10.1 General conclusion

The main aim of this dissertation was to contribute to a naturalistic philosophy of science by examining the evolutionary cognitive origins of systematic knowledge acquisition. One key finding is that the distinction between ordinary reasoning on the one hand and mathematical and scientific practice on the other is not as sharp as often proposed. Mathematics and scientific practice are not arcane, highly unnatural forms of reasoning, as McCauley (2000) supposed. To be sure, both require specific institutionalized environments in order to flourish, including ready access to epistemic artifacts that enhance our perceptual or computational capacities like tallies and tokens (chapter 4), measuring devices (chapter 9), symbolic notation systems that help us to circumvent cognitively intractable operations (chapter 5), and the minds of those who work on related issues (chapter 8). But these features are not unique to mathematics and science; they underlie many forms of what Hutchins (1995) has termed “cognition in the wild” (see subsection 1.3.4). Without much exaggeration, formalized mathematical and scientific practice can be seen as exemplars of this form of cognition.

As we saw in chapters 4 and 5, there are several versions of the extended mind thesis. The best-known version is undoubtedly Clark and
Chalmers’ (1998) active externalism, which regards cognition as a coupled cognitive system where, crucially, there is an isomorphism between internal and external cognitive processes (the parity argument). A more radical version, offered by authors like Mithen (2000) and Menary (2007), regards internal and external components of mathematical and scientific practice as complementary parts of an integrated whole. There is no parity required between internal and external cognitive processes, indeed, both can be quite distinct. We have seen that scientific and mathematical practices critically depend and build on cognitive biases that emerge in early development, including an ability to discriminate numerosities in the environment and to make elementary calculations (chapters 2 and 3), a capacity to detect causal relationships (chapter 8), and an intuitive way to parse objects into ontological categories, each with their own inductive inferences (chapter 6). Our evolved human cognitive architecture constrains and guides intuitions and creative processes that underlie scientific practice. As we saw in chapters 8 and 9, acknowledging these cognitive constraints does not compel us to adopt a radically skeptical position that threatens to undermine the naturalistic project. This is because externalized cognitive processes allow us to overcome constraints in human working memory, limits to computational abilities, and even limits in creativity, as in the use of symbols to represent mathematical concepts that are difficult to conceive (chapter 5) and the use of analogies in scientific discovery to overcome the effects of intuitive ontologies in scientific understanding (chapter 7).

10.2 Normative implications

Can we draw normative implications of this research for epistemology and philosophy of science? When Quine (1969a) outlined his “Epistemology naturalized”, he primarily saw epistemology as an annex or a part of science, i.e., epistemological statements as a subset of scientific (psychological) statements. However, several authors (e.g., Kim, 1988; Goldman, 1999) have expressed their dissatisfaction with this description of naturalistic epistemology, because no branch of empirical science (including psychology) specifies normative criteria for justification or knowledge\(^1\). These

\(^1\)However, many psychological studies, especially those on reasoning, are conducted with an implicit normative framework in mind (Elqayam & Evans, in press).
authors argue that naturalistic philosophy should not shirk from drawing normative epistemic implications. Indeed, given that knowledge is an intrinsically normative notion\textsuperscript{2}, taking away all considerations of normativity makes that we can no longer speak about scientific or mathematical knowledge, but rather have to limit ourselves to talk about scientific or mathematical beliefs (Kim, 1988). There are several ways in which naturalistic philosophers can consider normative issues. In his classic essay, Jaegwon Kim (1988) argued that normative epistemic properties, such as justification and reliability supervene on natural properties. For example, from the perspective of evolutionary epistemology (as we saw in subsection 9.3.2), we can expect that some belief-producing mental mechanisms yield reliable beliefs, because in those domains true beliefs are ecologically relevant, for instance, the distinction between what is edible and inedible can be gauged in less than a second by monkeys (Fabre-Thorpe et al., 1998).

