Philosophers' Imprint

VOLUME 25, NO. 29
OCTOBER 2025

CORE IMAGINATION

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doi.org/10.3998/phimp.5496

> [T]here is a massive central core of [...] categories and concepts which [...] change not at all. Obviously these are not the specialities of the most refined thinking [...] and yet [these] are the indispensable core of the conceptual equipment of the most sophisticated human beings.
>
> – Strawson 1959, 10

1. Introduction

Non-expert adult humans have lots of knowledge about what is possible and what is impossible. But how do non-experts acquire that modal knowledge? Philosophers and cognitive scientists alike argue that we sometimes acquire modal knowledge through imagination (e.g. Gregory 2004; Byrne 2007; Kung 2010; Dohrn 2019). The rough suggestion is that we judge p possible if we manage to imagine p. The main challenge this approach faces is to elucidate the constraints to imagination (Nichols 2006; Kung 2010; Kind & Kung 2016; Balcerak Jackson 2018; Vaidya & Wallner 2021). If imagination is to underlie modal knowledge acquisition, then its constraints must generate the relevant possibilities.[1]

This paper argues that developmental research into *core cognition* can elucidate the constraints to imagination (e.g., Spelke 1990, 2000; Carey 2009). In particular, we argue that core cognitive constraints are a proper

1. Traditionally, this debate focused on whether *conceivability* could play a role in modal knowledge acquisition. However, it is not obvious what conceivability is. Whereas Balcerak Jackson (2016) explicitly distinguishes it from imagination and describes it as a form of idealised perspective taking (e.g., taking the perspective of a Laplacian demon; cf. Chalmers 2002), others claim that conceiving is a kind of "modal imagining" (cf. Yablo 1993; Schoonen 2020b). But in the latter tradition, conceivability is a constructive (rather than a recreative) form of imagination. For further discussion, see Dohrn (2019); Schoonen (2020b).

subset of the constraints to imagination.[2] Unlike previous approaches to imaginative constraints (e.g., Nichols 2006; Williamson 2007; Langland-Hassan 2016), we engage in detail with work in cognitive science and answer some of the epistemological challenges that therefore arise.[3] We believe that our naturalistic approach offers a welcome alternative to the recent "metaphysics-first" approach to investigation of modal knowledge acquisition (e.g., Mallozzi 2021; Boardman & Schoonen 2023).

Modal epistemologists often bracket knowledge of more restricted modalities in order to investigate metaphysical modal knowledge. There are three main reasons that metaphysical modal knowledge has a central place in the recent literature. First, Kripke's (1980) arguments in favour of *a posteriori* metaphysical necessities constitute a serious challenge to the traditional view that necessities are known *a priori* in virtue of semantic knowledge (e.g., Yablo 1993; Chalmers 1996; Williamson 2007). Second, Chalmers' zombie argument and in particular its "modal premise" that if p is conceivable, then p is possible was quite controversial (e.g., Gendler & Hawthorne 2002).[4] Third, philosophical theories often entail metaphysical modal claims (e.g., physicalism entails that philosophical zombies are impossible). Although it is therefore no mere oversight that modal epistemologists haven't given much attention to knowledge of more restricted modalities, none of these factors suggest that we shouldn't now explore knowledge of more restricted modalities.

In fact, some pioneers have begun to explore acquisition of more restricted modalities (Nichols 2006; Vetter 2016; Strohminger & Yli-Vakkuri 2018a; Gregory 2020). Similarly, our interest is in knowledge of quotidian modalities. Quotidian modalities are the sorts of modalities at issue in everyday non-expert contexts (Ichikawa 2016, 130). These modalities are subject to more substantive restrictions than those physical modalities that more naturalistic modal epistemologists have drawn attention to (e.g., Nichols 2006). As we explain in Section 4.2, linguists have shown that quotidian modalities concern our circumstances and interests (Kratzer 2012; Portner 2009). Because we often inhabit different circumstances and pursue different interests, there are numerous quotidian modalities and which is relevant changes from context to context (Kratzer 1977). Note that our acquisition of quotidian modal knowledge is mysterious for some of the same reasons that metaphysical modal knowledge acquisition is mysterious. For many propositions p, we don't know p and yet we know that p is possible in the relevant quotidian sense.

Pulling these threads together, we argue that imagination constrained by core cognition yields modal knowledge of the sort of quotidian modalities at issue in everyday life. Here is the plan. We introduce core cognition (Section 2) and argue that the sort of imagination that has a role in modal knowledge acquisition inherits core cognitive constraints (Section 3). We then turn to some epistemological issues that arise in light of this proposal. Section 4 considers undergeneration objections, which suggest that core constraints rule out genuine possibilities. We argue that attention to the psychology of modal cognition and the semantics of modal expressions shows that core constraints are of the right strength. Section 5 considers overgeneration objections, which suggest that core constraints generate impossibilities. We argue that this isn't an issue since peripheral constraints (i.e., non-core constraints) and contextual beliefs block lots of impossibilities. We conclude that our discussion is of wider methodological interest as it implements a naturalistic methodological approach that appeals to core cognition, modal psychology, and modal semantics to investigate modal

2. Miyazono & Tooming (2024) also argue that imagination is constrained by core cognition. Unlike their work, ours investigates the role of imagination constrained by core cognition in modal knowledge acquisition. There are several further differences between our view and theirs. For instance, Miyazono & Tooming (2024, 397) claim that prior beliefs are a subset of imaginative constrainers. In contrast, our view is that principles are architectural constraints to imagination itself and contextual beliefs aren't part of the architecture of imagination but rather interact with imagination to block imagination of certain situations that are irrelevant in context (see Section 5 below).
3. We consider our work as a development of some suggestive but subsequently neglected discussion of the role of "expectations" and "folk theories" in Williamson (2007).
4. Kripke (1980) and Yablo (1993) were important precursors here.

knowledge acquisition.

