates the computational power of the language faculty, leading us down a misleading route when looking at human intelligence in a wider sense; the latter oversimplifies the situation in such a way that there is no room for language to be particularly important or interesting at all.

Part 2. Communication without Pure Translation

Before we proceed with producing a taxonomy of the mechanisms by which language does interact with thought, we should clarify how the language faculty meets the requirements of communication. By understanding the ordinary workings of the language faculty, we will be better able to understand how the interesting cognitive effects it generates arise and how they can best be categorized. The upcoming sketch of language comprehension and production is not meant to be definitive, it just provides a plausible account of the language faculty that does not rely on translating conceptual representations into commensurable linguistic representations, it is a fleshed-out version of the account of language that I begin to develop in the preceding chapters. Instead of seeing the role of language as translating thoughts from pre-linguistic cognition, it sees language as activating lexical items in response to the activation of conceptual representations; the job of the language faculty then is to ensure, through syntactic and semantic rules, stored as part of the lexicon, that the sentences produced are grammatical and sensible. Such an account mitigates the need for there to be representations produced by the language faculty that directly correspond to our conceptual thoughts.

As already discussed, there are two distinct levels of representation in the human brain, firstly the homogenous, unified format of linguistic representations, and secondly a vast array of different conceptual representations that are produced by different conceptual modules and do not share a unified representational format. By looking at each in turn we will better be able to see how they might relate to each other.

First let us look at the representations produced by the language faulty: these are linguistic representations and are seemingly domain-general, insofar as they can be represent anything. Complex linguistic representations or strings of internal monologue, are made up of atomic elements called lexical items. Lexical items are akin to words in spoken language. The lexical items are stored in the lexicon, a subsystem of the language faculty. Lexical items are connected with particular conceptual representations via a series of access points. The activation of a lexical item, either during comprehension or production of sentences, leads to the activation of the conceptual representations it is associated with. Lexical items can have access points in more than one conceptual representations, this happens when words have two meanings. For instance, the single lexical item 'bank' has (at least) two access points to the conceptual representations BANK [FINANCIAL INSTITUTION] and BANK

[RAISED EDGE OF RIVER]. Which one is activated on hearing the word "bank" is determined by the context of the heard word. A word's meanings may be closely related, in which case perhaps the access points link to two closely related conceptual representations, or they may be very distinct and therefore have access points in unrelated sections of the conceptual system.

The picture of the lexicon I favour has lexical items for each sense of a word, much like how a dictionary has separate entries for different meanings of words. Though this might lead to an easier account of sentence comprehension (as the language faculty has less work to do in working out which particular conceptual representation associated with a lexical item is fired, so long as the right lexical item is), I worry that in this case the lexicon is charged with having too heavy a burden of storage. Though it is not clear how we might go about measuring the limits of the lexicon's storage capacity we should nonetheless favour the more modest account when it comes to prescribing mental storage capacities.

Further, a system of lexical representations with potentially numerous access points to different, unrelated, conceptual representations, as opposed to a system that has a separate lexical item for each sense of a word, alleviates the problem of having to give criteria that specify when a related, but subtly different, sense of a word warrants a lexical item all of its own. For instance in the case of 'bank [financial institution]' and 'bank [raised edge of river]' it is clear that these two items might warrant different lexical representations but it is not clear whether the word 'bank' when used to refer to raised earth boundaries around a clearing or park would warrant a separate lexical item to 'bank [raised edge of river]' given that they are such closely related meanings. Under an account that sees the lexical item 'bank' having links to many conceptual representations, including but not limited to, RAISED EDGES and

RIVER and FINANCIAL INSTITUTION it is clear that in the case of talking about park boundaries only the first conceptual representation is appropriate to this particular tokening of the word “bank”, we do not need to worry about whether or not a new lexical item is required for this sense of the word, as in our account this new sense is only activating one element of the larger nexus of conceptual associations of the lexical item, for these reasons I believe we should favour a view of lexical items that have a variety of access points to deal with words having many meanings over a system that proposes many distinct lexical items for each meaning a word has.

Such an account turns on the idea of a lexical item activating the appropriate conceptual representations relative to the linguistic context the lexical item was used in. For this to work we need a system that responds to different semantic and syntactic contexts. This requires at least some information to be stored as part of the lexicon. It is fairly uncontroversial that the rules that help us understand syntactical context are stored as part of the language faculty and that lexical items contain syntactic information pertaining to their proper usage and during language use. For example when we hear the word “lead” (pronounced lɛd) used in the context of a noun we activate the conceptual representation of a heavy malleable metal and when it is heard in the context of a verb we now activate the conceptual representations associated with GUIDING. Syntactic context clearly constrains which associated conceptual representation should fire during speech comprehension. Thus the syntactic information stored as part of the lexical items helps guide meaning construal.

However, I also believe that a similar system is in operation for semantic contexts too. To ensure that we are understood we must produce sentences that are semantically as well as syntactically sound – as a request such as “could you get the milk out of the table for me please?” is just as improbable to produce and impenetrable to understand as “can you please get a milks out of the fridge for me please?” We do not tend to pass over semantically nonsensical sentences smoothly, we stumble over them and rarely produce them. And if we do hear a nonsense sentence we do not activate the nonsensical conceptual representation expressed in the sentence unless it is in a very deliberate context which encourages us to do so – such as surrealism or a joke. On hearing a semantically nonsensical sentence we ignore it, rewrite it or question our own understanding of the words involved. This behaviour I believe shows that we are just as tuned in to semantic context as we are to syntactic.

To achieve this sensitivity to semantic context, lexical items have access points between themselves, that increase the chance of the associated lexical item being activated when they are activated, and these access points effectively follow meaning associations. For instance, the lexical item ‘glove’ might be associated with ‘hand’ and ‘clothing’. This means a degree of semantic information is effectively stored, not as part of the lexical items themselves but as a function of the nexus of associations between the lexical items, encoded in the relationship between words that are laid down as we learn a language. The lexical item ‘glove’ therefore does not contain the information that gloves are clothes for hands, it just happens by virtue of learning associations to be connected with the lexical items ‘clothes’ and ‘hands’, because during learning it was heard in contexts with these other lexical items. Once these associations are established and we hear a sentence in which a lexical item is fired that does not fit in with the semantic context built up by the firing of lexical items over the course of the sentence, then we notice this: it was not what was expected to fire, just like when we hear a sentence that contains a syntactic mistake, and it stands out and surprises us.

There is a danger that by ascribing lexical items too much semantic information we make them into quasi-conceptual structures. However, under this picture a degree of semantic information is stored as a set of associations learnt through normal language learning between lexical items, meaning that we have enough semantic information to ensure the correct, context-appropriate conceptual representations are fired during language processing, but not so much that we begin to treat the lexical items as rich, information-containing structures. We should see the lexicon as a whole, rather than the lexical items individually, as containing a relatively sparse degree of information instantiated through associations, and only enough to allow effective communication. Linguistic representations do not contain rich amounts of information about the world.

