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RECENT WORK

The epistemology of modality

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1. *Introduction*

In this article the term 'modality', when unmodified, will refer to metaphysical modality. Metaphysical modality is what is expressed by 'possible' and variants such as 'possibly', as well as 'it could have been the case that . . . ' and variants, when these are used in the broadest objective sense. (Metaphysical necessity is the dual of metaphysical possibility, i.e. it is metaphysically necessary that *p* iff it is not metaphysically possible that it is not the case that *p*.) Perhaps the most straightforward way to characterize objective modality is negatively: it is what the modal words express when they are *not* used in any epistemic or deontic sense (a more precise characterization would take us too far afield).[1] Metaphysical modality is what these words express when they express objective modality and are not understood as restricted in any way. For example, 'Trump could not have won California' is true on various restricted objective readings, but in the completely unrestricted objective sense it *could have been the case* that Trump won California. In this sense, Trump could also have orbited Neptune, bicycled from Midtown Manhattan to Teotihuacán in one day, owned 17 talking donkeys, and had ever so many other extremely improbable achievements to his name; but he could not have been Hillary Clinton or any other individual actually distinct from Trump (although he could have looked, sounded, smelled, etc., exactly like Hillary Clinton and many others). The epistemology of modality inquires into the circumstances in which we can obtain knowledge that something is possibly so or necessarily so, in this sense.

The aim of this article is to survey the most important developments in the epistemology of modality of the last decade. (Some of the work we will discuss is more than a decade old, but in such cases it is part of a research program that extends into the last decade.) Much of the interest in the topic traces back to several decades earlier, when a revolution occurred in philosophers' understanding of the varieties of modality – a revolution in large part effected by a single work: Kripke's (1980) *Naming and Necessity* (*N&N*). *N&N* is largely responsible for our appreciation of the category of metaphysical modality and for distinguishing it from various epistemic and semantic

1 See Williamson 2016a: §1 for discussion.

Analysis Vol 00 | Number 0 | May 2017 | pp. 1–14 doi:10.1093/analys/anx058
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notions in the vicinity. (Kripke was by no means the first philosopher to focus on the metaphysical senses of the modal words. In doing so he was arguably rediscovering forgotten insights of the medieval period).[2] Some of *N&N*'s central theses have become orthodoxy: in particular, the claim that there are necessary *a posteriori* truths, and the claim that there are contingent *a priori* truths. For example, contemporary orthodoxy holds that it is necessary but *a posteriori* that Hesperus = Phosphorus, as well as that the atomic number of gold is 79, and that it is *a priori* but contingent that Hesperus is visible in the evening iff Hesperus is actually visible in the evening.[3] This revolution has caused many philosophers to reconsider how modal knowledge is possible. While Kripke himself has had little to say on the topic beyond some brief, suggestive remarks, *N&N* has been influential in shaping the discussion to the present day. Indeed, *N&N* contains passages that are suggestive of, and have been cited as inspiration for, each of the three main approaches we will discuss.[4]

We will use standard logical notation for abbreviation and clarity. In particular, '$\Box p$' will abbreviate 'It is necessary that p', and '$\Diamond p$' will abbreviate '$\sim\Box\sim p$' and can also be read as 'It is possible that p'. We will use abbreviations/names for two paradigms of the necessary *a posteriori*: '$H = P$' and 'G' will, depending on the context, either abbreviate, respectively, the sentences 'Hesperus = Phosphorus' and 'The atomic number of gold is 79', or serve as names for the propositions expressed by those sentences.

2. *Imaginability and possibility*

One common view whose roots trace back much further than *N&N* is this:[5] imaginability (or conceivability if these are distinct) entails possibility, perhaps with some exceptions. If so, there will be ways of coming to know that $\Diamond p$ that involve imagining that p. For example, one might imagine that p, know that one imagined that p, know the entailment, and use it to infer that $\Diamond p$. Or one might reliably form the belief that $\Diamond p$ when one imagines that p. If imaginability entails possibility, then both of these are ways of acquiring knowledge of possibility, and there may well be other ways. The literature has focused on the alleged entailment rather than the ways one could acquire knowledge of possibility given the entailment, and this will also be our focus.