2. Core Cognition

Adult humans have concepts that range from the mundane to the downright bizarre. We have concepts like PENCIL, DOG, SAMBA, ATOM, BLACKHOLE, INFINITE. Developmental psychologists attempt to explain our acquisition of this rich conceptual repertoire. Although some of us are born to dance, none of us come with the concept SAMBA built-in from the start. As is familiar from language acquisition (Chomsky 1959), acquisition problems can look insurmountable if we assume that learners start out with a *tabula rasa* and a few empiricist domain-general mechanisms (association, induction, etc.). The more meagre the initial state, the more difficult it is to explain the transition from it to our rich conceptual state.

Proponents of core cognition solve the problem of conceptual acquisition in part through their nativist thesis that the initial state is richer than we might've thought.[5] According to them, we start out with several domain-specific devices that are able to output rich concepts from our earliest moments.[6] Proponents of core cognition argue that there is excellent evidence to posit the three core systems of object, agent, and number cognition (Carey 2009). These systems are "core" in that their outputs—concepts like OBJECT and AGENT—have a crucial role in conceptual development across our lifespan (Carey 2009; Spelke 2011). In what follows, our focus is on core object cognition, which has been the main concern of psychological research for several decades.

5. Our positive proposal is consistent with non-nativist explanations of the empirical results that proponents of core cognition attempt to explain (e.g., Thelen & Smith 1994; Gopnik & Meltzoff 1997; Butterfill 2020). The crucial point is that cognition operates under substantive constraints. Whether those constraints are innate or the result of empiricist learning strategies is independent of our central point.
6. Just what 'domain-specific' means differs across scientific traditions and disciplines (Hirschfeld & Gelman 1994). For our purposes, some cognitive mechanism is domain-specific just in case it contains information about a specific subject-matter. The core object system, for instance, is specific to the domain of objects in the sense that it contains information about objects.

Core systems are perceptual-input analysers (Carey 2009). This means that the inputs to these core systems are the outputs of perceptual systems. For instance, core object cognition takes input from the visual system. The visual system outputs representations of the visual scene that represent spatio-temporal properties of that scene ("spatio-temporal cues"). The core object system automatically takes these spatio-temporal cues as input and analyses them using its own unique store of information. In effect, the core object system checks for signs that there are objects. If there are signs of objects, it outputs an enriched representation of the visual scene that categorises some entities under the concept OBJECT.

Core cognition is similar to perception in that it involves innate perceptual-input analysers that operate in an automatic fashion over spatio-temporal cues and outputs representations available to cognition at large. However, it is important to note the conceptual nature of core cognition too (Carey 2009, 10–11). Unlike perceptual representations, the outputs of core cognition have contents with rich and productive inferential links. As Carey (2009, 9) puts it, usually "almost nothing else follows from the fact that something is red, whereas rich inferences are licensed by identifying something as an agent" or an object. Since the fact that core concepts like OBJECT have rich inferential roles is the most important point for our purposes, we now explain it in more detail.

The core object system contains a domain-specific database that stores information about objects. This database contains information about the identification, individuation, and behaviour of objects. Spelke (1990) dubs this domain-specific database 'the principles of object perception'. It includes, for example, the principle that

(SOLID) objects are solid entities.

In other words, objects do not phase through each other. In addition, it includes the principle that

(NO-TELE) object trajectories consist of a series of adjacent points.

In other words, objects don't teleport. There are several further prin-

ciples (e.g., Spelke 1990). But as the epistemological issues that these principles raise are similar, we focus on **SOLID** and **NO-TELE**.

Given its domain-specific database, core object cognition generates a number of expectations about the entities in the extension of OBJECT. For any object x in the extension of OBJECT, and any principle of object perception, core object cognition generates the expectation that x conforms to that principle. For example, once the core object system categorises some x under OBJECT, we expect x neither to teleport nor to pass through other entities categorised under OBJECT. If x appears to you to violate the principles of object perception, then this surprises you.

3. From Core Cognition to Core Imagination

This section motivates and outlines our positive proposal that the sort of imagination that has a role in modal knowledge acquisition inherits core cognitive constraints. Section 3.1 sets out a puzzle about the origins of imaginative constraints. Section 3.2 adopts the "recreative solution" that imagination simulates "online" cognitive processes and therefore inherits their constraints. Section 3.3 argues that imagination involves simulation of core cognition and therefore inherits the core constraints.

Let us make two clarifications at the outset. First, we recognise that there is a "creative" sort of imagination that people use to fantasise about the magical, weird, and impossible. But we don't put forth any proposals about it, as it doesn't have a central role in modal knowledge acquisition (that is, we focus on the instructive, rather than the transcendent use of imagination, cf. Kind & Kung 2016). Second, we don't claim that core constraints *exhaust* the constraints to imagination. Rather, we argue that core constraints are a proper subset of the constraints to imagination. We return to this issue in Section 5.

3.1 The Problem of Missing Environmental Inputs

If we want to vindicate the role of imagination in modal knowledge acquisition, then we have to show that we imagine possible situations and that we don't imagine impossible situations. To a large extent, the constraints to imagination guarantee that we imagine possible situations and that we don't imagine impossible situations (but, as we argue in Section 5.2, contextual beliefs have a role too). This is perhaps the standard view of philosophers and psychologists alike (e.g., Nichols 2006; Kind 2016; Kind & Kung 2016; Langland-Hassan 2016; Williamson 2016b; Lane et al. 2016; Balcerak Jackson 2018; Harris 2021). The role of constraints in the cognitive science of imagination is just an instance of the more general role of constraints in cognitive science at large.

