

THE COGNITIVE SCIENCE OF CREDENCE

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ABSTRACT: Credences are similar to levels of confidence, represented as a value on the [0,1] interval. This chapter sheds light on questions about credence, including its relationship to full belief, with an eye toward the empirical relevance of credence. First, I'll provide a brief epistemological history of credence and lay out some of the main theories of the nature of credence. Then, I'll provide an overview of the main views on how credences relate to full beliefs. Finally, I'll turn to the empirical, and suggest some ways that cognitive science does and could answer questions about credence, such as what credences one has, how credences relate to beliefs, and the extent to which we can control our credences.

KEYWORDS: Credence, Belief, Degree of Belief, Confidence, Doxastic Voluntarism, Cognitive Science

1. INTRODUCTION

There are lots of things you likely believe: that the Earth is round, that Paris is the capital of France, that you're reading a super cool paper right now. What is belief? Belief is, roughly, the attitude of regarding something to be true or taking it to be the case (Schwitzgebel 2023). Belief is a doxastic attitude with *propositional* content; i.e. we believe propositions.¹ More specifically, for every proposition, you can believe it, withhold on it, or disbelieve it (i.e. believe its negation). This is known as the *tripartite model* of belief. For example: I believe the sun will rise tomorrow; I withhold belief that a fair coin will land heads; I disbelieve that Notre Dame beat Ohio State in football last year (sadly).

However, many epistemologists think that the tripartite model doesn't tell the full story about our epistemic attitudes. To see why, consider: I believe both that I'll be going to the gym later today and that the sun will rise tomorrow. However, my attitude toward these propositions isn't the same; I'm more confident in the former than the latter (my motivation to go to the gym often wanes as the day goes on). This leads many epistemologists to posit another attitude, often known as *credence*.

Credences are something like levels of confidence, and are represented as a value on the [0,1] interval. For example, my credence that I will go to the gym later today is around 0.8, but my credence the sun will rise tomorrow is much higher (~0.9999...). Credences are more fine-grained than beliefs, and there are (at least in principle) infinitely many possible credences one can take toward a proposition. Credences are also called *partial beliefs* or *degrees of belief* (but see Moon 2017), and many epistemologists liken them to subjective probabilities.

This distinction—between credences and beliefs—raises a host of questions (see Jackson 2019). Do we really have both of these attitudes? Does one reduce to another—i.e. are credences just a type of belief, or vice versa? What exactly are credences anyway? How could we know what

¹ As Schwitzgebel (2023) notes, this is standard. But see Moss (2018) for a view on which beliefs (and credences) are not propositional attitudes.

credences we—or others—have? This article will shed light on some of these questions about credence, including its relationship to full belief, with an eye toward the empirical relevance of credence.

This article proceeds as follows. In **Section 2**, I'll provide a brief epistemological history of credence and lay out some of the main theories of the nature of credence. In **Section 3**, I'll provide an overview of the main views on how credences relate to full beliefs. In **Section 4**, I'll turn to the empirical, and suggest some ways that cognitive science does and could answer questions about credence, such as what credences one has, how credences relate to beliefs, and the extent to which we can control our credences. I conclude in **Section 5**.

2. WHAT ARE CREDENCES?

Epistemologists' understanding of credence has evolved over time. When the term 'credence' was originally introduced (by e.g. Ramsey and Lewis), credences were widely taken to be a probability function that is necessarily coherent, i.e. obeys Kolmogorov's axioms of probability (see Ramsey 1926, Lewis 1974, 1980, de Finetti 1972, 1990, Kaplan 1996). Credences were also assumed to be precisely point-valued. In many of the original discussions of credence, it was unclear to what extent credences were supposed to be features of actual human persons; instead, credences were used in probabilistic representation, modeling ideally rational agents, and the like (which has notable applications in fields like computer science and artificial intelligence).

Credences have also long been associated with betting behavior. Some (e.g. de Finetti 1990) held that one's credences are simply reducible to one's betting behavior; others (e.g. Ramsey 1926: 166ff, Jeffrey 1965) maintained that betting behavior provides a measure of one's credences. As Ramsey (1926: 169) puts it, the "degree of a belief is a causal property of it, which we can express vaguely as the extent to which we are prepared to act on it." Carnap (1962: 305) is one of the first to introduce the term "credence" in this context:

The concept of probability in the sense of the actual degree of belief is a psychological concept... to be established by the investigation of the behavior of persons in situations of uncertainty, e.g., behavior with respect to bets or games of chance. I shall use for this psychological concept the technical term 'degree of credence' or shortly 'credence'.

More precisely, the betting interpretation of credence is as follows (see Hájek 2023: sec 3.3.2):

Your credence in p is n iff you'd pay n utils to buy or sell a bet that pays 1 util if p and 0 utils if not p .

So, for example, suppose I'm offered a bet that pays out \$1 if it rains tomorrow and \$0 if it doesn't rain tomorrow. If I'm willing to pay \$0.80 for that bet, then I have a 0.8 credence that it will rain tomorrow. But if I'm only willing to pay \$0.10 for that bet, I only have a 0.1 credence that it will rain tomorrow. While this betting-behavior interpretation of credence enjoyed popularity for a while, the close association of credence with betting behavior has since faced serious challenges from Eriksson and Hájek (2007), among others (see also Foley 1993: ch. 4, Plantinga 1993: ch. 6, Christensen 2004: 5.2, Steffánson 2017). While there are several different worries and counterexamples (and many of the problems for behaviorism apply), a famous counterexample is Eriksson and Hájek's Zen monk case: "Imagine a Zen Buddhist monk who has credences but no preferences. Gazing peacefully at the scene before him, he believes that Mt. Everest stands at the

other side of the valley, that K2 does not, and so on. But don't ask him to bet on these propositions, for he is indifferent among all things" (2007: 194). Generally, it seems like one could have credences without preferences or dispositions to bet (or act) on a proposition.