The most sophisticated development of an idea of this general shape is to be found in Chalmers's (2002, 2006, 2012) program of epistemic two-dimensionalism. In Chalmers's theory, the role of conceivability is played by the

2 See Knuuttila 1993.

3 The last example is not Kripke's. See Kaplan 1989: 539, n. 65.

4 We cite relevant passages of *N&N* at the beginning of each of §§2–4.

5 See *N&N*: 127 and Hume 1968: 32.

dual of a priority: it is, in the relevant sense, conceivable that p iff it is not *a priori* that it is not the case that p. We'll say that p is *Chalmers-conceivable* iff p is conceivable in this sense. In Chalmers's theory each sentence is associated with a *two-dimensional (2D) intension*, a kind of meaning that encodes certain of its epistemic and modal properties. On a first approximation, Chalmers's theory associates each sentence φ with a 2D-intension $I(\varphi)$, which is a function from worlds, considered as epistemic possibilities of a certain kind, to functions from metaphysically possible worlds to truth values. In particular, the worlds $I(\varphi)$ takes as arguments are to be thought of as maximally Chalmers-conceivable propositions, i.e. propositions p such that it is Chalmers-conceivable that p, and, for each q, either $p \supset q$ is *a priori* or $p \supset \sim q$ is *a priori*. $I(\varphi)(w)$ is the proposition that the sentence φ expresses in w. That proposition, in turn, is a function from metaphysically possible worlds to truth values, namely, the proposition that is true in v if $I(\varphi)(w)(v) = \text{Truth}$ and otherwise is false in v. The diagonal of $I(\varphi)$ – i.e. the function f such that $f(w) = \text{Truth}$ if $I(\varphi)(w)(w) = \text{Truth}$ and otherwise $f(w) = \text{Falsehood}$ – is what Chalmers calls the *primary intension* of φ. According to what Chalmers (2006: 64) has dubbed the *Core Thesis* of his program, a sentence is *a priori* iff its primary intension is true in every world. Equivalently: φ is *a priori* iff, for each world w, considered as an epistemic possibility in the sense indicated above, the proposition φ expresses in w is true in w, considered as a metaphysical possibility. (What is true in a world considered as an epistemic possibility will depend on how that world is represented – a complication that we set aside but Chalmers 2006: §3 does not.)

It is important to Chalmers's program that some sentences have constant 2D-intensions – i.e. 2D-intensions that assign the same proposition to each world – while others do not. The existence of non-constant 2D-intensions is required by both the necessary *a posteriori* and the contingent *a priori*. The 2D-intension of a sentence that expresses a necessary proposition but is not *a priori* must, by the Core Thesis, assign a non-necessary proposition to some world. And an *a priori* sentence that expresses a contingent proposition has a 2D-intension that assigns to the actual world @ a proposition that is false in at least one world, w^*; thus, by the Core Thesis, that 2D- intension must assign to w^* some other proposition, which is true in w^*. On the other hand, constant 2D-intensions deliver the desired link between Chalmers-conceivability and possibility: a sentence with a constant 2D-intension is Chalmers-conceivable iff it is possible (i.e. expresses in @ a proposition that is possibly true).

What is the epistemological cash value of this alleged connection between constancy of 2D-intension, Chalmers-conceivability, and possibility? And how is Chalmers-conceivability related to conceivability in some more ordinary sense? The answers to these questions depend on how we fill in the details in the sketch of a theory above – a task to which Chalmers has devoted much time over the last two decades. Here we can only offer a few suggestive remarks, and we advise readers who are interested in the nitty-gritty to read the works by Chalmers cited in the bibliography. The key idea is that there is an elite class of words, which Chalmers sometimes calls the 'semantically neutral' words, and all (but not only) sentences composed entirely of such words have constant 2D-intensions. These include perhaps, in addition to logico-mathematical vocabulary, the vocabulary of physics and of qualia ('green', 'pain', etc.), but not, *inter alia*, ordinary proper names or natural kind terms (thus $H = P$ and G do not have constant 2D-intensions). Chalmers is optimistic that there are enough semantically neutral words for us to be able to use inferences from Chalmers-conceivability to possibility to acquire knowledge of possibility. Perhaps, for example, 'There are zombies' contains only semantically neutral words; if so, we may come to know that it is possible that there are zombies in part by finding it to be Chalmers-conceivable that there are zombies.[6] How Chalmers-conceivability is related to conceivability in some more ordinary sense is a difficult question on which Chalmers's own views do not appear to be entirely settled. His most recent work (e.g., Chalmers 2012: Chs. 1–4) is suggestive of the following answer: φ is Chalmers-conceivable iff it is possible for a kind of idealized agent (a Laplacean demon equipped with a 'cosmoscope') to conceive or imagine a world in which φ is true.