The traditional picture has it that cognitive science concerns the constraints that govern transitions between mental representations (e.g., Chomsky 1980; Marr 1982). Constraints are what ensure that, given particular inputs, a narrow set of outputs are available. In the case of visual perception, constraints determine that, given a retinal representation of patterns of the light, there are just a few admissible transitions to representations of higher-level properties of the visual scene (edges, depth, etc.). Since the constraints to visual perception are able to track law-like connections between the presence of certain patterns of retinal stimulation and the presence of certain higher-level properties, visual perception outputs an accurate enough representation of the visual scene (at least in normal conditions).

But what are the origins of these constraints? In the case of visual perception, it isn't difficult to give a rough sketch. Retinal inputs provide the visual system with feedback about its model of the connections between retinal inputs and higher-level properties. In contrast, it is often thought that the search for the origins of imaginative constraints faces a problem of missing environmental inputs. For instance, since visual imagination doesn't involve retinal stimulation, it might seem that we must give a very different account of the origins of the constraints to visual imagination. These sorts of worries seem to have motivated some philosophers to think that, in contrast with visual perception, we choose the constraints to imagination ourselves (Wittgenstein 1967; Sartre 1972). However, this leads those philosophers to conclude that imagination is of little epistemic relevance (Balcerak Jackson 2018).

The issue is this. If we choose the constraints ourselves, knowledge through imagination is akin to financial gain through handing oneself a dollar (Langland-Hassan 2016). Suppose that, when you are using your imagination to make modal judgements, you chose to impose the constraint that people don't walk through walls. If you then infer that people can't walk through walls from the fact that you never imagine people walking through walls, it seems that your imagination didn't give you any interesting *new* modal knowledge. Although the constraint you impose is non-modal (that people *don't* walk through walls), your choice to impose it seems to draw upon your knowledge that people *can't* walk through walls. The natural upshot is that if imagination has a role in modal knowledge acquisition, it must operate under *unchosen* constraints. The next section discusses mental simulation as a plausible source of unchosen constraints.

3.2 The Recreativist Solution

According to the recreative view of imagination, imagination involves the mental simulation of other cognitive processes (e.g., Currie & Ravenscroft 2002; Goldman 2006). But what is mental simulation? For our purposes, some mental process *M** is a (mental) simulation of another mental process *M* just in case *M** is distinct from *M*, but nonetheless resembles *M* in some important respects (Goldman 2006). An important aspect of resemblance between the *offline* process (which simulates) and the *online* process (which is the target of simulation) is resemblance of functional profile. Mental simulation is important because it allows you to make use of the constraints of online processes without the need for the environment to provide the inputs that trigger them. This comes out clearest with propositional imagination or "offline belief". As the name suggests, offline belief simulates (online) belief. And due to this, offline belief inherits some of the functional features of (online) belief. For instance, if you believe *that if it rains it pours*, and you believe *that it rains*, then you believe *that it pours*. The same goes for offline belief. If you offline believe *that if it rains it pours*, and you offline believe *that it rains*, then you offline believe *that it pours*.

The crucial point is that if some online process is subject to constraints, then the offline process that simulates that online process inherits those constraints. The origins of the constraints to some offline process are no more mysterious than the origin of the constraints to the online process it simulates (and mental simulation itself).[7] Epistemic use of imagination is more like cashing a check than handing yourself a dollar.

3.3 Core Imagination

The recreative solution doesn't in itself tell us which online processes imagination recreates. It therefore doesn't in itself elucidate the nature of the constraints that imagination inherits from the processes it recreates. We adopt a pluralistic outlook that recognises that imagination involves the recreation of lots of different online processes and therefore inherits lots of different sort of constraints. We suggest that philosophers and cognitive scientists adopt a divide-and-conquer approach to the issue, investigating interestingly related clusters of imaginative constraints. This already happens, at least in broad outline. Some philosophers investigate recreation of perceptual processes (e.g., Balcerak Jackson 2018; Gregory 2020), others investigate recreation of more cognitive processes (e.g., Currie & Ravenscroft 2002; Nichols 2006; Williamson 2007, 2016a), and yet others focus on the simulation of sensorimotor loops (e.g., Jones & Wilkinson 2020; Rucińska & Gallagher 2021; Jones & Schoonen 2024).

Our implementation of the recreative solution says that there is a sort

7. We want to emphasise that the constraints to the offline processes aren't chosen. According to one prominent view, offline processes inherit the constraints of the relevant online processes because offline processes reuse the same underlying cognitive mechanism that the online processes use (e.g., Jones & Schoonen 2024). There is no revenge problem that we must choose to simulate this-or-that online process which involves some background modal knowledge. We take it that most plausible version of the recreativist position is that imagination recreates various online processes *by default* (Williamson 2016a).

of offline process, which we baptise 'core imagination', that recreates core cognition. Let us emphasise at the outset that our endorsement of the existence of core imagination doesn't involve commitment to a *sui generis* sort of imagination. The suggestion is rather that we are able to simulate (some) cognitive processes and that we therefore can and often do simulate core cognition. For us, 'core imagination' just refers to mental simulation of core cognition. Core imagination is just one (integral) part of the whole that is imagination. Importantly, there is reason to expect at the outset that exploration of this proposal is of interest given that core cognition sits at the intersection of perception and cognition. Given that core imagination inherits the perceptual-cum-cognitive nature of core cognition, it is of interest to those that investigate those imaginative processes that recreate perception and those that investigate imaginative processes that recreate cognition. We now turn to exposition of our positive view.