Along similar lines, some epistemologists have tried to define credence using representation theorems, on which your credences are derived from your preferences, assuming your preferences satisfy certain constraints, such as transitivity (i.e. if you prefer A to B and B to C, then you prefer A to C) (see Ramsey 1926; see also Thoma 2019 for a useful overview of various representation theorems). This representation-theorem definition of credence also faces serious worries, including the worry that our preferences don't always reflect our credences—to borrow an example from Meacham and Weisberg (2011: 646): “Knowing full well that cockroaches are harmless, many people would sooner leave the room than brush a cockroach off their desk.” Furthermore, representation theorems only work for people who are, to a degree, rational. However, real-life humans have incoherent credences and preferences that don't satisfy the constraints required for representation theorems (along with Meacham and Weisberg 2011, these and other worries are further developed in Zynda 2000 and Eriksson and Hájek 2007). In my estimation, epistemologists are no longer as eager to maintain that credences are (perfectly) definable by representation theorems or closely associate credences with betting behavior (although see Elliott 2021). That said, betting behavior and/or representation theorems might be a useful (although imperfect) heuristic for determining one's credences.

The notion of credence has evolved in other ways. First, epistemologists seem to have dropped the assumption that credences are necessarily coherent. Many think that probabilistic coherence (or something similar) is a requirement of *rational* credence,² but today, the possibility of irrational credences is a common admission.³ Further, epistemologists no longer assume that credence (or even rational credence) is always precisely point valued; the possibility and rationality of vague, fuzzy, and interval credences is a topic that has received much attention as of late (see Weisberg 2015: sec 4).

Additionally, there is good reason to question the orthodoxy of dispositionalism about credence. One, as noted above, serious objections have been raised to the traditional dispositionalist view that associates credence with betting behavior. Two, when it comes to views of belief, a number of major theories have been raised, developed, and defended, including representationalism, dispositionalism, interpretativism, functionalism, primitivism, and eliminativism.⁴ Besides dispositionalism (and perhaps interpretativism; see Lewis 1974), these theories of belief have largely not been applied to credence. A potentially promising area of further research involves developing, e.g., representationalist, functionalist, or primitivist views of the nature of credence.⁵

Today, many epistemologists are moving toward thinking about credences as similar to the more familiar attitude of confidence (see, e.g., McGrath and Goldman 2014: 251, Lennertz 2015, Dogramaci 2016, Schupbach 2018, Moon 2018, 2019, Jackson 2019, 2020). With the departure of

² Skyrms (1996), Joyce (1998), Hájek (2008), Kaplan (2010). But see also Dogramaci (2018) for a possible norm to replace probabilism.

³ Russell (1948) used “credence” early on to mean something closer to its modern usage. He says, “I think, therefore, that everything we feel inclined to believe has a ‘degree of doubtfulness,’ or, inversely, a ‘degree of credibility.’ Sometimes this is connected with mathematical probability, sometimes not; it is a wider and vaguer conception. It is not, however, purely subjective. There is a cognate subjective conception, namely, the degree of conviction that a man feels about any of his beliefs, but ‘credibility,’ as I mean it, is objective in the sense that it is the degree of *credence* that a rational man will give” (248, emphasis mine).

⁴ Schwitzgebel (2023) discusses all of these except primitivism.

⁵ Eriksson and Hájek (2007) endorse and sketch a brief outline of a primitivist view of credence. (However, Hájek no longer endorses primitivism about credence). See D’Ambrosio and Jackson (2024) for a functionalist view of credence.

thinking of credence as necessarily rational and necessarily point valued, it seems that credences are being treated less as merely a formal modeling tool and more as a feature of human persons. As Jonah Schupback (2018: 3) notes, "...credences are... naturally thought of as degrees of confidence. So construed, Bayesianism most straightforwardly provides a logic of confidences. As a normative theory, it examines how an agent's confidences ought to look." Schupback carefully places the role for perfectly probabilistic credences in the realm of the normative, rather than the descriptive. Actual humans have levels of confidence that may or may not be probabilistic, and, in turn, may or may not be rational.⁶ And, in my view, this reflects a general trend for how many Bayesians now think about credence.⁷

Further, belief and credence, as I understand them, describe and apply to normal humans, and part of what I'll consider is what credences (and beliefs) look like for *humans like us*. But, if credences are necessarily rational, always precisely point-valued, and the like, it's unclear whether humans even have credences (as Holton 2008, 2014, Horgan 2017, and Byrne 2021 argue). This isn't to say that human credences are never precisely point valued, especially, say, when considering your credence that a fair coin will land heads or when proportioning your credence to a particular statistic. Nonetheless, on the understanding of credence I will adopt in this paper—which is similar to the understanding of many contemporary epistemologists—credences are mental states had by actual human persons, and, while probabilistic and more fine-grained than full belief, they can be fuzzy, messy, irrational, and incoherent.

3. CREDENCE AND BELIEF

We've seen that many epistemologists employ a coarse-grained, tripartite model of belief on which one can believe, withhold, or disbelieve propositions. Other epistemologists discuss credence, a fine-grained attitude that measures our confidence in a proposition on a $[0,1]$ interval. This raises the question: how do credence and belief relate to each other? Does one reduce to another? This section briefly surveys various answers to these questions (for a more detailed overview, see Jackson 2020).

There are, of course, many questions about credence and belief besides the question of whether one attitude reduces to the other. First, there are normative questions about the relationship between rational belief and rational credence (e.g. is the Lockean thesis true, i.e. rational belief is rational credence above some threshold? See Jackson 2020: sec 3). While, in psychology, our failures to be rational Bayesian reasoners are widely documented (see, e.g. Kahneman et al 1982, Johnson et al 2020, Oaksford and Chater 2007), here my focus is on other, descriptive questions, such as the nature of credence and the relationship of credence to belief.

Second, there's a broader question of categorization: are belief and credence species of the same genus? In some sense, this is trivially the case, as belief and credence are both epistemic attitudes, i.e. they are evaluated by epistemic norms, responsive to evidence (at least when rational), and the like. But you might wonder: are these two kinds of *belief*?⁸ The answer largely depends on what you mean by "belief". Some ways of labeling these two attitudes, e.g. "outright belief" and "degree of belief," suggest that these are two kinds of belief or two ways of believing (see Van Leeuwen and

⁶ In the case of imprecise credences, they may be rational only if representable by a probability function. See van Frassen (1983: 311), Foley (1993: ch. 4).

⁷ While widespread, this trend isn't universal. Roger Clarke argues, in Clarke and Staffel (forthcoming: sec. 2), that we should be more careful to associate credence and confidence, and in some ways, return to the way authors such as Ramsey and de Finetti thought about credence.