Another recent idea relates possibility to a kind of imaginability under suppositions. Defenders of this idea accept that various impossibilities, such as $H \neq P$ and $\sim G$, are imaginable, but they deny that anything impossible is imaginable under correct suppositions about what is actually the case. In particular, $H \neq P$ and $\sim G$ are both allegedly unimaginable under the suppositions that, actually, $H = P$ and G. The imaginability-under-suppositions approach is typically combined with the view that, when we appear to imagine an impossible proposition under correct suppositions about actuality, what we are really imagining is some related possible proposition.[7] (In Chalmers's framework, the primary intension of the sentence we use to express the impossible proposition we appear to imagine is a plausible candidate for the related possible proposition.) Yablo (1993: 34, n. 66), Chalmers (2002: 171), and especially Gregory (2004) have defended views of this kind. Kung (2016) criticizes such views, focusing on Yablo and Gregory.

3. *Two-factor views*

Two-factor views take their inspiration from a famous passage in *N&N*, in which Kripke says that cases in which we come to know that $\Box p$ *a posteriori*

6 Chalmers (1996) originally developed his 2D approach to serve as a tool for the investigation of the possibility of (philosophical) zombies and related modal questions in the metaphysics of mind.

7 This combination of views, which Yablo (2000) has dubbed 'textbook Kripkeanism', is also inspired by certain passages in *N&N*.

by inferring it from the *a posteriori* known p and the *a priori* known $p \supset \Box p$ '*may* give a clue to a general characterization of *a posteriori* knowledge of necessary truths' (159). According to these views, *a posteriori* modal knowledge can always be 'factorized' into a modal component that is *a priori* and a non-modal component that is not. (Some two-factor views concern justification rather than knowledge. The substitution of 'justification' for 'knowledge' will not affect our discussion.)

Making this metaphor more precise without exposing it to pedestrian counterexamples turns out to be challenging. One precisification deploys

> a simple inferential model, on which *a posteriori* knowledge that $\Box p$ is gained by inference from a conditional major premise, $p \supset \Box p$, known *a priori*, together with its antecedent, p, as minor premise' (Hale 2013: 259).

More generally, the idea is something like this: one can only know an *a posteriori* modal fact by deducing it from an *a priori* modal fact one knows together with an *a posteriori* non-modal fact one knows. The fact that pretty much anything that can be known can be known by testimony poses an immediate problem for this proposal. At best the simple inferential model could be thought to describe the way an item of *a posteriori* modal knowledge enters a community, whereafter it may spread by testimony.[8] But even this is questionable, since it seems to be possible for humans to know modal facts by perception (Strohminger 2015), and one can easily imagine a non-human agent hard-wired to, say, non-inferentially accept the necessitation of an identity statement with proper names in circumstances in which a human would accept the identity statement, thereby coming to know various *a posteriori* necessities. Nor is it clear why the simple inferential model requires an *a priori* premise: one can deduce $\Box H = P$ directly from $H = P$, without the aid of a conditional connecting the two, just as one can deduce $p \vee q$ directly from p without the aid of $p \supset (p \vee q)$. Recent two-factor theorists tend to advance more modest claims.

Casullo (2003, 2010) discusses two more modest proposals linking a priority to modality. According to one:

> (K1B*) If p is a necessary truth and S knows that p is non-contingent, then S is in a position to know *a priori* that p is non-contingent.

(K1B*) would allow us to 'factorize' knowledge that $\Box p$, which may be *a posteriori*, into $(p \supset \Box p)$ & $(\sim p \supset \Box\sim p)$ ('p is non-contingent'), which is knowable *a priori* provided that it is known, and p. (p, however, may be modal, but perhaps the idea is that when p is modal, knowledge that p can be 'factorized' by iterated applications of (K1B*) into an *a priori* and a

8 This seems to be Peacocke's (1999: 168–71) view.

non-modal component.[9]) According to Casullo (2010: 357–58), '(K1B*) is an intuitively plausible, widely accepted principle that enjoys no independent support but faces no clear counterexamples'. Yet Anderson (1993: 11–13), Bird (2007: 176), and Williamson[10] have presented clear counterexamples to it. To simplify Anderson's example a bit, consider a necessary proposition N and a contingent proposition C such that S knows *a priori* that N is non-contingent, knows *a priori* that C is contingent, but is not in a position to know *a priori* whether N or whether C. The details can be filled in in such a way that S and the disjunction $N \vee C$ are a counterexample to (K1B*).