Alvin Goldman (1999, 3) argues that all “epistemic warrant or justification is a function of the psychological (perhaps computational) processes that produce or preserve belief” and that the “epistemological enterprise needs appropriate help from science, especially the sciences of the mind.” In a similar vein, Lorraine Code (1996) writes:

Taking the findings of such [psychological] research seriously enables epistemologists to tailor their normative demands to what people can achieve epistemically, to how they tend to process evidence and respond to incongruities. Thus, for example, exhortations about how knowers should go about justifying their probabilistic conclusions […] may be tempered by readings of Kahneman and Tversky’s experiments […] (Code, 1996, 3).

To Code (1996, 3), consideration of Kahneman and Tversky’s research should not lead us to tolerate violations of probability calculus, but rather, to offer guidelines for manageable and realistic improvements in ordinary people’s probability reasoning. As we saw in subsection 1.1.2, not all

\textsuperscript{2}It is intrinsically normative, because most philosophical conceptions of knowledge are still tied to the concept of justification. Although Gettier cases no longer allow us to equate knowledge with justified true belief, the characterization is still a reasonable one that holds in most cases. For a critical recent assessment of this problem, see Gutting (2009, chapter 3).
cognitive scientists agree with Kahneman and Tversky’s (1996) position that human reasoning is fundamentally flawed. Indeed, as we saw in chapter 9, such a position would ultimately be self-undermining. Nevertheless, in chapters 3 and 5, we surveyed evidence from the cognitive science of mathematics that indicates that not all mathematical concepts are equally easy to acquire, and that some difficult-to-grasp concepts need an extensive amount of cognitive scaffolding.

My normative conclusions thus go further than Code’s plea to temper our expectations of ordinary cognition to what can be realistically achieved. Rather, a picture of cognition that is broader than what subjects are capable of in the context of a psychological experiment (in vitro cognition) should also incorporate information on what humans can achieve epistemically when they make use of various cognitive tools, including symbolic notation and epistemic artifacts (in vivo cognition). If we value scientific and mathematical knowledge acquisition, then people should have access to epistemic artifacts and distributed knowledge whenever they engage in these activities, and learn how to work with them. This is especially the case for knowledge that is counterintuitive or cognitively demanding.

Goldman’s (1999, 3) moderate naturalism holds that epistemic justification is a function of the psychological processes that produce or preserve beliefs. As we saw in this dissertation (in particular in chapter 6), there are several psychological mechanisms that produce and preserve beliefs, each of which have their own peculiarities and biases. For example, we saw that intuitive numerical cognition is better suited to smaller cardinalities than to larger ones (chapters 2 and 3), and that intuitive biological cognition is better suited to an understanding of animal development (by postulating invariant species-typical essences) than it is to an understanding of evolution (chapters 6 and 8). However, in order to derive a full picture of epistemic justification, we need not only focus on internal psychological processes—as some naturalistic epistemologists, like Goldman (1999) seem to do—but also on our active engagement with the external environment\(^3\). For example, when I confidently state that

\(^3\)Goldman (1999) is an externalist with regard to epistemic justification. Nevertheless, his position is what Clark and Chalmers (1998) term “passive externalism”, i.e., the justification of a belief depends on its having the right relationship with the external world. Active externalism, as we saw earlier, not only requires the right relationship between internal cognitive processes and the external world, but also an active
10.2. Normative implications

the temperature in this room is $20^\circ$C, the justification of my claim does not come from internal processes, but rather from my ability to read off the temperature correctly from the thermometer. To be sure, my internal thermoreceptive capacity is not unimportant: for example, a room with a thermometer that shows only $20^\circ$C but that feels like it is well over $30^\circ$C can lead one to doubt the reliability of the instrument (given that one has not just exercised, does not run a fever, etc.). The justification for my belief that $4 \times 7 = 28$ stems from both my intuitive representation of numerosity and my immersion in external numerical representations such as number words and arabic digits. As argued at length in chapters 4 and 5, without these external representations we would not be able to make such calculations, or indeed, of representing the natural number 28 accurately. However, intuitive numerical representations continue to play a role in mathematical practice. For example, as surveyed in section 2.4, children with structural abnormalities in their intraparietal sulci, implicated in the intuitive representation of numerical magnitudes, have persistent difficulties in solving mathematical tasks (acalculia) (Molko et al., 2004).