⁸ Others have suggested that both belief and credence reduce to comparative confidence; see Stefánsson (2017).

Lombrozo 2023). On another view, the term “belief” is reserved for the coarse-grained attitude, and credences shouldn’t be regarded as degrees of belief (e.g. Moon 2017). Alternatively, this might be largely a matter of semantics, i.e. whether we use the term “belief” to pick out epistemic attitudes generally, or a specific kind of tripartite, course-grained representational attitude. Two things are clear. (1) Belief and credence are both *epistemic* and in that sense, belong to the same category. (2) Whether credences are a kind of belief depends on how general the category of “belief” is; a noteworthy issue, but not one I will take a stand on here. That said, I will use the term “credence” instead of “degree of belief”, as this terminology is less committal on these controversial issues of reduction and/or categorization.

Now, we’ll consider whether belief reduces to credence, or vice versa.

3.1 Reductionism

When it comes to belief and credence, there are two main reductionist views. The first is the *credence-first* view. On this view, beliefs reduce to credences. On a typical version of this view:

Credence-First: S’s belief that p *reduces to* S’s credence that p above some threshold.

There’s not a consensus on what that threshold is: some argue the threshold is 1 (Greco 2015; Dodd 2016); others argue for a fixed threshold less than 1 (Shear and Fitelson 2019); others argue for a vague threshold (Lee 2017); others argue for a threshold that varies with context or stakes (Weatherson 2005; Pace 2011). What all credence-first views have in common, however, is that the belief-attitudes (belief, withholding, disbelief), reduce to and can be understood as a matter of having particular credences. Credence is more fundamental, and we should understand belief in terms of it.

A second reductionist view is the *belief-first* view. On the belief-first view, credence reduces to belief. While there are variations of this view, a common version of this view is that credences are beliefs with particular content, e.g. beliefs about epistemic probability or epistemic modals (see Moon and Jackson 2020, Lennertz forthcoming, Buchanan and Dogramci forthcoming). Borrowing from Moon and Jackson (2020: 654, with slight modification):

Belief-First: S’s credence of X in p *reduces to* S’s belief that Mp (where M is an epistemic modal such as “probably” or “might”, and X and M correspond to each other).

So my 0.5 credence a coin will land heads is a belief that *the probability the coin will land heads is 0.5*. My high credence that will snow tomorrow is a belief that *it will probably snow tomorrow*. My non-zero credence that I will go to the gym later is my belief that *I might go to the gym later*. On this belief-first view, the numerical feature of credence is built into the content of what is believed. Other belief-first views attempt to capture the fine-grained features of credence in something other than the content of what is believed (Easwaran 2016; Kaus 2020). Nonetheless, all belief-first views reduce credence to a feature of coarse-grained beliefs, rendering belief the more fundamental attitude and credence the derivative attitude.

3.2 Non-Reductionism

Some epistemologists maintain that, not only do we have both beliefs and credences, but neither attitude reduces to the other. Both belief and credence are equally fundamental. This view is sometimes known as non-reductionism or belief-credence dualism, *dualism* for short (see Ross and

Schroeder 2014, Buchak 2014, Staffel 2019-a, Weisberg 2020, Jackson 2022-a, Jackson and Tan 2022).

Dualism: Belief does not reduce to credence, and credence does not reduce to belief.

The general idea behind dualism is that belief and credence each have their unique roles to play. Furthermore, the roles for belief cannot be played by high credence (perhaps the role of ruling out small error possibilities, as Clarke 2013 and Staffel 2019-a suggest) and the roles for credence cannot be played by probability- or modal-beliefs (perhaps the role of explaining how unsophisticated agents can have credences, even without the concept of probability, see Frankish 2009 and Jackson 2022-b).

4. THE EMPIRICAL RELEVANCE OF CREDENCE

This section looks at how the tools of cognitive science and psychology bear on (or could be applied to) questions regarding credence. **Section 4.1** discusses how empirical methods could shed light on the nature of credence and what credences people have. **Section 4.2** discusses empirical work on credence and belief and future directions this might take. **Section 4.3** discusses ways we might test whether we have voluntary control over our credences.

It's worth noting that some of the (actual and potential) studies mentioned will tell us about the folk theory of credence: e.g. asking people to report their credences, to describe their attitudes probabilistically, or for their instincts about credal control. And it's of course possible that the folk are misguided or wrong about the nature of credence. Insofar as we ultimately want to discover the nature of credence, there's a gap to be bridged; without argument, we shouldn't automatically conclude that credences are as the folk suggest. At the same time, if subjects make judgments about credence that drastically depart from the way many philosophers think about credence, it's worth considering whether philosophers ought to revise—or at least be more skeptical of—their conception of credence, especially if credences are supposed to be understood as a measure of confidence, a familiar human attitude. And it's reasonable to think the folk conception of X is, other things equal, noteworthy (but of course defeasible) evidence about the nature of X.

Second, some of these studies will ask people to report their credences. In practice, I suggest we should ask participants how “confident” they are that some proposition is true. Using confidence-talk is easier than trying to teach people the technical term “credence”; furthermore, it's not clear the word “credence” has the same meaning in ordinary English as it does in Bayesian epistemology (as Moon 2019: 276 suggests). People could then report their confidence on a 0-1 scale or a 0-100 scale; alternatively, they could be given an option to report their confidence more vaguely (e.g. “highly confident”, “moderately confident”, etc.), perhaps via a fill in the blank option.⁹

4.1 The Nature and Knowledge of Credence

A natural starting point is to ask whether, and to what extent, humans have credences. If we understand credences generally, as subjective probabilities or a probabilistic representation of a proposition, few philosophers deny that we have credences. Some, (e.g. Holton 2008, 2014, Horgan 2017) deny that we have precisely point-valued credences, but nonetheless maintain we have levels of confidence or partial beliefs to explain how we are more confident in some of our beliefs than in others. Johnson et al (2020: 5) point out that, given how commonplace it is to say

⁹ Thanks to Andrew Moon for helpful discussion.

things like “there’s a 70% chance of rain,” probabilistic attitudes are undeniably a part of human psychology. So, given a broad understanding of credence, it’s uncontroversial in philosophy and psychology that we have credences.