To motivate the view that core cognitive constraints constrain online thought, consider two classic experiments. In an experimental set-up in which a car rolls down a ramp and passes behind an occluder, Baillargeon (1986) has shown that infants (6- and 8-month olds) expect objects not to pass through each other (see also Baillargeon et al. 1985). In the test stage, there were two conditions. In the expectation-consistent condition, infants saw the occluder raise to reveal a block that stood behind the tracks (i.e., without blocking the path of the car). In the expectation-inconsistent condition, infants saw the occluder raise to reveal a block that stood on the tracks (i.e., blocking the path of the car). If children expect objects not to pass through each other, then the expectation-inconsistent condition in which it seems that the car teleports through the block ought to surprise them. This is what Baillargeon (1986) found.

In another classic experiment, Spelke et al. (1995) showed that infants expect that objects don't teleport. Infants were shown an initial discontinuous event in which there are two occluders with a gap in the middle. An object a passes behind the left occluder and then an object b with the same appearance exits the right occluder without any object appearing in the gap (it is ambiguous whether $a = b$). At the test stage, infants were shown two events in which the occluders were no longer present. In the one-object event, one object enters the scene left and exits right. In the two-object event, one object enters left and stops at the previous location of the left occluder and a distinct but similar object starts at the previous location of the right occluder and exits the scene right. If infants expect objects not to teleport, then their interpretation of the initial event is more similar to the two-object test event than the one-object test event. Hence, if infants expect that objects don't teleport, then the one-object event ought to cause dis-habituation. This is what Spelke et al. (1995) found.

Taken together, these two experiments (and others like them) support the view that the principles of object perception constrain infants' expectations about objects. Despite the emphasis of the role of core cognition in infant development, it is important to note that core cognition operates throughout the lifespan (Spelke 2000, 1253; Spelke & Kinzler 2007, 90; Carey 2009, 69-87; Rips 2017, 160).[8] Core cognitive constraints—like **SOLID** and **NO-TELE**—are constraints to online cognition.

We now want to put forth the hypothesis that core cognitive constraints are constraints to imagination (or "offline cognition"). In particular, principles of object perception like **SOLID** and **NO-TELE** constrain

8. Note that there are other core cognitive systems, like agent and number cognition, that have a crucial role in a wide range of basic cognitive activities. Someone might object that it implausible that imagination that inherits the constraints of core agent cognition has a role in modal judgement and knowledge acquisition (thanks to Barbara Vetter for raising this issue). For example, core agent cognition includes principles that seem to block the imagination of irrational agents (Carey 2009, Ch. 5). However, this is just a version of the objection we respond to in Section 4. It says the relevant constraints block genuine possibilities. We adopt the same response. The psychological results show that subjects judge irrational events impossible (Phillips & Cushman 2017). Modal semantics suggests that modal statements at issue in everyday life often exclude possibilities in which agents are irrational from their domain of quantification.

imagination. To motivate this claim, we offer an illustrative example. Suppose that you have a flight from Amsterdam to Dresden. Your plan was to get to the airport in your car. But at the last minute you lock your keys in your car. You want to know whether it is possible that you still make your flight. You use your imagination to acquire this knowledge. You imagine various situations. You imagine hailing a taxi, getting a train, cycling, and so on. But you don't imagine your keys teleporting into your pocket. And you don't imagine reaching through your car door in order to unlock the car from the inside. Nor do you ever imagine teleporting into your car or to your destination. Left to its own devices, your imagination just doesn't represent situations like that. Our suggestion is that imagination doesn't represent situations like that *because* it inherits core cognitive constraints.

But how do core cognitive constraints block the imagination of situations that violate those constraints? Just like in online thought, the principles of object perception generate (offline) expectations about entities that we categorise under OBJECT in imagination. For instance, since in imagination you categorise the keys under OBJECT, you expect in imagination that the keys don't teleport and that the keys don't pass through other objects. By default, our imaginative episodes don't develop in ways that violate those (offline) expectations (Williamson 2007, 2016a). If we suppose that imagination has its traditional role in modal judgement and knowledge acquisition (judge p possible if you imagine p), then our proposal predicts that adults don't judge violations of core constraints possible. We further embrace the more ambitious claim that an adult judges p impossible if they don't imagine p *by default*.

4. Undergeneration Objections

Given our main claim that imagination constrained by core cognition has a central role in modal knowledge acquisition, we must establish that core constraints are of the right strength. In particular, we must establish that the core constraints don't *undergenerate possibilities*. If core constraints are too restrictive, then those constraints block imagination

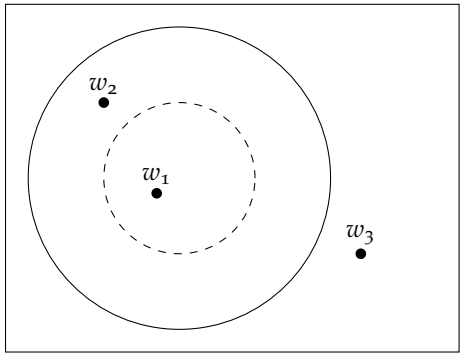

Figure 1: The dashed circle represents those situations consistent with core constraints. The outermost circle represents possible situations. w_1 is core consistent and possible, w_2 is core inconsistent but possible, and w_3 is core inconsistent and impossible. Undergeneration objections say that core inconsistent but possible situations like w_2 exist.

of situations that are in fact possible (see Figure 1). Roughly, undergeneration objections claim that there are possible situations that are "core inconsistent" (i.e., impossible in view of the core constraints). More precisely, there are descriptive and normative versions of that objection.