Casullo (2003) responds to Anderson's counterexample by agreeing that (K1B*) 'is not generally true' (198) and proposing that we recognize a class of counterexamples to (K1B*) that lack a feature he calls 'modal symmetry' (196). In particular, Casullo maintains, '[i]n the case of [$N \vee C$], modal symmetry fails' (198). This, however, is demonstrably false. Casullo defines a proposition as modally symmetric just in case 'regardless of the truth values of its [truth-functionally] simple components' (197) the proposition is such that

> either (a) if it is true then it is necessarily true and if it is false then it is necessarily false or (b) if it is true then it is contingently true and if it is false then it is contingently false (196).

In other words, p is modally symmetric iff p satisfies CASULLO regardless of the truth values of its truth-functionally simple components.

CASULLO: $((p \supset \Box p)\ \&(\sim p \supset \Box{\sim}p)) \vee ((p \supset {\sim}\Box p)\ \&\ (\sim p \supset {\sim}\Box{\sim}p))$

As the reader can check, CASULLO is a truth-functional tautology, so every proposition is modally symmetric.

Chalmers puts forward (as 'plausible') yet another two-factor view, according to which 'all modal truths are *a priori* entailed by some non-modal truths' (2012: 273). This view does not face any well-known counterexamples, but it is also difficult to find any powerful arguments to support it.

4. *Counterfactual-based accounts*

The third class of views we will discuss connect the epistemology of modality with the epistemology of counterfactual conditionals. According to them, the cognitive capacities that make knowledge of counterfactual conditionals possible also make modal knowledge possible. Williamson (2007: Chs. 5–6,

9 While (K1B*) could be applied in this way when, say, p is $\Box\Box H{=}P$, cases like $G \supset \Box G$, which do not seem to be *a priori* (see Salmon 1981: 256–60), may pose a problem.

10 Williamson's counterexample is reported by Edgington (2004: 11).

forthcoming) is the chief proponent of this view.[11] We will call accounts of modal knowledge that are committed to this view 'counterfactual-based'.

Counterfactual-based views are motivated by the standard assumption that modal logic is reducible to counterfactual logic in the way proposed by Stalnaker (1968) and Lewis (1973): namely, '$\Box p$' is logically equivalent to 'If it had not been the case that p, then it would have been the case that $\bot$'. (Here '$\bot$' stands for an arbitrary truth-functional contradiction.) In symbols:

($\Box$) $\Box p \equiv (\sim p \mathrel{\Box\!\!\rightarrow} \bot)$

Thus, by definition of $\Diamond$, $\Diamond p \equiv \sim(p \mathrel{\Box\!\!\rightarrow} \bot)$.

Williamson (2007: 155–58) observes that ($\Box$) is derivable, in the weakest normal modal logic **K**,[12] from two natural principles:

NECESSITY: $\Box (p \supset q) \supset (p \mathrel{\Box\!\!\rightarrow} q)$

POSSIBILITY: $(p \mathrel{\Box\!\!\rightarrow} q) \supset (\Diamond p \supset \Diamond q)$

NECESSITY says that strict implication implies counterfactual implication; POSSIBILITY says that anything counterfactually implied by a possible proposition is possible.

On its own, ($\Box$) already tells us something of epistemological interest: one can come to know a modal truth by deducing it from a logically equivalent counterfactual truth, provided that one can know the latter. However (*pace* Hill 2014: 295) counterfactual-based accounts need not maintain that such deductions are the only route to modal knowledge.[13] An advocate of a counterfactual-based view can maintain that one can come to know a modal truth directly by using whatever method one can use to come to know an equivalent counterfactual truth.

One advertised virtue of counterfactual-based views is that they obviate the need to posit any cognitive capacities not used in ordinary life to explain modal knowledge (Williamson 2007: 136). Furthermore, since there is a plausible evolutionary explanation of the reliability of the processes that produce our counterfactual judgments, an advocate of a counterfactual-based view may hope to offer an evolutionary account of the reliability of our modal judgments (Kroedel 2012).[14] Counterfactual-based views, however, are not alone in claiming these advantages (Martínez 2015, Vetter 2016).