Conceptual representations

On the other side of the mental representation coin we have the conceptual representations, these are the rich information-containing representations. There are various different forms of conceptual representations in the brain, collectively representing all the elements of reality to which we can cognitively respond. The different types of conceptual representation are all the products of distinct conceptual modules, where each of these modules presumably evolved to meet some distinct cognitive problem. The workings of these modules are, for the most part, inferentially isolated, and are conducted in their own particular representational format; further, we are equipped with no domain-general faculty in which the different forms of conceptual representations can be cognized together. The conceptual representations then lead an isolated life, each guiding cognitive behaviour in their own particular domain. The degree of isolation of the conceptual representations is quite striking at times; we have seen that even when the conceptual representational faculties have overlapping remits, they do not interact with each other and produce incommensurable representations of the same situation. This is so in the case of the geometry and landmark recognition modules, which both take their inputs from the visual array and produce representations of space, though they represent different elements of the visual array.

The conceptual representations contain rich information about perceived reality. These representations in some cases might be accurate models of certain elements of the environment, as with the geometry module, which we use to guide further problem solving; and in other cases they might be triggers that fire in response to certain stimuli that modulate further cognitive behaviour downstream, as with the disgust response firing at watching others pulling a gape face after eating something and then later avoiding that thing as a potential food source. In this case, the disgust module represents certain things as disgusting not by creating cognitive models of the world, but by triggering in response to some element in reality; in a similar way that a light on the washing machine that tells us the washing is done: the light does not represent a rich model containing information about the state of the laundry but is just a programmed response to something happening (in this case the washing cycle finishing) that guides our behaviour downstream.

Conceptual representations get fed downstream to other conceptual faculties that take them as an input, until eventually we get to a faculty that is set up to instigate evolutionarily adapted actions. In this way, our conceptual representations eventually lead to context-appropriate action without the need for a central intelligence to work out the best possible course of action. As an example of how this complex context-appropriate behaviour can arise without a central planning intelligence we can think of an ant trying to navigate its way back to the correct entrance of the nest: it will walk around the nest until the visual image of the nest matches the representation of the nest stored in the visual landmark recognition faculty. This matching event will trigger some cognitive activity downstream that results in the ant proceeding forwards, towards the nest(Judd & Collett, 1998). In this fashion, the ant returns to the nest without ever having to entertain general conceptual representations of needing to walk towards the right entrance. This sort of behaviour avoids the requirement for a general conceptual representational capacity to be able to respond to complicated stimuli; so long as the module has evolved to represent and respond to appropriate elements of the world to solve the relevant problems. Obviously the cases of ant-navigation and human conceptual thought are distinct and might arguably be solved on a different computational level, but I believe the lesson that complex behaviour can arise out of simple modular activity is one that should be taken on board.

The above example exemplifies the lack of flexibility inherent in modular accounts of the mind, which often claim that there is no general representational form that all concepts take. Such a representational format is unnecessary if there is no domain-general conceptual device with which to think. All these various forms of conceptual representations are entertained by cognitive faculties adapted to them. Under such accounts, we have a picture of the mind full of distinct conceptual representational faculties, producing conceptual representations of different aspects of the world that together allow us to respond appropriately to the situations we find ourselves in.

So how do the linguistic representations interact with the conceptual representations?

So if we wish to distance ourselves from a Pure Translation view we are left with? What is the nature of the interaction between the two levels of representation? One possibility is that there are two sets of relationships, or access points. Firstly, access points between lexical items and secondly access points between conceptual representations and lexical representations[8]. Let us look at speech production and speech comprehension in turn to see how each set of access points plays a part within these wider processes and allow us to deal with the difficulties associated with polysemy and ambiguity.

In the most straightforward case of speech production, the conceptual representations we want to express linguistically are activated by perceptual or cognitive stimuli. Through the access points these conceptual representations have in the lexicon, various lexical representations are activated, those lexical items which are most strongly activated form part of the complex linguistic representations we are constructing, in accordance with the rules of syntax inherent in the speech production subsystem. Obviously, there are always myriad words that might be chosen to express any given concept and so often the firing of a conceptual representation might partially activate a number of lexical items, the basic function of the speech production subsystem is to pick the most highly activated one.

When a lexical item is activated, potentially after being activated by association with a conceptual representation, it activates any associated lexical representations with the same effect as if a conceptual representation had

[8] There is a third set of relationships I have not mentioned here: the sets of relationships between conceptual representations. I will not discuss them here, but it is obvious that conceptual relationships will interact with each other to some degree but as we are investigating the functioning of the language faculty in cognition, the interrelationships of conceptual representations must remain outside of the scope of this thesis.

activated a lexical item; this process is called lexical priming. Lexical priming means that during speech production, saying one word activates, and thereby makes more likely to be said, any lexical items that it has access points to. When we come to select the appropriate word, any lexical items that are primed are more likely to be incorporated into the larger linguistic representation than those that are not. Often there will be lots of lexical items that have been primed by the context built up by the preceding sentence, the one that is activated most strongly, by either lexical or conceptual representations, will be incorporated into the overall linguistic representation. Once this new lexical item has been activated, it will in turn prime the lexical items it has access points in, and these activations will compound the existing pattern of priming, building up an ever richer lexical context that guides further speech production. It is through this means that both semantic context and the pattern of fired conceptual representations simultaneously guide speech production.

This claim is anecdotally supported by the observation that if you have been talking on one specific topic for ages, then suddenly come to talk about something entirely different, there is still a propensity to use terms and words from the initial context as though, despite the change in which conceptual representations are firing (which reflects the change in topic), the lexical items to do with the initial topic are still activated (and therefore still likely to be incorporated into speech) by having previously been primed by associated lexical items from within this topic's particular vocabulary.

The relative importance of the lexical and conceptual priming during sentence production is dependent on the nature of particular lexical items. Some lexical items have very strong lexical associations, and only a few weak conceptual associations, and are more likely to be primed linguistically; these are words that that have almost no meaning and are only ever used in certain linguistic contexts: for instance the lexical item “miny” is more often activated during speech production by being primed by the words “eenie, meeny...” than by any access points it has to corresponding conceptual representations

Lexical priming in speech comprehension

The process of lexical priming also plays a role during speech comprehension by facilitating the grasping of the speaker’s intended meaning. When we hear sentences, the lexical items for each word in the sentence are activated, which in turn partially activate the associated lexical items, and if a given word is partially activated via lexical priming we are then more likely to respond to that word when spoken. So, when I hear someone say, “he was driving a Rolls…” my lexical items ‘Royce’ and ‘car’ are primed ready; and so when I then hear the word “Royce” the system is already primed ready to be easily activated. This might seem an overly complex account of listening, but this mechanism is especially important in telling apart words that sound the same, such as “semantic” and “Semitic”.