The descriptive undergeneration objection concerns the fit between the core constraints and our modal judgements (rather than the fit between the core constraints and the modal facts). In other words, it asks whether core cognitive constraints permit situations that we judge possible *regardless of the modal status of those situations*. The objection gets its motivation from the suggestion that there are some situations that we judge possible which are nonetheless inconsistent with the core constraints. Someone that raises the descriptive question wants to know whether creatures like us in fact use imagination constrained by core cognition to make their modal *judgements*. The descriptive objection falls into the domain of psychologists and naturalistic epistemologists.

The normative undergeneration objection concerns the fit between the core constraints and the modal facts (rather than the fit between core constraints and our modal judgements). In other words, it asks whether

core cognitive constraints permit situations that are possible *regardless of our judgements about the modal status of those situations*. Someone that raises the normative undergeneration objection wants to know whether imagination constrained by core cognition gets the modal facts right and wonders whether modal judgement that results from core imagination amounts to knowledge. The normative objection falls in the domain of epistemologists.

Here is a more concrete elaboration of the descriptive and normative undergeneration objections. It is a principle of core object cognition that objects don't phase through objects. It follows that situations in which objects phase through objects are core inconsistent. But then, if imagination is constrained by core cognition, we cannot imagine phase objects. If so, our account predicts that we judge situations in which objects phase through objects impossible. But a descriptive objection then arises. If non-expert adults in fact judge phase objects possible, then it seems that adults don't use imagination constrained by core cognition to make (at least those) modal judgements. A normative objection also arises. Regardless of our judgements about the modal status of phase objects, if phase objects are in fact possible, then we can't know that phase objects are impossible. Quantum mechanical intuition pumps suggest that phase objects are possible (e.g., Lewis 2016, 287; Aimar 2019, 1687). For the sake of argument, we therefore suppose that for any principle of core object cognition, it is nomologically possible that some event is a violation of that principle. Hence, imagination constrained by core cognition might be seen to predict too much modal error.

We turn to resources from cognitive science to answer these undergeneration objections. In response to the descriptive version of the undergeneration objection, we argue that psychological results show that non-expert adults in fact judge events that violate core constraints impossible. The core imagination account therefore makes the right predictions about non-expert adults' modal *judgements*. In response to the normative undergeneration objection, we argue that semantics suggests that in the relevant quotidian senses of 'possible', phase object situations are impossible.[9] The core imagination account therefore makes the right predictions about non-expert adults' modal *knowledge*. Note that we don't adopt any *ad hoc* manoeuvres, additional assumptions, or concessions to show that undergeneration objections miss their mark. Rather, we just appeal to the results of the relevant sciences.

4.1 Descriptive Undergeneration

The descriptive objection claims that we make incorrect predictions about non-expert adults' modal judgements. It says that there are some situations, like phase objects, that (i) are core inconsistent and yet (ii) non-expert adults judge those situations possible. In response, we grant (i). The whole point of imagination constrained by core cognition is to take advantage of core constraints to block the imagination of situations that violate those constraints. But what we want to emphasise is that (ii) is an empirical claim and recent psychological literature about modal judgement suggests that it is false.

Psychologists use the technical term 'impossible event' to pick out events that violate core cognitive constraints rather than laws of nature or metaphysical principles—it therefore departs from standard usage of that term in the philosophical literature. For example, Shtulman & Carey (2007, 1017) chose their "impossible events" to "violate physical laws known at least implicitly by most children (see Spelke 1990)". Here Shtulman and Carey refer to Spelke's (1990) prominent work 'Principles of object perception', in which she argues that the principles of core object cognition constrain adults' expectations. This highlights that an event is an "impossible event" in Shtulman and Carey's sense if it violates core object constraints. In the mouths of psychologists,

9. Because there are numerous quotidian modalities our claim that core inconsistent situations are impossible amounts to the claim that every core inconsistent situation is impossible *with respect to every member of the set of quotidian modalities*. This is comparable to the sense in which '2+2=5' expresses an epistemic impossibility—i.e., it expresses a proposition that is impossible with respect to every member of the set of epistemic modalities.

utterance of 'adults judge "impossible events" impossible' means that adults judge events that violate core constraints impossible.

We can now ask whether, given some event that psychologists deem an "impossible event", children and adults judge that event impossible. If so, then our main predication that adults judge events that violate the core constraints impossible is borne out and the descriptive objection fails. Again and again developmental studies have found that children of at least four years are able to distinguish normal possible events from impossible events (see Shtulman & Carey 2007, 1020; Shtulman & Phillips 2018, 162; and the references therein). Given some normal possible event, like *cleaning a closet*, children judge that this event "could happen in real life". But given some impossible event, like *walking through a wall*, children judge that this event "couldn't happen in real life" (examples from Shtulman & Carey 2007). Of course, adults are able to make the same distinctions. Given some event that violates core constraints, adults are highly reliable in their judgements that these events are impossible—and this result persists across studies from different labs and experimental paradigms. The result persists even if adults are given time to reflect (Phillips & Cushman 2017). In fact, adults often cite (simplifications of) core constraints to justify their modal judgements. For instance, adults that judge it impossible to walk through a wall give justifications like "walls are solid".

The descriptive objection claims that our account makes incorrect predictions about non-expert adults' modal judgements. It says that there are some situations that (i) are core inconsistent and yet (ii) non-expert adults judge those situations possible. But we've just seen that (ii) is false. It is taken as an unsurprising result in modal psychology that children and adults judge events that violate core constraints impossible. So, the descriptive objection fails.

4.2 Normative Undergeneration

The normative version of the undergeneration objection says that core constraints permit fewer possibilities than there are. To answer that objection, we show that in the *quotidian* sense of 'possible' relevant in everyday life, violations of core constraints are impossible. That is, we delineate the target of our epistemology: non-expert adults' knowledge of everyday modal claims. These include claims such as 'The couch could fit into the room' and 'We could make that deadline'. In particular, we argue that non-expert adults use modal statements to communicate propositions with more substantive restrictions than some epistemologists of modality seem to realise.