11 Williamson (forthcoming) cites *N&N* (50, 113) as a precedent.

12 **K** is characterized by the axiom $\Box (\varphi \supset \psi) \supset (\Box\varphi \supset \Box\psi)$ and the rule $\varphi/\Box\varphi$, where φ is a theorem.

13 See Williamson 2016c: 801–2, n. 1.

14 One might also try to explain why it is that we are incapable of knowing certain modal truths by appealing to our unreliability in evaluating counterfactuals logically equivalent to them (Strohminger and Yli-Vakkuri forthcoming: §5).

Counterfactual-based views also need not directly compete with the views discussed in §§2–3. One could hold any combination of them. For example, one could propose that a form of the principle that imaginability entails or is evidence of possibility falls out of a proper account of the role of the imagination in the epistemology of counterfactuals. (Chalmers 2002: 171 on 'secondary conceivability' and Gregory 2004 are suggestive here.) One could also combine a counterfactual-based view with a two-factor view (as Hill 2006 does) or, as Malmgren (2011) observes, with the view that 'intuitions' are required for some modal knowledge.

One way to challenge counterfactual-based views is to challenge the reduction of modal to counterfactual logic on which they rest. This will involve rejecting either NECESSITY or POSSIBILITY, which together imply (□). Critics of counterfactual-based views almost invariably reject NECESSITY but accept POSSIBILITY. A notable recent example is Lowe (2012), who rejects NECESSITY, accepts POSSIBILITY, and proposes (following Lowe 1995) the following reduction of counterfactual to modal logic as a basis for an alternative combined epistemology of counterfactuals and modality.

LOWE: $(p \mathrel{\Box\!\!\rightarrow} q) \equiv (\Box\,(p \supset q)\ \&\ (\Diamond p \vee \Box q))$

Lowe's position is clearly false. First, in the uncontroversial modal logic **KT**, LOWE is inconsistent with the approximately equally uncontroversial principle of Reflexivity: $p \mathrel{\Box\!\!\rightarrow} p$ (everything counterfactually implies itself).[15] The falsehood of LOWE, then, is at least as certain as the validity of **KT** and Reflexivity. Second, even if we deny the validity of both Reflexivity *and* **KT**, we will presumably still want to affirm some instances of Reflexivity, such as: if the atomic number of gold had not been 79, then the atomic number of gold would not have been 79. But by LOWE this platitude implies the falsehood that it is either possible or necessary that the atomic number of gold is not 79. Third, a philosopher who is willing to bite this last bullet presumably does so by accepting the principle that an impossible proposition counterfactually implies nothing (and so does not counterfactually imply itself). But LOWE is inconsistent with that principle: by LOWE every impossible proposition counterfactually implies every necessary proposition, so, in particular, if the atomic number of gold *had not been* 79, then the atomic number of gold *would have been* 79! Fourth, in **S5**,[16] which is plausibly the logic of metaphysical modality, LOWE implies that all

15 **KT** results from adding to **K** axiom **T** ($\Box\varphi \supset \varphi$), which says that necessity implies truth. $(\bot \mathrel{\Box\!\!\rightarrow} \bot) \equiv (\Box\,(\bot \supset \bot)\ \&\ (\Diamond\bot \vee \Box\bot))$ is an instance of LOWE, and this and Reflexivity imply the **KT**-inconsistent and manifestly false $\Diamond\bot \vee \Box\bot$. LOWE is also inconsistent with Reflexivity in **KD**, whose characteristic axiom, $\Box\varphi \supset \Diamond\varphi$, says that necessity implies possibility.

16 **S5** results from adding axiom **5** ($\Diamond\varphi \supset \Box\Diamond\varphi$) to **KT**.

counterfactuals are non-contingent, so, for example, if it is true that Trump would have won the general election even if he had lost California's 10th congressional district, then it is *necessary* that Trump would have won the general election if he had lost CA-10 (Trump's victory is metaphysically necessitated by his loss of CA-10!). Finally, we note that several of Lowe's objections to Williamson's proposal are at least equally powerful objections to LOWE. For example, Lowe objects to Williamson's proposal on the grounds that it entails the equivalence of $\Box p$ with $\sim p \mathbin{\Box\!\!\to} p$ (this 'strains my credulity' [2012: 930, n. 7]) and with $\forall q(q \mathbin{\Box\!\!\to} p)$ ('an extraordinarily *big* claim' [929]). Yet LOWE also entails the equivalence of $\Box p$ with $\sim p \mathbin{\Box\!\!\to} p$ and with $\forall q(q \mathbin{\Box\!\!\to} p)$.[17]