Beyond this, by firing those lexical items associated with the lexical items for the words we hear, we build up a semantic context which allows us to easily understand which sense of an ambiguous word is meant by the speaker, without having to activate the conceptual representations associated with each possibility, and thereby simulate, each different interpretation. To return to the given example: after our interlocutor says, “he was driving a Rolls-Royce,” when he goes on to say, “he must have made a mint,” we know that by “mint” he means lots of money because hearing “Rolls-Royce” will have primed our conceptual representation of WEALTH, and the conceptual representation of the confectionary never gets fired (though it might turn out later that we were mistaken, and the man in question was in fact the CEO of Humbug & Humbug Mint co.).

So, say we hear the sentence, “he was driving a Rolls-Royce, he must have made a mint,” when we hear the word “driving” it primes not only our lexical representation ‘drive’ but also perhaps ‘car’, ‘road’, etc. The semantic background begins to take shape. If we were a golfer we might also have a competing context of golfing being formulated, but the car context is confirmed by hearing “Rolls-Royce”. At this point we have pinpointed the meaning of the words in the first phrase and a mental picture of a man driving a Rolls-Royce might have been generated by virtue of the activation of the atomic conceptual representations. The semantic context generated via the associations between lexical representations ensures that the correct associated conceptual representations are fired and we activate only the appropriate conceptual representation, and thereby generate hopefully a similar pattern of conceptual activity as the one the speaker intended us to have.

We can see then that both the understanding of sentences and the choice of words during sentence production are mediated by the relationships among the lexical representations. This mechanism allows us to overcome the problems of polysemy and ambiguity during speech production and comprehension. It is with this more variegated understanding of how words mediate which conceptual representations are activated that I think we are best able to see how language might have interesting effects on cognition.

Part 3. Mechanism and taxonomies

So how might normal language function, so conceived, affect cognition in ways that the Pure Translation view might overlook? The answer lies in the complex interactions of the access points between representations. Different systems have evolved, adapted themselves or been developed to exploit these interaction patterns to produce novel types of cognitive behaviour that we are not consciously aware of as being linguistic in origin but which are not feasible in the absence of language.

Over the course of this thesis we have looked at a number of different ways in which it has been suggested that language leads to increases in cognitive capacity, and how it is tempting to claim that language is responsible for the cognitive advantage we seem to have over non-linguistic thinkers. Now it is time to look at the scope and limits of the effects of language on cognition, and how much importance we should credit language with when investigating particularly human cognitive capacities.

My aim in this section is to group and categorise certain cognitive behaviours, involving the language faculty, that go beyond what a Pure Translation view might expect of language. I will explain briefly their workings in terms of the foregoing account of language. Further I will extrapolate, from the in-depth case studies of the previous chapters, general claims about language’s role in cognition and also touch on a few new case studies. We will also go on to look at some other contemporary theories of language’s role in cognition and see how they fit into our picture of the language faculty.

I have divided these various mechanisms into two main groups. They are not grouped so much by the nature of the workings of the mechanisms, for I believe that all the mechanisms by which language leads to interesting and novel cognitive behaviour, beyond that which is predicted by the Pure Translation view, are grounded in the same set of mechanisms that have evolved to deal with the problems associated with communication; but rather they are grouped by their differing ability to be consciously utilized by speakers. Firstly, we have the changes language causes in cognition that are invisible to us, these are system wide-spread changes that arise from the increase in potential patterns of activation opened up by the nexus of access points embodied by the language faculty. And secondly, we have those mechanisms where we actively use features of the language faculty to achieve cognitive ends that are not necessarily communicative. We might call the categories "implicit" and "explicit" effects on cognition, but I prefer the terms "systematic mechanisms" and "cognitive tools".

Though I have framed each of the mechanisms below in terms of the access points account of language functioning I favour, the taxonomy itself does not stand and fall with this account and each class of mechanism might just as well be framed in any alternative framework; the empirical phenomena (including those looked at in the preceding chapters) are the basis for the divisions of the taxonomy, and come before the framework into which they have been placed. I have described each type of mechanisms within the framework of the access points account because I believe it allows us to highlight the subtle differences between the mechanisms, while simultaneously illustrating the point that that they all arise from the functioning of a unified and consistent language faculty.

1: Systematic mechanisms

This category covers those effects that language has on cognition that are system-wide, as opposed to task-focused. They focus around the effects which language's ability to cause novel activation patterns of conceptual representations has on downstream behaviour. As we shall see the novel activation patterns that are made possible by the nexus of access points between linguistic and conceptual representations we lay down as we learn a language. We are not consciously aware of these processes happening and so it is hard to judge intuitively just how widespread they are or how important we should view them in terms of accounting for those uniquely human cognitive capacities.

1.1 Flexibility

The language faculty introduces an element of flexibility into the modularly structured mind[9]. By using the term "flexibility", I do not mean to suggest that possessing a language faculty endows us with the power to engage in totally domain-independent rational thought, but more modestly, that we are potentially able to respond to perceptual stimuli with conceptual responses that differ from those that the pre-linguistic modular system would otherwise respond with.

We came across this kind of flexibility in the case of navigation. To recap: when a lexical items fires in response to the activation of a conceptual representations (itself triggered by perceptual cues) the lexical item in turn activates other conceptual representations it is associated with, which themselves were not fired by the perceptual cues. In the case of reorientation, in which humans attend to two sets of conceptual representations of space simultaneously where non-linguistic animals do not, the geometry module is activated after being disorientated, which in turn activates the linguistic representations associated with the conceptual representations of the geometry modules via the process of lexical priming, in this case perhaps 'left' and 'right'. This lexical priming is a normal part of the language faculty's functioning, that

[9] I am not claiming by this that it is the only source of flexibility as I am not tied to a traditional Fodorian account of modules as necessarily inferentially isolated.

ensures ready communication. These activated lexical items in turn trigger the other conceptual representations they are associated with, in this case the representations of the landmark recognition module.

Via the patterns of association and activation in lexical and conceptual representations, the language faculty allows two conceptual representational faculties of the brain to be activated simultaneously and attended to in action planning, which would not happen in the absence of language. The upshot of this is that humans are able to respond to a greater number of stimuli simultaneously which gives rise to the flexible reorientation behaviour that characterizes human navigation.

This mechanism has come about because we have a linguistic system that deals with the problems arising from communicating information from two different pre-linguistic conceptual faculties with overlapping remits, by having them share lexical items. It seems likely that there are many conceptual faculties that will have overlapping remits and therefore shared lexical items; and it therefore seems likely then that the mechanisms like those seen in navigation may well occur frequently.

I suggest that social cognition might offer a particularly rich topic of research in trying to identify more cases of such a mechanism. The overlapping use of lexical items used to communicate representations from the cognitive faculties tasked with knowledge ascription, emotion gauging and facial cue reading cognitive faculties suggests that this domain might be rife with interesting linguistic effects (see (J. G. De Villiers & De Villiers, 2000), for one potential account of language's role in social cognition).