Stephen Downes (1993) has observed that much naturalistic philosophy of science still conceptualizes scientific cognition as a process that goes on inside the heads of individual scientists. Although this is less the case today (see e.g., Giere, 2004), most work that examines normative implications for justification still focuses on individual rather than collective cognition, for example, on biases and heuristics that are typically displayed by individuals in psychological tests. Yet there is substantial evidence that groups of interacting reasoners are less susceptible to such biases and errors (see e.g., Mercier, 2010; Mercier & Sperber, 2011, for reviews). Interestingly, this view of science as a social practice that improves epistemic standards and increases reliability of results has not been widely recognized in philosophy of science. Quite to the contrary, some authors, undoubtedly motivated by social constructivist critiques on scientific realism, hold that social factors have a corrupting influence on science. According to Churchland (1989), for example, if social factors were an influence conceptual change, this would lead to a global skepticism about scientific claims. His concern is rooted in the belief that social factors are somehow extrinsic to scientific practice, and that these engagement with external media.
can easily be disentangled from the scientific process. As a result, most naturalistic philosophers of science have not yet drawn normative implications that take the social nature of scientific practice into account.

In chapter 8, we saw how disagreement and interaction between scientists is an important ingredient of scientific progress. The analytic model speaks against some claims in epistemology that hold that disagreement between epistemic peers is undesirable, or even unjustified. In recent years, epistemologists like Feldman (2007) and Elga (2007) have argued against epistemic peer disagreement. Using simple and clear-cut cases, where the relevant evidence is surveyable and static, they argue that one cannot reasonably disagree with one’s epistemic peers. Rather, they claim that any given body of evidence $E$ allows at most one rationally justified attitude towards a proposition $p$. Scientific practice is of high relevance to the debate on uniqueness, since it is an area of human reasoning where the notion of epistemic peers has practical applicability, as, for example, in the notion of peer review, or open peer commentary. In scientific practice, disagreement is the norm rather than the exception. Some philosophers of science, like Okasha (2010) have criticized the extent to which scientists disagree. To him, a plurality of approaches is permitted, as long as scientists reach the same conclusions. If they do not, so Okasha (2010, 653) argues, they damage the field: “In allowing a plurality of approaches—a healthy thing in science—to descend into tribalism, biologists risk causing serious damage to the field of social evolution, and potentially to evolutionary biology in general.” Yet, as Kuhn (1962) and Kitcher (1990) already observed, disagreement in science can and does often play a positive role. As we saw in section 8.5, disagreement between scientists is an important element of scientific progress: pace Okasha (2010), it is important that scientists not only use different methods, but also draw different inferences. Indeed, we found that both the number of active scientists working in a field ($N$), and the degree to which these scholars come up with different inferences ($\beta$) contribute to scientific progress. However, since the model takes the natural logarithm of the total number of scientists into account, increases in $N$ only have a significant effect if the initial number of scientists working in the field is small. By contrast, we can expect that even small increases in $\beta$ have a marked effect, regardless of population size. In other words, differences in inferences can allow for a quick increase in scientific knowledge acquisition.
10.3 Metaphysical implications