A second objection, which we have not found in the literature, runs as follows. Counterfactuals are context-sensitive. In ordinary contexts we use them to generalize over not all metaphysical possibilities but only some relevant ones. ($\Box$) will only hold in special contexts in which $\Box\!\!\to$ is used to generalize over all of the metaphysical possibilities. One might worry about whether one can ever get into that kind of context; if one cannot, then one can never truly assert the equivalence on which counterfactual-based views rely.[18] One possible reply, which strikes us as plausible, is that a counterfactual of the form $\sim p \mathbin{\Box\!\!\to} \perp$ tends to have the effect of shifting the context into one in which one does generalize over all possibilities, so one can sometimes get into the right kind of context simply by asserting ($\Box$). This view can be supported by appreciating the disorienting effect of B's response to A and the naturalness of A's response to B below.

A: *Trump could not have won California.*

B: *So, if Trump had won California, then he would have been both human and not human.*

A: *What? That's false! Surely Trump could have won California without being both human and not human. For example, if only white men had voted in California, Trump would have won California. But he wouldn't have then been both human and not human.*

17 $\Box\varphi$ is equivalent to $\Box(\sim\varphi \supset \varphi)$ and therefore to $\Box(\sim\varphi \supset \varphi)$ & $(\Diamond\sim\varphi \vee \Box\varphi)$ in **K**, so, by LOWE, $\Box\varphi$ is equivalent to $\sim\varphi \mathbin{\Box\!\!\to} \varphi$. In the standard axiomatization of propositionally quantified **K** (**AxK**π in Fine 1970), $\Box(\sim\varphi \supset \varphi)$ is equivalent to $\forall p\Box(p \supset \varphi)$, so to $\forall p(\Box(p \supset \varphi)$ & $(\Diamond p \vee \Box\varphi))$, so, by LOWE, $\Box\varphi$ is equivalent to $\forall p(p \mathbin{\Box\!\!\to} \varphi)$. The equivalence of $\Box\varphi$ with $\forall p(\Box(p \supset \varphi)$ & $(\Diamond p \vee \Box\varphi))$ can also be shown using the standard semantics for propositionally quantified modal logic, in which the variables are interpreted by the powerset of the model's set of worlds (Fine 1970, Kaplan 1970).

18 Vetter (2016) raises a related worry: natural language counterfactuals have epistemic readings, on which ($\Box$) fails. But even if we are able to get into a context in which only non-epistemic readings are relevant – as we presumably are – ($\Box$) will fail if the non-epistemic readings are restricted.

The effect of B's assertion appears to be similar to that of familiar examples of domain-expanding sentences. We may truly assert 'Everyone has a pencil and paper', meaning by it that everyone in the classroom has a pencil and paper. But if we follow this up with 'Everyone in the universe has a pencil and paper', we have said something false, and that can only be because we are speaking in a new context in which the 'everyone' is not restricted by an implicit 'in this classroom'. Counterfactuals of the form $\sim p \mathrel{\Box\!\!\rightarrow} \bot$ appear to have a similar effect.[19]

5. *Stepping back*

Our discussion so far has focused on three putative ways of obtaining modal knowledge: by means of certain kinds of imaginative exercises, by whatever methods yield *a priori* knowledge, and by whatever methods yield counterfactual knowledge. It is clear that there are other methods. For example, since one can come to know that $\Diamond p$ and (given **S5**) that $\Box\Diamond p$ by deducing these from one's knowledge that p, any method whatsoever that generates knowledge is capable of generating knowledge of both necessity and possibility when combined with deduction. Some less obvious examples of other methods are discussed in the recent literature. Williamson (2016a) discusses a variety of ways in which natural science delivers knowledge of certain restricted objective modalities, such as nomological possibility and nonzero objective probability, from which knowledge of metaphysical possibility can be derived. Yli-Vakkuri (2013: §3) argues that having a proof that p is in some cases sufficient for knowing that $\Box p$. Strohminger (2015) argues that one can sometimes know that $\Diamond p$ by perception and deduction even when p is false: for example, one can know that a cup that never breaks is breakable by perception, and deduce from this that it is possible that the cup breaks. Roca-Royes (2016) argues that one can sometimes know that $\Diamond p$, when p is false, by an inductive inference: for example, if one knows that various duplicates of a certain cup that never breaks possibly break (because they have broken), one can infer, and thereby come to know, that it is possible that the cup breaks.