This account of flexibility in cognition offered by language should be contrasted with that proposed by Carruthers (Carruthers, 2002; 2006) and Mithen (Mithen, 1996), who suggest that language provides flexibility by allowing us to combine any pre-linguistic conceptual representations into one single lexical representation, effectively bypassing the encapsulation that a modular architecture hardwires into our cognitive systems. Unlike with Carruthers's account, I am not suggesting that language provides a novel means of representing information from distinct conceptual modules; we are still left with the same representational capacities, but we are just not bound by their original adapted activation cues to utilize them. Through language old conceptual representations can be co-opted into serving other ends. Under this account, language brings flexibility to cognition because it allows our traditional conceptual representations to fire in response to novel stimuli, as mediated by associations with lexical items.

These novel activation patterns of conceptual faculties may seem relatively insignificant but they can lead to novel behaviour by creating action plans that respond simultaneously to two distinct conceptual representations that would not have been formulated in the absence of language. However, during these novel activation patterns it does not seem to us like we are performing any particularly remarkable or difficult cognitive feat; think about how it feels to reorient yourself – it does not feel to us like we are engaged in some particularly advanced cognition. Despite the evidence that shows it to be a significantly more complex process than those found in even our closest animal relatives, it just seems like normal brain functioning. Because of the imperceptible nature of the process it is very hard to judge through introspection how widespread or significant these kinds of processes are in a wider sense of cognition without empirical investigations, like the ones that highlighted the interesting way humans navigate. I am inclined to believe that the flexibility language endows us with has a subtle effect on cognition but on a wide scale: anytime we use words that have more than one conceptual access point to describe a situation they may well be priming other cognitive representations to fire and accordingly leading us to form action plans that would not be available to non-linguistic animals.

The limits on flexibility are determined by the nexus of relationships; learning any given language involves establishing in the speaker a different set of lexical representations and associations between those lexical representations and cognitive representations. The make-up of the nexus of access points will determine what associations are made between conceptual modules and will delimit what potential cognitive behaviour language might engender. The degree of flexibility is, in another sense, limited by the demands on language for communication: words that have lots of meanings, and therefore lots of conceptual access points, may well increase the opportunities for flexible application of conceptual representations, but if a word has too many meanings it is prevented from being a practical tool for communication; it can become just too ambiguous. If a word has an impractically large range of meanings, and the ambiguity amongst them is detrimental to effective communication, it will eventually drop out of the lexicon, being replaced by other terms - they are to borrow Dennett's genetic analogy, unfit (Dennett, 2009). Therefore, the defgree of flexibility that language adds to the modular framework is delimited by the nexus of connections between lexical items and conceptual representations; which in turn is moulded by social factors and the requirements for communication.

Another limit on the scope of this mechanism to shape cognition comes from the fact that not all the conceptual representations that get primed via lexical means during cognition will go on to be incorporated into action plans, if say they are not activated strongly enough or if the representation is not pertinent to the current cognitive problem being faced. We saw that in the navigation case the landmark recognition module is adapted to representing the situation being dealt with, and so the conceptual representations it generates of the situation also get fed into the action planning faculties, and accordingly we respond to the problem of reorientation with an action plan that attends to conceptual representations from two distinct conceptual faculties. But during other occasions the activation of a second cognitive module via lexical means, akin to how the landmark recognition module is activated in the navigation example, might not lead to the formation of action plans that contain information from two pre-linguistic representational sources because the second module that is activated is either only partially activated or does not generate appropriate representations of the given situation. Just because lexical items have access points in two very distinct conceptual representations they do not necessarily go on to get conflated or used together during cognition; if one simply has no bearing on the situation and is therefore not at all activated by other perceptual or conceptual stimuli, it will not be incorporated into an action plan. Again, we can see that the kind of flexibility I am talking about is far from the totally domain-general kind of intelligence that other commentators propose language grants us.

1.2. Expansion of the domains of emotions

There is an important subset of the flexibility mechanism that we addressed in the chapter on swearing. This is the use of language to expand the domain of our emotions, leading to an emotional response that has evolved to guide behaviour in one scenario becoming applicable to another.

The case study we looked at demonstrated language's role in the spreading of the basic emotion of disgust, which primarily evolved to limit the risk from the spread of disease (Rozin et al., 2008), into the realm of social and moral behaviour. Through swear words, language facilitates the expansion of disgust's applicable domain.

The mechanism outlined for disgust, relied heavily on the particulars of the pre-linguistic disgust response's propensity towards spreading through contagion; which does not seem to be a quality shared by all other emotions (though laughing appears to spread happiness in a similar way). So, should we think that this type of mechanism is restricted to disgust only or might there be other cases where linguistic functioning has led to the spread of an emotion traditionally associated with one situation to be used in another? Cognitive domains that might yield positive results are those where a noted emotional response is at odds to the one we might expect. Two examples that spring to mind are euphoria at physical pain in zealous religious practices and *gallows humour*: the propensity to laugh about even the most serious and dangerous situations. Both examples are interestingly also associated with their own particular and peculiar form of language use, and the occurrence of both behaviours is associated with a particular and unusual type of linguistic practice. In the case of religious self-flagellation we have the overwhelming language of revelation and almighty godly redemption, a linguistic form very far removed from the quotidian linguistic practice of describing perceptible existence. And in the case of gallows humour we have the linguistic practice of making jokes by playing with the relationship between the situation and the language we use describe it, to make light of even the most serious or sombre of situations. This is a deliberate abuse of the normal practice of language to describe things accurately.

Both cases require further investigation to test this hypothesis but I am sure with enough looking we will find more cases where language has played an important role in the spread of an emotion's domain. It will probably be the case that, where the spreading of emotional responses from one situation to another has happened, it may not even have been noted it is felt to be normal and appropriate. This is why the people quizzed about disgust elicitors, in Haidt's studies, saw nothing interesting or notable in describing both bloody wounds and ambulance-chasing lawyers both as disgusting (Haidt, Rozin, Mccauley, & Imada, 1997). To us disgust feels just as appropriate a response in the extended context (moral disgust) as in the context the response originally adapted to (visceral); it is not consciously clear to us when an emotional response's remit has been extended and so perhaps other emotional responses might also have been extended via this linguistic mechanism without our recognizing which ones. Without further investigation, it is hard for us to assess how widespread the mechanism of language extending the remit of our evolved emotional responses is.

1.3 Thinking for Speaking

One of the most important accounts of the interaction between language and thought in recent years is Dan Slobin's Thinking for Speaking hypothesis. He suggests that instead of looking for areas where language appears to determine the categories of perception, as the traditional linguistic relativity supporters have done, we should look more seriously at the implications of speaking one language, rather than another, has on the processes of encoding experience (Slobin, 1987 1996;). He suggests that the language we think we are going to be reporting experience in changes which elements of experience we actively pay attention to. To give an example, it is obvious that speakers of all languages can attend to the number of objects in the visual array but English speakers necessarily have to encode this information if they are to make grammatical sentences about any given situation, since English requires that we specify whether there is one thing or many things being talked about via a system of pluralization. On the other hand, in some languages there is no such requirement, for instance Turkish has no grammatically mandated pluralisation, so any number of cups on a table could be talked about without ever having to reveal whether there was one or more than one, this is impossible with English's pluralization system. Further Turkish requires other information to be encoded in order to make grammatical sentences, including some epistemological facts, particularly whether a reported event was experienced first-hand or is known through testimony. Slobin argues that the grammatical requirements set by each language determine what things we as observers pay attention to during experience, and channels our attention and therefore to some degree our cognitive behaviour.