James Ladyman (2007) points out that the general acceptance of scientific realism in philosophy\textsuperscript{4} has kindled something of a renaissance of metaphysics. Scientific realism is committed to the existence of unobservable entities, such as subatomic particles or fields. Ladyman makes the case for physics, but the claim can be easily extended to cognitive science. Cognitive scientists clearly go beyond the observable data of brain scans and behavioral responses when they posit cognitive modules (see subsection 3.2.1) or innate knowledge (see chapter 2). Given that most scientific theories use at least some unobservable entities, it seems that metaphysical questions can be addressed through scientific methods. Of course, since metaphysics does not make empirical predictions, we cannot use scientific results to directly test and rule out some metaphysical claims. Although some metaphysical assumptions are more compatible with specific scientific theories than others, there is a general problem that scientific theories underdetermine philosophical positions. Take the question of innate knowledge, surveyed in chapter 2. As we have seen, a number of developmental cognitive scientists (e.g., Spelke & Kinzler, 2007) argue for the view that some human knowledge is innate. To support this claim, they rely on carefully controlled experimental procedures that attempt to eliminate empiricist alternative accounts, and they infer to the best explanation that nativism is the most reasonable position, given the current experimental evidence. However, empiricist accounts (e.g., Haith, 1998) cannot be rejected in principle, and we have pointed out that even for the persuasive case of infant arithmetic, it is always possible to come up with new empiricist accounts. As a result, we cannot directly make the philosophical case for nativism based on empirical evidence. A similar problem can be identified for researchers who propose that the human mind is composed of several domain-specific computational modules (see section 3.2.1). Although some form of modularity seems reasonable in the light of current cognitive psychological and neuroscientific evidence, it remains unclear whether the mind is composed

\textsuperscript{4}Despite influential arguments against scientific realism in its classic form, such as the pessimistic meta-induction (Laudan, 1981) or constructive empiricism (van Fraassen, 1980), most philosophers today are scientific realists. In a recent PhilPaper survey, 75\% of respondents accept or lean toward scientific realism, see http://philpapers.org/surveys/results.pl for the results of this survey.
of many different modules or rather of a limited set of core knowledge domains.

Another problem that Ladyman (2007) identifies is that in many scientific disciplines there are several competing scientific research programs, each with distinct metaphysical commitments. In examining the cognitive basis of mathematical and scientific knowledge acquisition, I have relied mainly on adaptationist and nativist research programs. However, cognitive science is a broad field with many other possible frameworks. To mention but one example, neo-empiricism is a successful research program that has as its main metaphysical commitment the idea that all knowledge is ultimately derived from sensory experience (see e.g., Machery, 2006; Prinz, 2002, for reviews). Neo-empiricists, unlike nativists, do not allow for innate knowledge, only for (fairly low-level) innate learning mechanisms. A picture of human knowledge acquisition based on neo-empiricism would consequently look quite different from one based on developmental psychological nativism. For example, one can compare my account of the cognitive basis of arithmetic, outlined in chapters 2, to 5, to George Lakoff and Rafael Núñez’ (2000), which relies extensively on neo-empiricist views of embodied cognition and places decidedly less emphasis on innate mental content. The fact that current cognitive science allows for such widely diverging naturalistic philosophical accounts is intriguing, and may lead to a re-evaluation of the relationship between philosophy and scientific practice, as will be discussed in the next section.

10.4 Naturalism as philosophy of the gaps?

This dissertation started with a discussion of Quine’s (1969a) naturalized epistemology. Quine argued that the best way to make sense of the scientific worldview is to use the best resources provided by the scientific worldview itself: “we seek no further basis for science than science itself, so we are free to use the very fruits of science in investigating its roots” (Quine, 1995, 16). The ultimate goals of philosophy and science are, to Quine, the same: we need to get an understanding of what there is and of how it is possible that we get to know what there is. Most recent characterizations of naturalistic philosophy follow Quine. For example, Devitt (1996, 49) characterizes naturalistic philosophy as a form of empiricism: “there is only one way of knowing, the empirical way that is the basis of science”, and Papineau (1993, 5) characterizes it as the view that we
10.4. Naturalism as philosophy of the gaps?

should “set philosophy within science.” The use of scientific data to adjudicate between competing philosophical programs, or to assess the truth value of particular philosophical propositions is not new. The historian of philosophy Eric Schliesser (2011) terms views that use the authority of science to settle debates within philosophy “Newton’s Challenge”⁵.