Logicians and philosophers have known for some time that modal expressions are similar (if not identical) to quantifier expressions (Copeland 2002). But linguists made it clear that natural language modal expressions, like natural language quantifier expressions, often come with *implicit domain restrictions* (Kratzer 1977, 1981, 2012). To illustrate the point, we start with a brief discussion of implicit quantifier domain restriction.

Implicit quantifier domain restriction is everywhere (Westerståhl 1984; Von Fintel 1994; Marti 2003; Kratzer 2021). Consider a commonplace example like (1).

(1) Everyone is asleep.

Imagine (1) spoken from Father to Mother at their children's bedtime. The surface form of (1) doesn't settle the restriction to the domain of 'everyone'. An alien might think that Father intends to communicate that everyone in the universe is asleep. But Mother knows that what Father communicates receives a more perspicuous expression in the surface form of (2).

(2) Everyone that is a child of ours is asleep.

The restriction to 'everyone' in (2) is quite explicit. The restriction is to children of Father and Mother. The point is that the explicit restrictions to 'everyone' in (2) are implicit in (1). To see this, consider that it is no objection to the proposition that (1) communicates (in the relevant context) that the kids next door are still awake.

Implicit modal domain restriction is unavoidable.[10] To illustrate this, consider everyday examples like (3).

(3) This sofa can't fit into the living room.
[e.g., the entrance is too narrow]

Imagine (3) as spoken from Father to Mother in IKEA. The surface form of (3) doesn't reveal any restriction to the domain of 'can' (an existential quantifier that ranges over the set of possible worlds). The proverbial Martian (or a philosopher) might think that Father intends to communicate that there is no possible situation whatsoever in which the sofa fits into the living room. But Mother knows that what Father communicates receives a more perspicuous expression in (4).

(4) In view of the circumstances [e.g., the dimensions of the sofa and the entrance], and in view of our priorities [e.g., our goal to expend a reasonable amount of our resources], this sofa can't fit into the living room.

The restriction to (4) is quite explicit. The restriction is to situations that have a match of circumstances and that align with our priorities to a reasonable extent (Kratzer 1981; Portner 2009). The point we want to make is that the explicit restrictions to the domain of 'can' in (4) are implicit in (3). To see this, consider that it is no objection to the proposition that (3) communicates (in the relevant context) that Father and Mother might demolish several walls in their house to fit the sofa.[11]

Despite the fact that modals with implicit domain restrictions are widespread in natural language usage, epistemologists of modality often restrict themselves to investigation of our knowledge of modalities that have very few, if any, substantive restrictions. In particular, they focus upon knowledge of *metaphysical* modal statements. However, while it is appropriate to explore our acquisition of metaphysical modal knowledge, philosophers ought to avoid a stance that ignores other types of modal knowledge that are of more use in everyday life to non-philosophers.[12] From this everyday perspective, metaphysical modal knowledge is just a marginal type of modal knowledge. Just as epistemologists of visual perception don't restrict themselves to long-distance sight, epistemologists of modality shouldn't restrict themselves to the acquisition of metaphysical modal knowledge.

Nichols (2006, 245) suggests that epistemologists of modality ought to pay more attention to our knowledge of *nomological* possibilities (i.e., that which is possible in view of the laws of nature) since these are the sort of modals relevant to decision and action. We think that this is a step in the right direction. But most of the modal statements relevant to everyday decision and action are far more restricted than nomological modals (Strohminger & Yli-Vakkuri 2018a, 1157). For instance, quantum possibilities with low objective probabilities (e.g., phase objects) aren't relevant to everyday decision and action. To see this, consider (3) again. Suppose Mother responds with (5).

(3) This sofa can't fit into the living room.

(5) # I know my quantum mechanics! This sofa can fit. You've just got to phase the sofa right through the wall.

As a response to (3), (5) sounds terrible to us. It isn't just that Mother expects too much of Father (i.e., expects him to instantiate events with very low objective probabilities); it is that (5) just isn't responsive to the proposition that Father communicates with (3). The proposition that (3)

10. This, of course, is itself a claim with an implicit domain restriction. As Strohminger & Yli-Vakkuri (2018a, 1171-1172) highlight, if we use special methods to shift the context, we can quantify over all possibilities whatsoever. In those cases, there is no modal domain restriction implicit or otherwise (or, it is a limiting case where the restriction is empty or trivial). The usual case is nonetheless that modals come with implicit domain restrictions.

11. It isn't straightforward to use retraction data to challenge our point. Someone might retract (3) because the literal content of (3) misleads *vis-à-vis* the proposition the speaker intends to communicate. But retractions of that sort don't show that the proposition the speaker intends to communicate with (3) lacks substantial restrictions. Compare Von Fintel & Gillies (2008).

12. Some notable exceptions are Ichikawa (2016); Vetter (2016); Williamson (2016b); Strohminger & Yli-Vakkuri (2018a); Schoonen (2024).

communicates in IKEA just quantifies over possibilities that are normal in some sense of that difficult term (Knobe & Szabó 2013; Yalcin 2016; Phillips & Bloom 2017; Phillips & Knobe 2018; Aimar 2019). It is no response to (3) then to point out that there are abnormal possibilities in which the sofa fits.

Notice that (5), as a response to (3), is comparable to (6) as a response to (1).

(1) Everyone is asleep.

(6) # I'm not deaf! The kids next door are still awake.

The right response to those that insist upon surface forms and ignore propositions communicated is to point out their mistakes. Father didn't communicate that the kids next door were asleep. Father just communicated a true claim about his own children. If you think that (6) isn't an appropriate response to (1), then we think that you ought to adopt the same attitude to (5) and (3) since there is no relevant difference between them.