How does such a view fit into our proposed account of language? The grammatical requirements on sentence production of a given language are instigated by controlling which lexical items are primed during experience. Whenever conceptual representations are activated through perceptual stimuli, the corresponding lexical items are primed ready for us to communicate our experience and use it. We have seen already that which lexical items are activated though heard speech can have significant cognitive effects downstream by activating interesting conceptual patterns that might not otherwise be triggered. It seems like Slobin's thinking for speaking mechanism might offer the same sort of rippling effect, where different languages spoken by people will trigger the same perceptual experiences to trigger different lexical items, depending on the grammatical requirements of each language. These different patterns in turn will activate different conceptual representations depending on the make-up of the access points between lexical items and conceptual representations.

It is not clear how much effect Slobin's account of thinking for speaking will have in the wider cognitive behaviour of an individual but the account of language that we are working with indicates that some effect is indeed likely and so I include it here, even without the solid case studies we have in place that we have for the other mechanisms.

2. Cognitive tools and lexical items

The second set of mechanisms by which language affects our cognition I am calling "cognitive tools". They are mechanisms and techniques which we can actively engage in to achieve cognitive ends. Through practice (either as a society or as individuals) we have learnt ways of using the workings of the language faculty to achieve non-communicative goals. The effects are much more explicit effects than the ones looked at in the previous section, though perhaps have less wide-reaching consequences. These mechanisms see linguistic representations not as merely alternative translations of the conceptual representations but as independent cognitive entities that can be entertained and utilized in ways that differ to the ways we cognize and utilize the pre-linguistic conceptual representations.

2.1. Lexical representation as memory

In the chapter on numbers we saw that one of the pre-requisites of learning the meanings of the number words was the ability to learn, by rote, ordered sets of meaningless symbols. This ability was facilitated by the mechanism of lexical priming, which meant that the deliberate activation of the first lexical item in the list activated the following one and this in turn activated the one after that, thereby allowing us to activate in order the lexical items in the list without requiring us to store the information about their order explicitly in some other cognitive repository. The ability to easily recall large strings of lexical items can be exploited to help aid memory of information that might be beyond other memory capacities.

The mechanism of lexical priming, necessary for effective communication, can be deliberately co-opted during cultural practices (teaching children to recite ordered lists or rhymes) to serve another purpose, as a means of remembering large quantities of information. And we often use linguistic tools to help us remember things that we could not remember otherwise. A good example is telephone numbers: we often store telephone numbers not as an accurate number representation but as a linguistic pattern. And, though we cannot extract from that verbal pattern information about parts of the number because it all depends on the production of the linguistic representation via lexical priming it does allow us to remember a series of digits that is beyond our capacity to recall otherwise. Another common example is the mnemonics which we are taught to help us remember semi-arbitrary rules that we might not be able to entertain or remember conceptually, such as the number of days in the month, or the colours of the rainbow. Even knowing the alphabet is for most of us nothing more than the ability to rattle of the letters in the correct order, which we do via lexical priming. Saying "a, b, c, d, …" sets up such a strong lexical priming condition that it becomes almost impossible for us to say anything other than "e" and so forth. In this situation, the role of lexical priming is so strong that only very deliberate cognitive behaviour can make us alter the course of speech production and say a different term.

The claim that the alphabet is stored solely as a function of the lexical access points between the lexical items that make it is supported by the difficulty we have in manipulating the information contained in the list to achieve different tasks, such as saying the letters in the reverse order, saying whether a letter comes before or after another one, or saying what position a letter comes in the alphabet. If the alphabet was stored as part of the conceptual system we would expect that we would be able to perform conceptual processes over these representations to yield these answers easily.

The skill of remembering the larger linguistic representation works by setting up strong access points between the constituent lexical items via deliberate over-learning of linguistic representations, i.e. repeating a phone number over and over to ourselves. This system does not work by remembering the required object as a whole – there is not a lexical item of the whole alphabet, but instead, the recall of the whole pattern works by laying down access points between the atomic lexical items that make up the pattern. By exploiting a feature of the workings of the language faculty we are able to utilize it to perform cognitive behaviours that would otherwise not be possible.

2.2. Bootstrapping

Further, we saw in the chapter on number, that the ordered lexical lists learnt by rote provide the foundations for the development of number concepts via the bootstrapping process. We should conclude that language is essential in our conceptual development in a more significant way than just being the means by which we learn about concepts that are beyond our perceptual faculties.

Carey and others (Carey, 2004; 2009); (Beck, 2017) suggest that the bootstrapping process is responsible for the development of many of our more advanced conceptual representations. Besides the case of number which we have looked at, Carey also suggests the possibility that the bootstrapping process is key to overcoming the developmental discontinuities in theory of mind reasoning (Carey, 2009; 2011) and it seems likely that a bootstrapping mechanism is behind the development of lots of our more complex concepts.

I am fairly confident that it is the formation of the ordered sets of lexical items, whose order is determined and stabilized by the set of access points, which provides the prerequisite ordered set of empty placeholders required for the bootstrapping process to take place, and so we should consider language a fundamental tool in the bootstrapping process. However, whether language plays a role beyond just providing the placeholders is a different question; the investigation into the problem of learning number concepts makes me suspect that it does. In the chapter on learning number concepts we saw that the language faculty, as well as just being the means by which we remember and entertain the blank placeholders, also guarantees that the process of bootstrapping can take place by offering a firm and stable order that means that crucial inductions can take place by offering repeatable experiences; the linguistic code guides the non-linguistic inductions by ensuring that the mental objects which induction operates on always occur in a stable order.

2.3. Scaffolding action

We can use language to structure our environments in such a way as to make it easier to complete complicated actions. This is especially true of situations in which we are learning novel actions, that we do not yet understand fully; and research shows that a properly structured linguistic environment makes it possible for children to complete tasks that would otherwise be beyond them, such as tying a shoelace (as reviewed in (Berk, 1992)).

The simplest way a learning environment can be structured is by a teacher telling the learner how to complete a task by breaking it down into a series of simple action instructions. Under the guidance of these instructions a child might succeed where otherwise they might fail. But we do not need to rely on external guidance for long. By remembering the instructions linguistically children can then call them up and recite them to themselves and thereby direct their own actions. Evidence that this system of reciting remembered instructions to oneself does enhance children's cognitive abilities comes from Berk and colleagues; who show that children engage in self-directed speech more when task demands are greater, indicating that it is a strategy employed when faced with a difficult problem, and moreover, are more likely to succeed than those children that do not engage in self-directed speech (Berk, 1985; 1992).

And this is not a cognitive tool that is used exclusively during learning: there is evidence that, as adults, we can linguistically enhance our own performance at practised behaviours by engaging in self-directed linguistic instruction. Evans gives the example of a darts player who really does slow their breathing down by telling themselves to, under their breath, before making a shot (Evans, 2015); and in our everyday lives, we often talk ourselves through a complicated procedure before embarking upon it.