Even on this broad understanding of credence, however, questions loom. First, given the long tradition of understanding credence in terms of betting behavior, it would be interesting to test whether, and to what extent, credences correlate with betting behavior. Philosophers have suggested that one might have a credence in p but, for many reasons, not be willing to take the bets on p (because they are risk averse, or they are morally opposed to betting, or they are a Zen Monk with no preferences, or they are irrationally afraid of cockroaches, etc.). Even conceding this, there are still open questions about the extent to which credence and betting behavior come apart. A more ambitious study might ask subjects to report their credences in various statements, then actually offer them real bets on the truth of those statements. Alternatively, after reporting their credences, subjects could simply be asked whether they’d take hypothetical bets on the same propositions. This could shed light on the degree to which betting behavior is a generally good guide to one’s credences, and to what extent (or in what contexts) credence and betting behavior come apart.¹⁰

Another interesting question involves the scope of credences: do we have credences in all propositions in which we have beliefs? Is it possible to believe p without having a credence in, or a probabilistic representation of, p at all (see Moon 2019)? It would be interesting, for example, to ask subjects about their belief-attitudes toward various propositions. Then, ask them to report their confidence level or credence in those same propositions. Then, once they reported a confidence level, ask if they’d describe themselves, in the second task, as *forming* or merely *introspecting* the credences in question. If they weren’t willing to report any kind of confidence level corresponding to the belief-attitude, that itself would be noteworthy, although, in studies like these, it might be hard to distinguish between a credence’s being difficult to introspect from one’s not having a credence, period.

The topic of credal introspection raises other questions: do we have a special kind of access to our own credences? The betting behavior interpretation of credence suggests no: insofar we can (at least in principle) observe the behavior of others just as easily as our own behavior, we have equally good access to our own credences as we do to the credences of others. Some, notably Dogramaci (2016), have challenged this, and argued that we have special access to our own credences—in the same way it seems, at least *prima facie*, that we have special access to our own beliefs, desires, hopes, fears, etc.

To test whether there’s a self-other asymmetry regarding credal introspection, we might ask subjects first-person questions about their own attitudes, observing to what extent they are willing to describe their attitudes probabilistically. Then, after providing a detailed third-person vignette about another’s behavior, we could ask them to describe that person’s credence(s). It would be interesting to see if there were differences in how readily subjects were willing to attribute credences first-personally compared to third-personally. If the credal attributions are symmetrical, this may suggest that we don’t have unique introspective access to our credences. However, if there are asymmetries, either in a willingness to attribute a credence altogether, or in the precision of the credences, this might suggest a difference in credal accessibility.

¹⁰ Relevant to the betting behavior test is the literature on which tradeoffs people will accept; many, for instance, are hesitant to put economic or monetary value on goods like friendship. This may, in turn, make people hesitant to take particular bets on propositions involving (say) family and friends. See Tetlock et al (2000). Thanks to Tania Lombrozo.

Furthermore, and relatedly, it would also be interesting to see the extent to which people were willing to describe their probabilistic attitudes as precisely point valued, and to what extent people would only merely want to commit to imprecise descriptions such as “highly confident”, “moderately confident”, or “not at all confident.” Many philosophers agree that we have *some* precisely point-valued credences, often when we form credences in response to precise evidence (e.g. a coin toss, dice roll, or a specific piece of statistical evidence). On the other hand, it’s also widely thought that some credences are imprecise: e.g. even after considering the matter carefully, I won’t form a 0.648 credence that my neighbor has a can of tuna in their pantry. But are most of our credences imprecise? Are there certain propositions that we’re more inclined to describe in precise probabilistic terms and others for which we’d only want to commit to an imprecise description? Does this vary from person to person? Again, asking subjects to report their credences (perhaps while varying the precision of the evidence provided) is a way to shed light on these questions.

4.2 Credence and Belief

4.2.1 *Testing Reductionism*

Recall that both the credence-first and the belief-first view make claims about reduction: on the former, belief reduces to high credence; on the latter, credence reduces to probability belief. These stronger reductionist claims entail coextensivity claims: e.g. the former entails that for every belief there is a high credence; the latter entails that for every credence there is a probability-belief.

These coextensivity claims seem, at least to a degree, amendable to empirical verification. For example: are people willing to describe all of their beliefs in probabilistic terms? This wouldn’t necessarily require their reporting a precise probability for each belief, but rather a willingness to call their believings highly probable, their disbelievings highly improbable, and the like. While this wouldn’t prove any kind of reductionism, it could serve as positive evidence for a credence-first view. If, however, people were unwilling to describe their beliefs in probabilistic terms, that could potentially be a worry for the credence-first view (although you’d want to rule out alternative explanations, such as having credences that are difficult to introspect).

For the belief-first view, the relevant claim is whether credences and probability-beliefs are coextensive. There are at least two areas where empirical methods seem especially relevant (but these are by no means exhaustive). First, some authors, notably Keith Frankish (2009: 77), maintain that small children and animals have credences. Consider how readily we attribute levels of confidence to them, e.g. “my dog is pretty confident we are about to go on a walk” or “my child has little confidence that the green vegetable tastes good.” Frankish is skeptical, however, that children and animals are cognitively sophisticated enough to have the concept of probability. Frankish concludes that a child or animal could have a credence without a probability belief, contra the belief-first view. Dogramaci (2018) and Moon and Jackson (2020) reply that either these creatures are sophisticated enough to have concepts like “probably” or “might” (and other simple epistemic modals), or for the very unsophisticated creatures (e.g. honeybees), probabilistic behavior (e.g. checking the spot that is 90% likely to have nectar before the spot that is 50% likely to have nectar) is explained by subpersonal mechanisms, not mental states, so they actually don’t have credences *or* probability beliefs. Note that both parties in this debate (those objecting that creatures have credences without probability-beliefs, and those responding that either the creatures have both attitudes or lack both attitudes) are, to a degree, making empirical claims. Therefore,

empirical research on child and animal mental states and probabilistic behavior is extremely relevant for the truth of the belief-first view.¹¹