Unsurprisingly, several philosophers have expressed discomfort with Newton’s challenge. For example, John McDowell (1996) terms naturalistic attempts to understand the origins of our ability for (normative) reasoning “bald naturalism”, and Daniel Hutto (2011) denotes naturalistic investigations of the mechanisms underlying folk psychology as “presumptuous naturalism.” Both critiques see (some species of) naturalism in philosophy as overtly scientistic, i.e., as programs where science is used in an inappropriate fashion to approach inherently philosophical questions. I think that such critiques, as well as some versions of the naturalistic program itself, may be subject to a mistaken view on the relationship between philosophy and science which one could label the “philosophy of the gaps” view. In analogy with the “God of the gaps” view, where God can only be invoked in those cases where scientific explanations are not (yet) available, the “philosophy of the gaps” view sees the role of philosophy as describing or uncovering truths about propositions on which scientific knowledge is not (yet) available. Consequently, the domain about which philosophical statements can be expressed, shrinks as scientific knowledge grows. A stronger version of this view is that a naturalistic philosophy cannot rely on specifically philosophical resources and tools. In the words of Paul Roth (2007):

Philosophy as a naturalist conceives of it shares with more conventional philosophical approaches a concern to conduct a type of meta-level examination of particular sciences. That is, a philosopher qua naturalist examines, systematizes and generally seeks to make explicit the rules by which the first order endeavor proceeds [...] But a key difference between naturalists and others in formulating and articulating such matters arises from naturalism’s commitment to the view that in do-

⁵When Newton published his *Principia* in 1678, philosophy and science were not truly separate domains. The terminology “Newton’s challenge” is useful, given Newton’s successes in outlining a mechanistic natural philosophy, but the ideas underlying Newton’s challenge are much older; as Schliesser (2011) himself acknowledges, many of them can be traced back to Francis Bacon.
ing this, philosophy has no special methods or resources other than those which belong to the sciences collectively examined (Roth, 2007, 684).

This seems on the face of it a very unattractive form of the naturalistic project, since it demotes philosophy of science to the position of shadowing scientific practice itself\(^6\). Undoubtedly, this metaphilosophical picture underlies Hawking and Mlodinow’s (2010, 5) declaration that philosophy, in the wake of modern science, is dead. The problem with this view is that it presents an inaccurate picture of how science and philosophy interrelate. As Watson and Arp (2008) note, there is a certain irony in claims like this, given that they are explicitly philosophically motivated. For instance, the model-dependent realism Hawking and Mlodinow (2010) advocate throughout their book is a distinctly metaphysical position that cannot be vindicated through scientific practice. Moreover, scientific practice often helps itself to philosophical concepts and tools, as we saw in the discussion on nativism in cognitive science in chapter 2. As we will see below, philosophical arguments and thought-experiments have also frequently served as inspirations for experimental designs. Next to this, some key metaphysical assumptions of scientific practice cannot be resolved by scientific study. As Douven and van Brakel (1995) argued, scientific realism by itself is not an empirically testable hypothesis. Scientists (and most philosophers of science) are committed to a metaphysical picture of the nature of science.

The philosophy of the gaps view is also popular in some domains of cognitive science. Two recent examples illustrate this. Held et al. (2011) investigated Molyneux’ problem, an until recently unsolved (and some would perhaps argue still unsolved) problem in the philosophy of perception. Molyneux (17th c.) was an Irish natural philosopher who was interested in vision and optics. He asked Locke whether or not a blind man who regained sight would be able to immediately visually recognize an object previously known only by touch. Locke (1689), in keeping with his empiricist philosophy, thought that the man would not be able to do so. Held et al. (2011) studied teenagers from India who had been blind from birth or early infancy. The subjects were offered free surgical treatment that restored their vision. Prior to this surgery, they were

\(^6\)I owe this metaphor to Hasok Chang, during a comment at the Biannual Meeting of the Society for the Philosophy of Science in Practice, Exeter, 23 June 2011.
given objects in different shapes. After the operation, they were asked to identify which objects they had previously held. The results indicate that “the answer to Molyneux’s question is likely negative. The newly sighted subjects did not exhibit an immediate transfer of their tactile shape knowledge to the visual domain” (Held et al., 2011, 552).