The importance of this practice was brought to light by Soviet psychologist Lev Vygotsky, who argued that the kind of talk children engage in during problem solving is not a simple monologue – as Piaget claims(Piaget, 1926) – that is qualitatively different from communicative language in adults, but instead should be viewed as an instance of self-directed communicative language (Vygotsky, 2012). This self-directed language is both practice for future communicative situations and a tool employed during problem solving.

This system works because, as we saw above, we can remember large amounts of information in sentence form without necessarily needing an accompanying conceptual representation of the situation. In this case, these linguistic representations are a series of sentences which each detail some part of the broken-down whole action plan required to complete the overall task. The linguistic representations break down the whole problem into smaller actions that we have the corresponding conceptual capacities to understand and therefore complete.

When we say these sentences to ourselves, the activated linguistic representations trigger the conceptual representations required to complete different stages of the overall task. In this way we can trigger the movement of lifting one end of the lace over the other end of the lace without ever having to represent the topological structure of a bow and work out from this representation an appropriate action plan for completing the bow. This happens in exactly the same fashion as if we had triggered the linguistic representations ourselves, by thinking about how to tie a bow or if we had had specific verbal instruction. The firing of the linguistic representation of 'left end over,' etc. is enough to set off the representations of the appropriate actions regardless of how it was fired. In these situations, language acts as a shortcut for triggering behaviour that we might struggle to understand in a wider context and thereby trigger otherwise. After a while, with familiarity through practice, the action plan for tying a bow gets stored in another mental faculty and we no longer need to repeat the mantra to ourselves to trigger the behaviour.

2.4. Drawing attention: thought as the object of thought

Recent accounts of language by Jackendoff and Clark detail language's role as a cognitive tool that we utilize to expand our cognitive abilities (A. Clark, 1998; 2006; Jackendoff, 1994). Both focus on the idea of externalizing thought by distilling it into linguistic objects. These linguistic objects are stable and can become the subject of further computational procedures themselves, outside of the thoughts which original triggered them.

Jackendoff argues that this is the only means by which conceptual representations generated in cognition can come to be analysed in and of themselves instead of merely being had in response to perceptual or conceptual stimuli. Whether he is right that it is the only means that we can come to entertain thoughts about our own thoughts is an issue that is outside the scope of this particular analysis. For our purposes, we just need to assess whether this mechanism is (a) feasible in terms of the account of linguistic functioning we are using and (b) whether it might lead to interesting cognitive behaviours that would not have happened without language.

So, can we adapt Jackendoff's claims to fit within our own account of language functioning? *Prima facie* it seems like there might be trouble, since Jackendoff's story revolves around the ability to consciously entertain thoughts while in linguistic form and analyse them. This is how language apparently allows us to entertain thoughts which otherwise we cannot have – i.e. those about the nature of our own thoughts. One of the key rationales behind our investigation was to move away from accounts of language that see it as a domain-general computational device that can entertain propositionally structured thoughts, that cannot be entertained within one of the pre-linguistic conceptual faculties.

However, if we consider that there is a module that responds to the mental states of our conspecifics, we can see how Jackendoff's proposed mechanism might come about due to the normal functioning of the language faculty. When the language faculty comes to represent our conceptual representations, say for example our being sad, we might form the lexical representation 'I am sad', where the original conceptual representations triggered the activation of the lexical items 'I', 'am' and 'sad'. If the lexical item 'sad' is triggered strongly, as it may well be in this emphatic context, it might activate the other conceptual representations associated with it, amongst which are representations from some faculty that has evolved to represent the mental states of others (such a module must exist if we are to exist in large social groups). The representation SAD (OF ANOTHER) is not produced by the same system that produces our own emotional states and therefore would not have been activated as part of our initial mental state that led us to form the lexical representation 'I am sad'. By this means language sets up a feedback loop by which our own cognitive representations can be analysed by the same faculties that normally respond to the conceptual representations of others.

This is a very hypothetical claim but I am merely trying to show that there is a way that Jackendoff's claims can be understood in terms of an account of language that downplays computational abilities in favour of a rich nexus of associations between lexical and conceptual representations. Jackendoff sees language's role as one of directing attention; it is not clear how to parse this into our account of language functioning but we can see how language might allow us to analyse our own conceptual representations by effectively passing them back to different faculties in the brain.

Conclusion

I hope it has become clear that language produces effects in cognition that go beyond what we expect from a system that sees its role purely as to communicate our conceptual thought to other speakers, by rejecting the Pure Translation view of linguistic communication view we can begin to see that these interesting effects arise out of the normal communicative functions of language and not because of any extraneous computational or representational capacities we might be tempted to ascribe to it. All the mechanisms and case studies we have looked at play on the disconnect between the representational capacity of lexical items and conceptual representations that leads us to interesting cognitive behaviour that we might not have expected under a view of language functioning that assumes a simplistic translation between thoughts and language. The richness of the access points, built up over the course of language learning leads to conceptual patterns firing in the brain that go beyond those that perceptual stimuli alone can cause and so we should credit language with an important role in our cognitive behaviour.

During the course of this thesis I have analysed three different areas of cognition and shown that in each case language plays a role in cognition beyond simply expressing our thoughts, these interactions between language and thought contribute to the richness of human cognitive behaviour. Further, in each of these cases we have seen that language plays a subtly different role. We have thereby shown that language's role in cognition is not only more significant than often assumed by cognitive science as a whole, but also more varied than most commentators, even those who think that language has an important role in cognition(Carruthers, 2002; A. Clark, 1998; Jackendoff, 1994), suppose.

Then, in response to the varied mechanisms looked at in cognitive domain I have produced a taxonomy which groups mechanisms by their ability to be actively called upon during human thought and then suggests further avenues of research into which we could look at to fill out the taxonomy further.

Alongside this, throughout the thesis I have begun to sketch out a model of language processing that can accommodate within its framework all the different mechanisms within the taxonomy. Although this thesis does not provide much independent argument for this access point account I believe its ability to incorporate, readily, the different mechanisms the case studies highlight, speaks to its plausibility and suggest it should be developed further. On the other hand, if you are not swayed by the access points view I favour, the taxonomy provides a set of fixed points around which an alternative account of language functioning should be built.

References

Beck, J. (2017). Can bootstrapping explain concept learning? *Cognition, 158*, 110–121.

Beers Fägersten, K. (2007). A sociolinguistic analysis of swear word offensiveness. *Saarland Working Papers in Linguistics (SWPL)* 1. 14-37

Bek, J., Blades, M., Siegal, M., & Varley, R. (2010). Language and spatial reorientation: evidence from severe aphasia. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *36*(3), 646.

Berk, L. E. (1985). Why Children Talk to Themselves. *Young Children, 40*(5), 46–52.

Berk, L. E. (1992). Children's private speech: An overview of theory and the status of research. *Private Speech: From Social Interaction to Self-Regulation*, 17–53.