To summarise, non-expert adults use modal statements to communicate modal propositions whose restrictions are more substantive than the laws of nature. It seems, rather, that non-expert adults use modal statements to quantify over situations that are normal—i.e., quotidian possibilities. We admit that it is somewhat unclear what the right analysis of "normal" is. But that is everyone's problem. Our response to the normative undergeneration objection is just that situations that violate core constraints *are in fact* quotidian impossibilities. We know them when we see them and phase objects are not quotidian possibilities. Plausible theories of the nature of quotidian modalities must capture this intuition.

5. Overgeneration Objections

Some philosophers might attempt to further press *over*generation objections against our positive proposal. Overgeneration objections claim that the core constraints overgenerate possibilities. In other words, these objections claim that there are impossible situations that are "core consistent"—i.e., possible in view of the core constraints (see Figure 2).[13] In response, we do not attempt to argue that our proposal rules out impossible situations that are core consistent. Rather, we argue that it is a methodological mistake to impose such a requirement. This is because some impossible situations are blocked by "peripheral constraints" and some are blocked by "contextual beliefs" (as Sections 5.1 and 5.2 explain respectively).

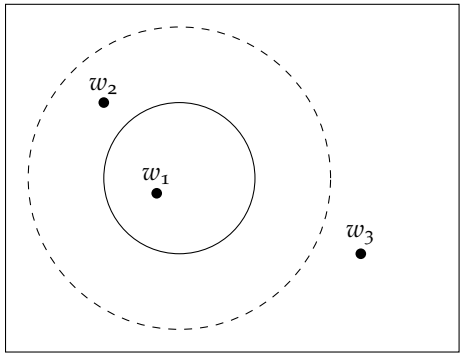

Figure 2: The innermost circle represents possible situations. The dashed circle represents those situations that are consistent with core constraints. w_1 is core consistent and possible, w_2 is core consistent but impossible, and w_3 is core inconsistent and impossible. Overgeneration objections say that core consistent but impossible situations like w_2 exist.

5.1 Peripheral Constraints

Here is an instance of the overgeneration objection. The imagination relevant to modal knowledge acquisition shouldn't allow transition from a state i_1 that depicts that x is a human to a state i_2 that depicts that x is an African bullfrog. Presumably humans can't become African

13. More precisely, there are again descriptive and normative versions of this objection. However, overgeneration objections are inappropriate in view of quite general methodological considerations. Hence, we needn't further elaborate those versions of the objection in our response.

bullfrogs. But core cognitive constraints probably don't block transitions of that sort. Hence, core constraints overgenerate possibilities.

This is no genuine objection to our proposal. This is because it is no part of our positive proposal that core constraints *exhaust* the constraints to imagination. We admit that there are further important "peripheral" constraints to imagination.

(Peripheral) Some constraint to imagination is peripheral just in case it is not a member of the deductive closure of the set of core constraints.

In the African bullfrog example, there is probably some more general peripheral constraint at work that rules out that a member of a species S becomes a member of another species S' (cf. Gelman 2003 and the references therein). But since it is hopeless to give an informative discussion of every constraint to imagination in a single paper, it is a methodological mistake to expect us to further explore that issue here. We admit that if imagination has a role in modal knowledge acquisition, some peripheral constraints must block that transition. But our thesis is that core constraints are an important *proper subset* of the constraints to imagination and that is enough to generate the substantive philosophical problems that we have sought to address in this paper (especially Section 4).[14]

For purposes of illustration, we draw analogies with another science which concerns the generative strength of cognitive constraints: generative linguistics. Generative linguists attempt to state principles that have the right strength in that those principles permit grammatical sentences and rule out *relevant* ungrammatical strings. The linguist doesn't give a grammar of an entire language. Rather, the linguist provides a "fragment" of the grammar that rules out *some* ungrammatical strings. For instance, a linguist might state some principles that govern question-formation. Those principles rule out those ungrammatical strings that violate principles of question-formation. But of course, these principles won't rule out unrelated ungrammatical strings like 'runs smokes'. We would not say that the linguist's proposal overgenerates sentences because it doesn't rule out 'runs smokes'. Clearly the linguist is just giving a fragment of the complete grammar and expects that some other "peripheral" principle of the complete grammar will rule out 'runs smokes'. The linguist indulges in the theoretical hopes of an optimistic scientist engaging in normal science. We intend our proposals in that spirit.

5.2 *Contextual Beliefs*

Here is another instance of the overgeneration objection. Suppose that Thomas is trying to get to the airport. His car broke down. He can't get to the airport in a Ferrari because his wife doesn't have one. But core constraints don't block Thomas's imagination that his wife turns up in a Ferrari to take him to the airport. Hence, core constraints overgenerate possibilities.

This is no genuine objection to our proposal. There is no reasonable requirement that core constraints or peripheral constraints block the imagination of situations that are impossible for highly contextual reasons. To illustrate, it is no constraint to imagination that Thomas's wife doesn't have a Ferrari. Suppose that a few years later, Thomas learns that his wife got herself a Ferrari. Next time he gets stuck in the airport he *can* imagine that he gets to the airport in a Ferrari. Genuine constraints to imagination don't change from context to context. Instead, contextual beliefs have a role in blocking imagination of some impossible situations.