Another recent study, conducted by Izard, Pica, Spelke, and Dehaene (2011) probed geometrical intuitions in Mundurukú and US subjects, asking questions like “Can a [straight] line be drawn through 3 unaligned points?”, “Do these (nonparallel) lines cross each other at the small-angle side?” The authors investigated whether or not the Mundurukú, who, as mentioned earlier, are members of a small-scale illiterate South American culture, have geometrical intuitions that are in line with Euclidean geometry. Indigenous South Americans and people from the United States have very different geometrical experiences: Mundurukú have much more challenging navigational tasks (e.g., during foraging in a dense jungle) compared to Americans, but they do not have any formal geometrical instruction. Yet, the authors found that both Mundurukú and American participants have intuitions that are closely in line with Euclidean geometry. They argued that “Although Kant’s argument for the existence of an a priori intuition of space is philosophical in nature, it implies that the human mind is spontaneously endowed with Euclidean intuitions, an empirically testable proposal that belongs to cognitive science” (9782, my emphasis). Further on in their discussion they state:

> In line with our previous research on intuitive arithmetic and geometry in the Mundurucú and with Plato’s views on education as developed in the Meno, the present results indicate that sophisticated protomathematical intuitions for both arithmetic and geometry can be revealed in all humans provided that the relevant abstract concepts are exemplified by concrete situations (Izard et al., 2011, 9786).

These remarks lead to the impression that we can easily adjudicate between philosophical theses on the basis of cognitive psychological research, and that some philosophical problems are more properly regarded as belonging to the domain of cognitive science. Similar claims (e.g., Schwitzgebel & Gordon, 2000) have been made for the unsolved “Mary’s

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7Note however, that Izard et al. (2011) entirely sidestep the fact that Plato’s and Kant’s notion of innate knowledge was quite different from our present-day understand-
room” thought experiment, and for Nagel’s (1974) critique of physicalism based on the supposedly unique phenomenological qualities of sonar perception in bats.

The central question of this concluding chapter thus becomes: can one be a naturalist and yet endorse the autonomy of philosophy, or is the naturalistic philosopher committed to a philosophy of the gaps or to a philosophy as a shadow of science? I submit, pace Quine (1969a) and Roth (2007), that a naturalist does not need to be committed to either view. After all, empirical studies like the ones outlined above typically elicit a host of new philosophical questions as well as answering some of them, for example, regarding the notion of innateness in current cognitive science. In the Held et al. (2011) study, the subjects who initially failed in the cross-modal task of visually identifying objects they had previously only felt, did succeed with novel objects after only five days since their first testing. While they initially were not able to cross-modally map haptic and visual stimuli, they learned to do so in a remarkably short space of time, just like other sighted people are able to make such cross-modal mappings. The authors conclude that this unusual rapidity of acquisition “suggests that the neuronal substrates responsible for cross-modal interaction might already be in place before they become behaviorally manifest” (Held et al., 2011, 552). This view is compatible with some forms of nativism (see e.g., Marcus, 2004), namely that, given a normally developing organism, the capacity for cross-modal mapping is in place prior to experience. The neural wiring responsible for this capacity needs some minimal environmental input to work properly, but it does not come into being solely as a result of this environmental input. Studies on the imitation of facial gestures (e.g., tongue protrusion) in newborns (Meltzoff & Moore, 1977) indicate that some forms of cross-modal mapping (in this case, mapping between visual input and motor actions) do not need any empirical input at all, given that the neonates never received visual feedback on their facial expressions. Rather than settling the debate between empiricism and nativism in any definite way, studies like these prompt us to re-evaluate philosophical concepts of nativism and empiricism, and to call into question the view that nativism and empiricism are diametrically opposed and mutually incompatible\textsuperscript{8}. Such philosophical notions

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\textsuperscript{8}This incompatibilist position is widely shared by philosophers and cognitive sci-
of nativism that take empirical evidence into account can then provide a conceptual toolbox to design new procedures and interpret new empirical findings. As Watson and Arp (2008, 18) put it, the interrelations between science and philosophy provide “checks and balances on their respective investigations into reality.” To be sure, the case of nativism illustrates that naturalistic philosophy and scientific investigations can be closely interrelated and interdependent. But the dependence relationship is not unidirectional from science to philosophy⁹.