Another area where empirical methods are relevant to the belief-first view involves human reasoning. Richard Holton (2014: 21-25) points out that, in reasoning, it's much easier to reason when natural frequencies are presented in the content (e.g. 10 out of every 1000 women have breast cancer; 8 of these 10 women with breast cancer will have a positive mammogram result) than when they are presented as conditional probabilities (e.g. the probability that a woman has breast cancer is 1%; if she has breast cancer, the probability of a positive mammogram result is 80%). Holton explains that significantly more people answered questions about probability correctly, and appropriately incorporated base rate data, when the data was presented as natural frequencies rather than conditional probabilities. Holton argues that this supports the belief-first view: "...if the probabilities were really in the attitudes, then to do the calculation the subjects would need to have credences of the correct degree before they could apply Bayes' rule. But the relevant degrees of credence are exactly what they are given when the problems are presented as conditional probabilities" (2014: 24). While this doesn't prove the belief-first view (dualists and credence-firsters think there are probability-beliefs, and simply because probability-beliefs aid in reasoning doesn't provide that credences reduce to them; see Staffel 2013 and Byrne 2021 for related discussion), it would be interesting if probabilistic reasoning was easier, and more frequently performed, with probabilities in the content rather than the attitude. This claim and similar claims about the role for credence in reasoning seem amendable to further empirical test, and could help adjudicate the content vs. attitude question.

4.2.2 Testing Non-Reductionism

Evidence from cognitive psychology also bears on belief-credence dualism, the view that neither belief nor credence reduces to the other. Jonathan Weisberg (2020) draws this connection very clearly, arguing that our best psychological evidence supports dualism. He considers three areas of psychological research: (i) judgment & decision-making, (ii) cognitive closure, and (iii) memory & metacognition. In each case, he discusses recent research and then shows how the data is best explained by non-reductionism. The general line he pushes is that, in some cases, we treat a proposition as flat-out true; whereas other times, we treat the same proposition probabilistically. Our tendency to view uncertain propositions as probabilistic in some contexts but not others is best explained by dualism. Moreover, he argues that belief and credence "cooperate in effective and efficient reasoning, rather than stumbling over one another, or colliding with foolish results" (11). Generally, Weisberg also provides a nice model bringing together empirical methods and careful philosophical thinking. Along similar lines, Johnson et al (2020) argue that, while on the one hand, people clearly have probabilistic attitudes (i.e. credences), at the same time, people tend to treat uncertain information as true or false and ignore small probabilities when making downstream predictions. With a bit of philosophical argument, these empirical observations are—as Weisberg argues—tentative support for dualism.

Furthermore, recent work on the cognitive science of belief suggests that we have different kinds of beliefs or epistemic attitudes. For example, Van Leeuwen and Lombrozo (2023) propose a pluralist view of belief, on which there are many kinds or ways of believing. More specifically, some philosophers and psychologists have suggested that "think" and "believe" (roughly) map onto two different kinds of belief. On these views, people generally report that they "think" that p when p is presented in a factual context, e.g. as a well-established scientific or empirical fact,

¹¹ See e.g. Smith et al (2003), Smith and Washburn (2005), Balci et al (2009), Crary (2012), Hanus and Call (2014), Denison and Xu (2014), Beran et al (2015), Tecwyn et al (2017), Byrne (2021: sec. 6.1).

whereas they say they “believe” that *p* if presented in a more personal context, such as a religious or ethical context.¹²

In some preliminary studies by Vesga, Van Leeuwen, and Lombroso (2024), a person John was described as having strong evidence for a particular claim, either in a religious context or in a matter-of-fact context. Then, participants were asked to naturally fill in the sentence: “John _____ that [claim].” As noted, participants were more likely to describe John as *believing* the claim in the religious context and more likely to describe John as *thinking* that that claim is true in the matter-of-fact context. Furthermore—and even more interesting for the dualist—participants were more likely to describe John’s belief in *p* in probabilistic terms in the matter-of-fact contexts, whereas they were more likely to describe John’s belief in *p* as binary in the religious context. This suggests several things. First, the folk find it natural to think that we have binary and probabilistic attitudes toward the same proposition and that we utilize each in different contexts. Second, the folk think that we are more likely to rely on our credence in *p* in a matter-of-fact context and more likely to rely on our belief that *p* in a personal context. If this is correct, then probabilistic reasoning is correlated with factual matters like history or science, but binary reasoning is correlated with personal, moral, or religious matters. This again is tentative but notable support for a dualist picture of belief and credence, and suggests that the folk conceive of unique roles for each attitude.

4.3 Credal Voluntarism

Both philosophers and psychologists are interested in what kinds of control we exercise over our doxastic attitudes. Doxastic control is often considered to be relevant to—if not necessary for—doxastic responsibility and doxastic evaluations. Put differently, many think that in order to hold someone responsible for their attitude, and/or to evaluate the attitude as permissible, obligatory, etc., a degree of control over the attitude is required (see Alston 1988).

Almost all philosophers working on doxastic voluntarism (the view that we have voluntary control over our beliefs) have focused only on whether we have control over full belief: could we believe that *p* (or withhold belief that *p*) at will?¹³ Similarly, the psychological work that’s been done on mental state control has focused on flat-out belief.¹⁴ The question of what kind of control we exercise over our *credences*, in contrast, is untested and underexplored.

There doesn’t seem to be any principled reason for this asymmetry, as most of the reasons to care about voluntary belief also apply to credence. We evaluate credences as rational and irrational; arguably, the Bayesian project is primarily about exploring and defending requirements on rational credence. Furthermore, we hold people accountable for their credences: for example, you might reasonably be upset at your spouse if they were overly confident in a negative rumor about you; we also hold people responsible for having high credences in propositions that are sexist or racist (Fritz and Jackson 2021; see also Gao 2019). It’s surprising, then, that questions of credal voluntarism are so underexplored.

A few philosophers mention credal voluntarism in passing. For example, Wolterstorff (2010: 76) briefly suggests that we can intentionally and voluntarily alter our levels of confidence in various propositions, especially by *maintaining* our confidence in light of doubts and *strengthening* our levels

¹² See Heiphetz et al. (2013); Heiphetz et al. (2014); Heiphetz et al. (2021); Van Leeuwen et al. (2021); Van Leeuwen (2022); Davoodi & Lombroso (2022); Van Leeuwen & Lombroso (2023).

¹³ See Alston (1988), Audi (2001), Hieronymi (2006), Steup (2008), and Roeber (2019); see Boespflug and Jackson (2024) for an overview of the philosophical literature on doxastic voluntarism.