Contextual beliefs are beliefs about contextually relevant matters. In Thomas's case, he wants to know whether it is possible in view of his circumstances that he can get to the airport in a Ferrari. His beliefs

14. This means that various philosophical puzzles about the peripheral constraints to imagination remain. For instance, we leave it open whether constitutive truths are among the peripheral constraints. Given that, we don't contribute to Williamson's (2007; 2021) and Yli-Vakkuri's (2013) attempt to rebuff the problem of modal epistemic friction (Roca-Royes 2011; Vaidya & Wallner 2021). This important issue is beyond the scope of this paper.

about whether his wife has a Ferrari are therefore the contextual beliefs in that situation. In his original conundrum, he believes that his wife doesn't have a Ferrari. In conjunction with other contextual beliefs and imaginative constraints, this belief blocks his imagination that he gets to the airport in a Ferrari. But after he learns that his wife bought a Ferrari, his contextual beliefs and imaginative constraints permit imagination that he gets to the airport in a Ferrari.

This is just the ubiquitous phenomenon of *variation within constraints*. Whenever there is variation within constraints, plausible proposals about the constraints ought not rule out any of the permissible variation. The constraints block whatever is impermissible in any context. The variation within constraints is explained by input from the variable ambient environment. For instance, that cognitive device that infants utilise in their acquisition of competence with the grammar of their ambient language must include principles that rule out sentences or structures that are ungrammatical in every possible human language. However, it ought not include principles that rule out strings that are ungrammatical in some languages but grammatical in others. It shouldn't include principles that block permissible variation. Permissible variation is instead explained as a result of the setting of parameters—i.e., the interaction between the subject and its variable context (cf. Chomsky 1981).

6. Conclusion

Our approach has drawn upon core cognition, modal psychology, and modal semantics to offer a naturalistic explanation of our knowledge of a class of modal statements that is of significance to everyday life. To an extent, our conclusion is modest. We haven't suggested that every instance of imagination results in modal knowledge, nor that every instance of modal knowledge acquisition is the result of imagination. Rather, we have argued that to the extent that imagination plays a crucial role in acquisition of quotidian modal knowledge, it inherits constraints from core cognition. We submit that this naturalistic approach provides a welcome alternative to recent metaphysics-first approaches (cf. Mallozzi 2021; Boardman & Schoonen 2023).[15]

A worry that might remain is that we haven't shown that core imagination has a role in acquisition of knowledge of more exotic metaphysical possibilities.[16] There are at least two possible responses to this kind of worry and, importantly, our proposal is compatible with both. First, one might adopt a form of *modal modesty*: it might very well be that these more exotic possibilities are not knowable for mere mortals such as ourselves (cf. Van Inwagen 1998; Hawke 2011; Machery 2017; Strohminger & Yli-Vakkuri 2018b; Schoonen 2020a, Ch 12). If so, the request to explain our knowledge of whether or not philosophical zombies are possible is, in a sense, misguided, as we simply cannot know such things (cf. Williamson 2007, 164). Even given modal modesty, certain instances of quotidian modal knowledge are philosophically relevant—e.g., knowledge that Gettier cases are possible (Hawke & Schoonen 2021). Alternatively, one might suggest that we can extend our knowledge of quotidian modalities to gain knowledge of metaphysical modalities, using various methods (e.g., Vetter 2016; Roca-Royes 2017). If that is right, we make an indirect contribution to the anti-exceptionalist project by elucidating a potential "entry point"

15. One might wonder whether the use of imagination when engaging with fiction is restricted by the constraints of core cognition—and, if so, whether we could never imagine, e.g., phase objects in fiction. Note that it isn't clear that there is *one* cognitive faculty of "the imagination" that does all the work that we ascribe to imagination in our daily parlance (cf. Stevenson 2003; Kind 2013; Van Leeuwen 2013). It is probable that there are additional forms of "imagination" that are involved when we are engaging with fiction, which are distinct from what we have called 'core imagination'. We don't claim that core (or instructive) imagination is the only kind of imagination that we engage in. Nor do we claim that core imagination has no role in fiction. Weisberg & Goodstein (2009) show that in more realistic instances of fiction, imagination seems to follow the real-world facts more than in more exotic fiction (Kind 2016; Lane et al. 2016; Williamson 2016a; Harris 2021). Theorists of imagination might account for this by suggesting that when imaginings violate expectations, agents 'intervene' in their imaginings (e.g., Langland-Hassan 2016; Özgün & Schoonen 2024). Thanks to two anonymous reviewers for raising this question.

16. Thanks to two anonymous reviewers for urging us to address this worry explicitly.

into knowledge of metaphysical modalities.[17] Both of these options are compatible with our proposal. Ultimately, it is a partly empirical question whether core imagination plays a role in the acquisition of exotic metaphysical modal knowledge.[18]

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17. Here the relevant sort of anti-exceptionalism is *strong anti-exceptionalism*: the cognitive capacities we use to acquire metaphysical modal knowledge are the same capacities we use to acquire knowledge of quotidian modalities (Ichikawa 2016; Vetter 2016; Schoonen 2024). This is stronger than the requirement that the cognitive capacities we use to acquire metaphysical modal knowledge are the same capacities we use to acquire knowledge (modal or otherwise) in everyday life (Williamson 2007).

18. **Acknowledgements:** This paper was presented in the Naturalised Epistemologies of Modality workshop at the Centre for Advanced Studies in the Humanities, "Human Abilities" as well as the FU Berlin Theoretical Philosophy Colloquium. Many thanks to the audience for their questions and feedback. A special thanks to Nathaniel Baron-Smith, Max Goetsch, Sophie Kikkert, Richard Roth, Beatriz Santos, Barbara Vetter, Richard Woodward. This paper was written at *Human Abilities, a Centre for Advanced Studies in the Humanities* (grant number 409272951), funded by the *Deutsche Forschungsgemeinschaft* (DFG). During the time of writing, Samuel Boardman was part of the research project *Capacities and the Good* (grant number 439616221), funded by the *Deutsche Forschungsgemeinschaft* (DFG).

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