Some authors (e.g., Kitcher, 1992; van Inwagen, 2006; Hutto, 2011) have observed that many contemporary analytic philosophers regard themselves as naturalists. Still, explicitly naturalistic work occupies only a relatively small place in analytic philosophy. Most work in contemporary analytic philosophy is simply neutral with respect to a naturalistic or non-naturalistic picture of the world, or, to put it differently, it is compatible with a naturalistic as well as an anti-naturalistic ontology (van Inwagen, 2006). A reasonably broad conception of analytic philosophy regards it as a discipline that searches for philosophical truth through a critical analysis of arguments. Analytic philosophers draw on various nonphilosophical methods and sources to help them in this task, including formal logic, mathematics, the physical and biological sciences, linguistics and various branches of cognitive science¹⁰. Incorporating these sources says nothing intrinsic about their relationship to philosophy. The use of formal mathematical techniques to arrive at philosophical insights by no means implies that analytic philosophy is a descriptive activity that can only be invoked when we cannot rely on mathematical proofs. In a similar vein, an analytic philosopher is justified in drawing on empirical results from the sciences to complement or even assess the truth-value of philosophical statements. History of philosophy can serve as a useful model entists. For example, although Prinz (2002) regards some innate mental content as unavoidable, he goes at great length to attack nativist alternative explanations for his neo-empiricist approach to concepts.

⁹In this, I agree with Friedman (1997), who also incorporates mathematics into the interdependence relationship. According to him, science, philosophy and mathematics are autonomous, yet interdependent fields of inquiry.

¹⁰Most analytic philosophers do not make use of the humanities, such as anthropology, archeology or history. In chapters 2, 3, 4, 5 and 6 I have also incorporated findings from the humanities in order to get a fuller picture of mathematical cognition than one would get through an account solely based on the cognitive psychological study of western subjects, but such approaches are rare.
Peter van Inwagen (2006) provides us with the following thought experiment: imagine an analytic philosopher, who is making an extensive study of Kant’s concept of free will. She does not do this because she is particularly interested in Kant’s philosophy, or in the history of the concept of free will in modern philosophy. Rather, this analytic philosopher is interested in learning more about free will, and she hopes that Kant may have something useful to say about this. She would like to assess whether Kant’s theory of free will is true or not, and in order to do so, she needs to study Kant’s writing in detail. Similarly, results from cognitive psychology can be used to assess questions in various branches of philosophy, including epistemology, ethics, metaphysics, philosophy of language and philosophy of mind that are not accessible through conceptual analysis alone. Statements like “humans have an innate sense of number” (see e.g., chapter 2) or “natural selection promotes the evolution of truth-conducive belief-producing mechanisms” (see e.g., chapter 9) can only be sensibly answered by considering relevant cognitive psychological and anthropological literature. Of course, this evidence needs to be interpreted through conceptual analysis, in casu on the notion of innateness and the relationship between reliability and natural selection.

This dissertation has sought to shed some light on the question of how humans are able to obtain systematic knowledge, in particular mathematical and scientific knowledge, in view of their inherent cognitive limitations. In order to answer this question, I provided both an empirically-informed account of which cognitive capacities underlie these types of knowledge acquisition, and suggestions of which external cognitive tools might play a role in extending cognition. It is my hope that the empirically-informed conclusions outlined in this dissertation can elucidate more general philosophical questions.

\[11^{\text{Nichols (2006) develops a similar argument.}}\]