¹⁴ See Turri et al (2018), Cusimano and Goodwin (2019, 2020), Buckwalter and Turri (2020), Weiss et al (2021), Nottelmann et al (2023), Cusimano et al (2024).

of confidence. Elizabeth Jackson (2019: 2487–8) points out that we shouldn't move too quickly from the conclusion that belief is (in)voluntary to the conclusion that credence is (in)voluntary. Furthermore, she argues that the feasibility of this inference depends, in part, on the relationship between belief and credence. For example, if the belief-first view is true and credences are probability-beliefs, it would be surprising if we have a different kind of control over beliefs with probabilistic content than beliefs without probabilistic content. However, if dualism is true and belief and credence are irreducible, then there's no *a priori* reason to conclude that our control over belief and credence would be the same.

John Pittard's unpublished manuscript (2024) is one of the only paper-length treatments of credal voluntarism. In a Bayesian framework, one's credence in a proposition p is largely taken to be a product of one's evidence regarding p and ur-priors (ur-priors represent p 's plausibility before considering empirical evidence). Pittard argues that we can voluntarily control our credences by controlling our ur-priors. He also argues that we likely won't control our credence to p in isolation (which could compromise credal coherence), but rather our credences in many propositions at once; put differently, we can choose our credences by choosing between two opposing outlooks or worldviews.

I'm not aware of any psychological work addressing mental state control over credence. However, this seems to be an easy yet noteworthy extension of the previous work on mental state control. Psychologists have, alongside belief, tested lay intuitions about our control over states such as desire, intention, and emotion (e.g. Cusimano et al 2024); similar tests could be applied naturally and straightforwardly to credences. While this would tell us most directly about laypeople's views of credal control, it would also bear on the plausibility of credal voluntarism. And as we've seen, credal voluntarism has implications for many noteworthy issues, including credal evaluation and responsibility, whether practical and/or moral factors affect (rational) credence, the relationship between belief and credence, and the extent to which credence and belief are normatively and descriptively (a)symmetrical. Thus, I hope that credal voluntarism is a subject of future psychological and philosophical work.

5. CONCLUSION

Credences are subjective probabilities, assigned a value between 0 and 1, often likened to levels of confidence. We saw a brief history of credence, including the original introduction of "credence" by Ramsey and de Finetti, and how the notion of credence has evolved since. Then, we discussed three views on how credences relate to full beliefs: on the belief-first view, credences are beliefs about probability; on the credence-first view, beliefs are credences above some threshold, and on the dualist view, neither belief nor credence reduces to the other; they are equally fundamental. Finally, we turned to the cognitive science of credence, and examined some ways that cognitive science does and could answer questions about credence, such as what credences one has, how credences relate to beliefs, and the extent to which we can control our credences. While psychologists have done ample work on heuristics and biases and how these can cause credal irrationality (and I hope this work continues), I also hope that more philosophers and psychologists will apply empirical methods to questions such as the nature of credence, the relationship between belief and credence, and credal voluntarism.

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WORKS CITED

- Alston, William. (1988). "The Deontological Conception of Epistemic Justification." *Philosophical Perspectives* 2: 257–299.
- Audi, Robert. (2001). "Doxastic Voluntarism and the Ethics of Belief." In *Knowledge, Truth, and Duty: Essays on Epistemic Justification, Responsibility, and Virtue* (In Matthias Steup, ed.), pp. 93–109. Oxford: OUP.
- Balci, F., D. Freestone, and C. R. Gallistel. (2009). "Risk Assessment in Man and Mouse." *The Proceedings of the National Academy of Sciences of the United States of America* 6(7): 2459–63.
- Beran, M. J., Perdue, B. M., Futch, S. E., Smith, J. D., Evans, T. A., & Parrish, A. E. (2015). Go when you know: Chimpanzees' confidence movements reflect their responses in a computerized memory task. *Cognition* 142, 236–246
- Boespflug, Mark and Elizabeth Jackson. (2024). "Doxastic Voluntarism." *Stanford Encyclopedia of Philosophy* (Edward Zalta, ed.).
- Buchak, L. (2014). "Belief, Credence, and Norms." *Philosophical Studies* 169, 285–311.
- Buchanan, Ray, and Sinan Dogramci. (Forthcoming). "Belief about Probability." *Journal of Philosophy*.
- Byrne, Alex. (2021). "Perception and Probability." *Philosophy and Phenomenological Research* 104(2): 1–21.
- Carnap, Rudolf. (1962). *Logical Foundations of Probability*. Chicago: The University of Chicago Press.
- Christensen, David. (2004). *Putting Logic in its Place*. Oxford University Press.
- Clarke, R. (2013). "Belief is Credence One (In Context)." *Philosopher's Imprint* 13, 1–18.
- Clarke, Roger, and Julia Staffel. (Forthcoming). "Are Credences Different From Beliefs?" In Blake Roeber, Matthias Steup, John Turri & Ernest Sosa (eds.), *Contemporary Debates in Epistemology*, 3rd edition. New York: Wiley Blackwell.
- Crary, A. (2012). "Dogs and Concepts." *Philosophy* 87 (2): 215–73.
- Cusimano, C., & Goodwin, G. P. (2019). "Lay beliefs about the controllability of everyday mental states." *Journal of Experimental Psychology*, 148(10): 1701–1732.
- Cusimano, Corey, and Geoffrey P. Goodwin. (2020). "People Judge Others to Have More Voluntary Control over Beliefs than They Themselves Do." *Journal of Personality and Social Psychology* 119(5): 999–1029.
- Cusimano, Corey, Natalia Zorrilla, David Danks, and Tania Lombrozo. (2024). "Psychological Freedom, Rationality, and the Naïve Theory of Reasoning." *Journal of Experimental Psychology: General*. 153(3): 837–863.