While our discussion, like the literature, has focused on knowledge of particular modal facts, such as $\Box H = P$ and $\Box G$, the epistemology of modality of course also encompasses the epistemology of the most general modal facts. As such it overlaps the methodology of the metaphysics and logic of modality. One view here, defended by Lewis (1986: 3) and more recently by Williamson (2013: 423–29), is that the correct methodology of these areas of philosophy is abductive. According to this view, the correct way to evaluate a

19 Ichikawa (2016: 139) has also noticed the apparent context-shifting potential of sentences of the form $\sim p \mathrel{\Box\!\!\rightarrow} \bot$, but he thinks this is a problem for Williamson's view. We disagree.

principle of modal logic-*cum*-metaphysics, such as the necessitist principle $\Box\forall x\Box\exists y\ x=y$ ('necessarily everything is necessarily something'), is to develop necessitist and anti-necessitist theories and to compare these for simplicity, strength, and any other theoretical virtues.

Recently, Sider (2016) has challenged this view by arguing that modal logic and metaphysics lack the kind of connection to fundamental science which according to him legitimizes the application of abductive methodology to various non-fundamental sciences. Sider's challenge to Williamson's abductivism rests in part on his conventionalist conception of modality (Sider 2011: Ch. 12), according to which, roughly, to be necessary is to be a logical consequence of a list of 'modal axioms', the membership of which is determined by, and fickly depends on, the global pattern of our use of the modal words. Roughly speaking, Sider proposes that $\Box$ is *semantically plastic* in the way Williamson (1994) thinks vague words are.[20] In his reply, Williamson (2016b) both criticizes Sider's account of the legitimacy of abductive methodology for non-fundamental science and argues for the continuity of modal logic-*cum*-metaphysics with fundamental science. Meanwhile, Strohminger (2013: 398) argues that Sider's conventionalism supports no revisionary epistemological conclusions.

In a survey of work on the epistemology of modality one might also hope to find some discussion of work aspiring to greater generality concerning the subject matter of the epistemology of modality itself. While much of the discussion in the literature concerns fairly specific principles such as (K1B*), one can also raise far more general questions, such as: what are *all of the truths* expressible by the sentences of a language in which $\Box$ and a knowledge operator (or some other epistemic operator) are the only non-truth-functional logical operators, and the atomic sentences are understood as variables ranging over all propositions? In asking such a question one is asking for a combined logic of knowledge (or some other epistemic notion) and modality. Recent years have seen an increase in interest in epistemic-modal logics. For example, Fritz (2013, 2014) investigates the logic of $\Box$, actuality, and a priority; Chalmers and Rabern (2014) investigate the logic of $\Box$ and a priority; and Litland and Yli-Vakkuri (2016) and Yli-Vakkuri (2016) investigate the logic of $\Box$, actuality, and an epistemic definiteness operator. This recent work has uncovered some new problems related to old topics such as the contingent *a priori*. For example, Chalmers and Rabern (2014) take as their starting point the following puzzle (due to Forbes 2011): (A1)–(A3) are inconsistent in **K**.

(A1) $Ap\ \&\ {\sim}\Box p$

(A2) $Ap \supset \Box Ap$

(A3) $\Box\ (Ap \supset p)$

20 The term 'semantic plasticity' is from Hawthorne (2006).

Yet, when '*A*' is interpreted as expressing a priority, (A1) is true on some interpretation of '*p*', provided that there are contingent *a priori* truths, and (A2) (if *p* is *a priori* then *p* is necessarily *a priori*) and (A3) (necessarily, if *p* is *a priori*, then *p* is true) are prima facie plausible on any interpretation of '*p*'. Modal-epistemic logic has the potential to both deliver solutions to such puzzles and introduce greater systematicity and rigour into our thinking about the epistemology of modality.[21]

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21 We would like to thank David Chalmers, Peter Fritz, Jeremy Goodman, Dominic Gregory, John Hawthorne, Beau Madison Mount, and Timothy Williamson for helpful comments and discussions.

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Keywords: Epistemology of modality; modality; conceivability; counterfactuals; a priori knowledge; philosophical methodology