Bloom, P., & Wynn, K. (1997). Linguistic cues in the acquisition of number words. *Journal of Child Language*, *24*(3), 511–533.

Bransford, J. D., & Franks, J. J. (1971). The abstraction of linguistic ideas. *Cognitive Psychology*, *2*(4), 331–350.

Carey, S. (2004). Bootstrapping & the origin of concepts. *Daedalus, 133*(1), 59–68.

Carey, S. (2009). The origin of concepts.

Carey, S. (2011). Concept innateness, concept continuity, and bootstrapping. *Behavioral and Brain Sciences*, *34*(03), 152–162.

Carruthers, P. (2002). The cognitive functions of language. *Behavioral and Brain Sciences*, *25*(06), 657–674.

Carruthers, P. (2003). On Fodor's problem. *Mind & Language*, *18*(5), 502–523.

Carruthers, P. (2005). The case for massively modular models of mind. *Contemporary Debates in Cognitive Science*, 205–225.

Carruthers, P. (2006). The Architecture of the Mind: Massive Modularity and the Flexibility of Thought. Oxford University Press UK.

Chapman, H. A., Kim, D. A., Susskind, J. M., & Anderson, A. K. (2009). In bad taste: Evidence for the oral origins of moral disgust. *Science, 323*(5918), 1222–1226.

Cheng, K. (1986). A purely geometric module in the rat's spatial representation. *Cognition*. (86)9004 1-7

Cheng, K., & Newcombe, N. S. (2005). Is there a geometric module for spatial orientation? Squaring theory and evidence, *12*(1), 1–23.

Cherniak, C. (1990). Minimal rationality. MIT Press.

Chomsky, N. (1975). Reflections on language. Pantheon Books.

Chomsky, N. (1995). The minimalist program, MIT Press.

Clark, A. (1998). Magic words: How language augments human computation. *Language and Thought: Interdisciplinary Themes*, 162–183.

Clark, A. (2006). Language, embodiment, and the cognitive niche. *Trends in Cognitive Sciences*, *10*(8), 370–374.
Clark, E. V., & Nikitina, T. V. (2009). One vs. more than one: Antecedents to plural marking in early language acquisition. *Linguistics*, *47*(1), 103–139.
Clayton, N., Emery, N., & Dickinson, A. (2006). The rationality of animal memory: Complex caching strategies of western scrub jays. *Rational Animals*, 197–216.
Curtis, Val, Aunger, R., & Rabie, T. (2004). Evidence that disgust evolved to protect from risk of disease, *271*(Suppl 4), S131–S133.
Curtis, Valerie, & Biran, A. (2001). Dirt, disgust, and disease: Is hygiene in our genes?, *44*(1), 17–31.
De Villiers, J. G., & De Villiers, P. A. (2000). Linguistic determinism and the understanding of false. *Children's Reasoning and the Mind*, 191–228.
Dehaene, S. (2011). The number sense: How the mind creates mathematics. Oxford University Press
Dehaene, S., & Cohen, L. (1991). Two mental calculation systems: A case study of severe acalculia with preserved approximation. *Neuropsychologia*, *29*(11), 1045–1074.
Dennett, D. C. (2009). The cultural evolution of words and other thinking tools, *74*, 435–441.
Dewaele, J.-M. (2004). The emotional force of swearwords and taboo words in the speech of multilinguals, *25*(2-3), 204–222.
Ekman, P., & Friesen, W. V. (1971). Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology*, *17*(2), 124.
Ekman, P., & Friesen, W. V. (1986). A new pan-cultural facial expression of emotion. *Motivation and Emotion*, *10*(2), 159–168.
Evans, V. (2006). Lexical concepts, cognitive models and meaning-construction, *Cognitive Linguistics,* Volume 17, Issue 4, Pages 491–534
Evans, V. (2015). What's in a concept? *The Conceptual Mind: New Directions in the Study of Concepts*, 251–290.
Feigenson, L., Carey, S., & Hauser, M. (2002). The representations underlying infants' choice of more: Object files versus analog magnitudes. *Psychological Science*, *13*(2), 150–156.
Fodor, J. A. (1983). The modularity of mind: an essay on faculty psychology, Cambridge, MA: Bradford.
Fodor, J. A. (2001). The mind doesn't work that way: The scope and limits of computational psychology. MIT Press
Frank, M. C., Everett, D. L., Fedorenko, E., & Gibson, E. (2008). Number as a cognitive technology: Evidence from Pirahã language and cognition. *Cognition*, *108*(3), 819–824.
Gallistel, C. R. (1990a). Representations in animal cognition: an introduction. *Cognition*, *37*(1), 1–22.
Gallistel, C. R. (1990b). The organization of learning. MIT Press
Gallistel, C. R., & Gelman, R. (2000). Non-verbal numerical cognition: From

reals to integers. *Trends in Cognitive Sciences*, *4*(2), 59–65.
Garcia, J., Hankins, W. G., & Rusiniak, K. W. (1974). Behavioral regulation of the milieu interne in man and rat. *Science*, *185*(4154), 824–831.
Goldman, A. I., & Sripada, C. S. (2005). Simulationist models of face-based emotion recognition. *Cognition*, *94*(3), 193–213.
Gordon, P. (2004). Numerical Cognition Without Words: Evidence from Amazonia. *Science*, *306*(5695), 496–499.
Haidt, J., Rozin, P., Mccauley, C., & Imada, S. (1997). Body, psyche, and culture: The relationship between disgust and morality. *Psychology & Developing Societies*, *9*(1), 107–131.
Hermer, L., & Spelke, E. (1996). Modularity and development: The case of spatial reorientation. *Cognition*, *61*(3), 195–232.
Hermer, L., & Spelke, E. S. (1994). A geometric process for spatial reorientation in young children. *Nature*, *370*(6484), 57–59.
Hermer-Vazquez, L., Spelke, E. S., & Katsnelson, A. S. (1999). Sources of flexibility in human cognition: Dual-task studies of space and language. *Cognitive Psychology*, *39*(1), 3–36.
Hoey, M. (2005). Lexical priming: A new theory of words and language. Psychology Press.
Hurlburt, R. T. (1990). Sampling normal and schizophrenic inner experience. Springer US
Jackendoff, R. (1994). How Language Helps Us Think, *Pragmatics and Cognition* 4 (1):1-34.
Jay, T. (2009a). Do offensive words harm people? *Psychology, Public Policy, and Law*, *15*(2), 81.
Jay, T. (2009b). The Utility and Ubiquity of Taboo Words. *Perspectives on Psychological Science*, *4*(2), 153–161.
Jay, T., & Janschewitz, K. (2008). The pragmatics of swearing. *Journal of Politeness Research. Language, Behaviour, Culture*, *4*(2), 267–288.
Jay, T., King, K., & Duncan, T. (2006). Memories of punishment for cursing. *Sex Roles*, *55*(1-2), 123–133.
Judd, S. P. D., & Collett, T. S. (1998). Multiple stored views and landmark guidance in ants. *Nature*, *392*(6677), 710–714.
Kelly, D. R. (2011). Yuck!: The nature and moral significance of disgust. Bradford
Laurence, S., & Margolis, E. (2005). Number and Natural. *The Innate Mind: Structure and Contents*, *1*, 216.
Le Corre, M., & Carey, S. (2007). One, two, three, four, nothing more: An investigation of the conceptual sources of the verbal counting principles. *Cognition*, *105*(2), 395–438.
Margolis, E., & Laurence, S. (2008). How to learn the natural numbers: Inductive inference and the acquisition of number concepts. *Cognition*, *106*(2), 924–939.
Mechner, F., & Guevrekian, L. (1962). Effects of deprivation upon counting