- D'Ambrosio, Justin and Elizabeth Jackson. (2024). "Credal Functionalism." Unpublished Manuscript.
- Davoodi, T., & Lombrozo, T. (2022). "Explaining the existential: Scientific and religious explanations play different functional roles." *Journal of Experimental Psychology: General* 151(5): 1199.
- Denison, S., & Xu, F. (2014). The origins of probabilistic inference in human infants. *Cognition*, 130, 335–347.
- Dodd, D. (2016). Belief and Certainty. *Synthese* 194(11), 4597–4621.
- Dogramaci, Sinan. (2016). "Knowing our Degrees of Belief." *Episteme* 13(3): 269–287.
- Dogramaci, Sinan. (2018). "Rational Credence Through Reasoning." *Philosophers' Imprint* 18(11): 1–25.
- de Finetti, Bruno. (1990). *Theory of Probability*. Vol. I (first edition 1974). New York: Wiley.
- de Finetti, Bruno. (1972). *Probability, Induction, and Statistics*. New York: Wiley.
- Easwaran, K. (2016). "How I Learned to Stop Worrying and Love Bayesian Probabilities." *Noûs* 50(4): 1–38.
- Elliott, Edward. (2021). "Betting Against the Zen Monk: On Preferences and Partial Belief." *Synthese* 198: 3733–3758.
- Eriksson, Lina, and Alan Hájek. (2007). "What are Degrees of Belief?" *Studia Logica* 86(2): 183–213.
- Foley, Richard. (1993). *Working without a Net*. Oxford: Oxford University Press.
- Frankish, K. (2009). Partial Belief and Flat-Out Belief. In: *Degrees of Belief*. Ed. by Franz Huber and Christoph Schmidt-Petri, pp. 75–96. New York: Springer.
- Fritz, James, and Elizabeth Jackson. "Belief, Credence, and Moral Encroachment." *Synthese* 199(1–2): 1387–1408.
- Gao, Jie. (2019). "Credal Pragmatism," *Philosophical Studies* 176: 1595–1617.
- Greco, Daniel. (2015). How I Learned to Stop Worrying and Love Probability 1. *Philosophical Perspectives* 29, 179–201.
- Hájek, Alan. (2008). "Arguments for—or Against—Probabilism?" in the *British Journal for the Philosophy of Science* 59(4): 793–819.
- Hájek, Alan. (2023). "Interpretations of Probability." *Stanford Encyclopedia of Philosophy* (Edward Zalta, ed.). <https://plato.stanford.edu/entries/probability-interpret/>
- Hanus, D., & Call, J. (2014). "When maths trumps logic: Probabilistic judgements in chimpanzees." *Biology letters* 10, 20140892.

- Heiphetz, L., Landers, C. L., & Van Leeuwen, N. (2021). "Does think mean the same thing as believe? Linguistic insights into religious cognition." *Psychology of Religion and Spirituality*, 13(3), 287.
- Heiphetz, L., Spelke, E. S., Harris, P. L., & Banaji, M. R. (2013). "The development of reasoning about beliefs: Fact, preference, and ideology." *Journal of experimental social psychology*, 49(3), 559–565.
- Heiphetz, L., Spelke, E. S., Harris, P. L., & Banaji, M. R. (2014). "What do different beliefs tell us? An examination of factual, opinion-based, and religious beliefs." *Cognitive development*, 30, 15–29.
- Hieronymi, Pamela. (2006). "Controlling Attitudes." *Pacific Philosophical Quarterly* 87 (1): 45–74.
- Holton, Richard. (2008). "Partial Belief, Partial Intention." *Mind* 117(465): 27–58.
- Holton, Richard. (2014). "Intention as a Model for Belief." *Rational and Social Agency: Essays on the Philosophy of Michael Bratman* (Manuel Vargas and Gideon Yaffe, eds). Oxford: OUP.
- Horgan, Terry. (2017). "Troubles for Bayesian Formal Epistemology." *Res Philosophica* 94(2): 233–255.
- Jackson, Elizabeth. (2019). "Belief and Credence: Why the Attitude-Type Matters." *Philosophical Studies* 176 (9): 2477–2496.
- Jackson, Elizabeth. (2020). "The Relationship Between Belief and Credence." *Philosophy Compass* 15 (6): 1–13.
- Jackson, Elizabeth. (2022-a). "On the Independence of Belief and Credence." *Philosophical Issues* 32(1): 9–31.
- Jackson, Elizabeth. (2022-b). "Why Credences Are Not Beliefs." *Australasian Journal of Philosophy* 100 (2): 360–370.
- Jackson, Elizabeth, and Peter Tan. (2022). "Epistemic Akrasia and Belief-Credence Dualism." *Philosophy and Phenomenological Research* 104 (3): 717–727.
- Jeffrey, Richard. (1965). *The Logic of Decision*. (second edition 1983). University of Chicago Press.
- Johnson, Samuel G.B., Thomas Merchant, and Frank C. Keil. (2020). "Belief digitization: Do we treat uncertainty as probabilities or as bits?" *Journal of Experimental Psychology: General* 149(8): 1417–1434.
- Joyce, James M. (1998). "A Nonpragmatic Vindication of Probabilism." *Philosophy of Science* 65(4): 575–603.
- Kahneman, D., Slovic, P., & Tversky, A. (Eds.). (1982). *Judgment under uncertainty: Heuristics and biases*. Cambridge, UK: Cambridge University Press.
- Kaplan, Mark. (1996). *Decision Theory as Philosophy*. Cambridge: Cambridge University Press.

- Kaplan, Mark. (2010). "In Defense of Modest Probabilism." *Synthese* 176(1): 41–55.
- Kauss, Dominik. (2020). "Credence as doxastic tendency." *Synthese* 197(10): 4495–4518.
- Lee, M. (2017). "On the Arbitrariness Objection to the Threshold View." *Dialogue* 56: 143–158.
- Lennertz, Benjamin. (Forthcoming). "Credences are Beliefs about Probabilities: A Defense from Triviality." *Erkenntnis*.
- Lennertz, Benjamin. (2015). "Quantificational Credences." 15(9): 1–24.
- Lewis, David. (1980). "A Subjectivist's Guide to Objective Chance." In Richard C. Jeffrey (ed.), *Studies in Inductive Logic and Probability* (Volume II). Berkeley: University of California Press, 263–293.
- Lewis, David. (1974). "Radical Interpretation." *Synthese* 27 (July-August): 331–344.
- Liquin, E. G., Metz, S. E., & Lombrozo, T. (2020). Science demands explanation, religion tolerates mystery. *Cognition*, 204, 104398.
- McGrath, Matthew, and Alvin Goldman. (2014). *Epistemology: A Contemporary Introduction*. Oxford: Oxford University Press.
- Meacham, Christopher J. G. and Jonathan Weisberg. (2011). "Representation theorems and the foundations of decision theory." *Australasian Journal of Philosophy* 89(4): 641–663.
- Moon, Andrew. (2017). "Beliefs Do Not Come in Degrees." *The Canadian Journal of Philosophy* 47(6): 1–19.
- Moon, Andrew. (2018). "The Nature of Doubt and a New Puzzle about Belief, Doubt, and Confidence." *Synthese* 195(4): 1827–1848.
- Moon, Andrew. (2019). "A New Puzzle About Belief and Credence." *Canadian Journal of Philosophy* 49(2): 272–29
- Moss, Sarah. (2018). *Probabilistic Knowledge*. Oxford: Oxford University Press.
- Nottelmann, Nikolaj, Anthony Booth, and Rune Lomholt. (2023). "Are We Pre-Theoretically Committed to Doxastic Voluntarism?" *Review of Philosophy and Psychology* 14 (3): 1077–1098.
- Oaksford, Mike and Nick Chater. (2007). *Bayesian Rationality: The Probabilistic Approach to Human Reasoning*. Oxford: OUP.
- Pace, Michael. (2010). "The Epistemic Value of Moral Considerations: Justification, Moral Encroachment, and James' 'Will To Believe'." *Noûs* 45 (2): 239–268.
- Pittard, John. (2024). "Credal Voluntarism and the Christian Faith." Unpublished Manuscript.

- Ramsey, Frank. (1926). "Truth and Probability," in Ramsey, 1931, *The Foundations of Mathematics and other Logical Essays*, Ch. VII, p.156-198, edited by R.B. Braithwaite, London: Kegan, Paul, Trench, Trubner & Co., New York: Harcourt, Brace and Company.
- Roeber, Blake. (2019). "Evidence, Judgment, and Belief at Will." *Mind*, 128 (511): 837–859.
- Ross, J., and M. Schroeder. (2014). "Belief, Credence, and Pragmatic Encroachment." *Philosophy and Phenomenological Research* 88(2), 259–288.
- Russell, Bertrand. (1948). *Human Knowledge: its Scope and Limits*. Oxford, England: Simon & Schuster.
- Schupbach, Jonah. (2018). "Troubles for Bayesian Formal Epistemology? A Response to Horgan." *Res Philosophica* 95(1).
- Schwitzgebel, Eric. (2023). "Belief." *Stanford Encyclopedia of Philosophy* (Edward Zalta, ed.). <http://plato.stanford.edu/entries/belief/>
- Shear, T. and B. Fitelson. (2019). "Two Approaches to Belief Revision." *Erkenntnis* 84(3), 487–518.
- Skyrms, Brian. (1996). "The Structure of Radical Probabilism." *Erkenntnis* 45(2-3): 285–297.
- Smith, J. D., Shields, W. E., & Washburn, D. A. (2003). The comparative psychology of uncertainty monitoring and metacognition. *Behavioral and Brain Sciences*, 26, 317–339.
- Smith, J. D., & Washburn, D. A. (2005). Uncertainty monitoring and metacognition by animals. *Current Directions in Psychological Science*, 14, 19–24.
- Staffel, J. (2013). "Can There be Reasoning with Degrees of Belief?" *Synthese* 190: 3535–51.
- Staffel, Julia. (2019). "How do Beliefs Simplify Reasoning?" *Noûs* 53 (4): 937–962.
- Steffánson, H. O. (2017). "What Is 'Real' in Probabilism?" *The Australasian Journal of Philosophy* 95(3). 573–587.
- Steup, Matthias. (2008). "Doxastic Freedom," *Synthese* 161: 375–392.
- Tecwyn, E. C., Denison, S., Messer, E. J., & Buchsbaum, D. (2017). Intuitive probabilistic inference in capuchin monkeys. *Animal Cognition*, 20, 243–256.
- Tetlock, Philip E. Orié V. Kristel, S. Beth Elson, Melanie C. Green, and Jennifer S. Lerner. (2000). "The Psychology of the Unthinkable: Taboo Tradeoffs, Forbidden Base Rates, and Heretical Counterfactuals." *Journal of Personality and Social Psychology* 78(5): 853–870.
- Thoma, Johanna. (2019). "Decision Theory." In Richard Pettigrew & Jonathan Weisberg (eds.)'s *The Open Handbook of Formal Epistemology*. PhilPapers Foundation.
- Turri, J., D. Rose, and W. Buckwalter. (2018). "Choosing and refusing: doxastic voluntarism and folk psychology." *Philosophical Studies* 175: 2507–2537.

- Van Leeuwen, Neil. (2022). "Two Concepts of Belief Strength: Epistemic Confidence and Identity Centrality." *Frontiers in Psychology*, 13, Article 939949.
- Van Leeuwen, Neil and Tania Lombrozo. (2023). "The Puzzle of Belief." *Cognitive Science* 47: 1–5.
- Van Leeuwen, N., Weisman, K., & Luhrmann, T. M. (2021). "To believe is not to think: A cross-cultural finding." *Open Mind*, 5, 91–99.
- Vesga, Alejandro, Neil Van Leeuwen, and Tania Lombrozo. (2024). "Evidence for distinct cognitive attitudes of belief in the theory of mind." Unpublished Manuscript.
- Weatherson, B. (2005). "Can We Do Without Pragmatic Encroachment?" *Philosophical Perspectives* 19, 417–443.
- Weisberg, Jonathan. (2015). "You've Come a Long Way, Bayesians." *Journal of Philosophical Logic: 40th Anniversary Issue* 44(6): 817–34.
- Weisberg, Jonathan. (2020). "Belief in Psyontology." *Philosophers' Imprint* 20 (11): 1–27.
- Weiss, Alexa, Matthias Roestmann, and Pascal Burgmer. (2021). "Moralizing mental states: The role of trait self-control and control perceptions." *Cognition* 214: 1–21.
- Wolterstorff, Nicholas. (2010). "Ought to Believe: Two Concepts." In *Practices of Belief: Selected Essays*. Vol. 2. Edited by Terence Cuneo, 62–85. Cambridge, UK: Cambridge University Press.
- Zynda, Lyle. (2000). "Representation Theorems and Realism about Degrees of Belief." *Philosophy of Science* 67: 45–69.