and timing in rats. *Journal of the Experimental Analysis of Behavior*, *5*(4), 463–466.
Meck, W. H., & Church, R. M. (1983). A mode control model of counting and timing processes. *Journal of Experimental Psychology: Animal Behavior Processes*, *9*(3), 320.
Mithen, S. J. (1996). The Prehistory of the Mind a Search for the Origins of Art, Religion and Science. Thames & Hudson
Nabi, R. L. (2002). The theoretical versus the lay meaning of disgust: Implications for emotion research. *Cognition & Emotion*, *16*(5), 695–703.
Nemeroff, C., & Rozin, P. (1994). The contagion concept in adult thinking in the United States: Transmission of germs and of interpersonal influence. *Ethos*, *22*(2), 158–186.
Nemeroff, C., & Rozin, P. (2000). The makings of the magical mind: The nature and function of sympathetic magical thinking. In K. S. Rosengren, C. N. Johnson, & P. L. Harris (Eds.), Imagining the impossible: Magical, scientific, and religious thinking in children (pp. 1-34). Cambridge University Press.
Orwell, G. (1990). Nineteen Eighty-Four. 1949. *The Complete Works of George Orwell. Ed. Peter Davison*, *9*, 1986–1987.
Piaget, J. (1926). The thought and language of the child. Jean Piaget New York: Harcourt, Brace, and Company.
Platt, J. R., & Johnson, D. M. (1971). Localization of position within a homogeneous behavior chain: Effects of error contingencies. *Learning and Motivation*, *2*(4), 386–414.
Rips, L. J., Asmuth, J., & Bloomfield, A. (2006). Giving the boot to the bootstrap: How not to learn the natural numbers. *Cognition*, *101*(3), B51–B60.
Rips, L. J., Bloomfield, A., & Asmuth, J. (2008). From numerical concepts to concepts of number. *Behavioral and Brain Sciences*, *31*(06), 623–642.
Robbins, P. (2002). What domain integration could not be. *Behavioral and Brain Sciences*, *25*(06), 696–697.
Rozin, P., & Singh, L. (1999). The moralization of cigarette smoking in the United States. *Journal of Consumer Psychology*, *8*(3), 321–337.
Rozin, P., Haidt, J., & McCauley, C. R. (1999). Disgust: The body and soul emotion. *Handbook of Cognition and Emotion*, 429–445.
Rozin, P., Haidt, J., & McCauley, C. R. (2008). Disgust. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), Handbook of emotions (pp. 757-776). New York, NY, US: Guilford Press.Rozin, P., Millman, L., & Nemeroff, C. (1986). Operation of the laws of sympathetic magic in disgust and other domains. *Journal of Personality and Social Psychology*, *50*(4), 703.
Samuels, R. (2002a). Nativism in Cognitive Science. *Mind & Language*, *17*(3), 233–265.
Samuels., R. (2002b). The spatial reorientation data do not support the thesis that language is the medium of cross-modular thought, *25*(06), 697–698.
Sarnecka, B. W., Kamenskaya, V. G., Yamana, Y., Ogura, T., & Yudovina, Y. B.

(2007). From grammatical number to exact numbers: Early meanings of ‘one’,‘two’, and “three”in English, Russian, and Japanese. *Cognitive Psychology*, *55*(2), 136–168.
Slobin, D. I. (1987). Thinking for speaking. In Annual Meeting of the Berkeley Linguistics Society (Vol. 13, pp. 435-445).
Slobin, D. I. (1996). Slobin, D. I. (1996). From "thought and language" to "thinking for speaking." In J. J. Gumperz & S. C. Levinson (Eds.), Studies in the social and cultural foundations of language, No. 17. Rethinking linguistic relativity (pp. 70-96). New York, NY, US: Cambridge University Press
Spaepen, E., Coppola, M., & Spelke, E. S. (2011). Number without a language model. Presented at the Proceedings of the ….
Spelke, E. S. (2003). What makes us smart? Core knowledge and natural language. *Language in Mind: Advances in the Study of Language and Thought*, 277–311.
Spelke, E. S. (2011). Natural number and natural geometry. *Space, Time and Number in the Brain: Searching for the Foundations of Mathematical Thought*, 287–317.
Spelke, E. S., & Tsivkin, S. (2001a). Initial knowledge and conceptual change: space and number. *Language Acquisition and Conceptual Development*, 70–100.
Spelke, E. S., & Tsivkin, S. (2001b). Language and number: A bilingual training study. *Cognition*, *78*(1), 45–88.
Sperber, D. (2001). In defence of massive modularity. Language, brain and cognitive development: Essays in honor of Jacques Mehler, 47.
Taylor, L. J., & Zwaan, R. A. (2009). Action in cognition: The case of language. *Language and Cognition*, *1*(01), 45–58.
Van Lancker, D., & Cummings, J. L. (1999). Expletives: Neurolinguistic and neurobehavioral perspectives on swearing. *Brain Research Reviews*, *31*(1), 83–104.
Varley, R. A., Klessinger, N. J., Romanowski, C. A., & Siegal, M. (2005). Agrammatic but numerate. *Proceedings of the National Academy of Sciences*, *102*(9), 3519–3524.
Vygotsky, L. S. (2012). Thought and language. MIT Press
Wang, N. (2013). An analysis of the pragmatic functions of “swearing” in interpersonal talk. En: Griffith Working Papers in Pragmatics and Intercultural Communication, 6, 71-79.
Wang, R. F., & Spelke, E. S. (2002). Human spatial representation: Insights from animals. *Trends in Cognitive Sciences*, *6*(9), 376–382.
Whalen, J., Gallistel, C. R., & Gelman, R. (1999). Nonverbal counting in humans: The psychophysics of number representation. *Psychological Science*, *10*(2), 130–137.
Wittgenstein, L. (2012). Tractatus logico-philosophicus. Simon and Schuster.
Wynn, K. (1990). Children's understanding of counting. *Cognition*, *36*(2), 155–

193.
Wynn, K. (1992a). Addition and subtraction by human infants. *Nature*, *358*(6389), 749–750.
Wynn, K. (1992b). Children's acquisition of the number words and the counting system. *Cognitive Psychology*, *24*(2), 220–251.
Xu, F., & Spelke, E. S. (2000). Large number discrimination in 6-month-old infants. *Cognition*, *74*(1), B1–B11.