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Can there be reasoning with degrees of belief?

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Abstract In this paper I am concerned with the question of whether degrees of belief can figure in reasoning processes that are executed by humans. It is generally accepted that outright beliefs and intentions can be part of reasoning processes, but the role of degrees of belief remains unclear. The literature on subjective Bayesianism, which seems to be the natural place to look for discussions of the role of degrees of belief in reasoning, does not address the question of whether degrees of belief play a role in real agents' reasoning processes. On the other hand, the philosophical literature on reasoning, which relies much less heavily on idealizing assumptions about reasoners than Bayesianism, is almost exclusively concerned with outright belief. One possible explanation for why no philosopher has yet developed an account of reasoning with degrees of belief is that reasoning with degrees of belief is not possible for humans. In this paper, I will consider three arguments for this claim. I will show why these arguments are flawed, and conclude that, at least as far as these arguments are concerned, it seems like there is no good reason why the topic of reasoning with degrees of belief has received so little attention.

Keywords Reasoning · Degrees of belief · Harman · Probability

1 Introduction

In this paper I am concerned with the question of whether degrees of belief can figure in reasoning processes that are executed by humans. Reasoning, as I understand it here, is the mental activity of forming or revising one's attitudes based on other attitudes. It is generally accepted that outright beliefs and intentions can be part of reasoning

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processes, but the role of degrees of belief remains unclear. The literature on subjective Bayesianism, which seems to be the natural place to look for discussions of the role of degrees of belief in reasoning, does not address the question of whether degrees of belief play a role in real agents' reasoning processes. Subjective Bayesianism tends to be concerned instead with modeling reasoning processes of certain kinds of ideal agents, but it usually does not discuss how these models relate to human psychology. Some authors even think that subjective Bayesianism seems more akin to a logic of degrees of belief, which is quite different from a theory of reasoning.[1] On the other hand, the philosophical literature on reasoning, which relies much less heavily on idealizing assumptions about reasoners, is almost exclusively concerned with outright belief.[2]

One possible explanation for why no philosopher has yet developed an account of reasoning with degrees of belief is that reasoning with degrees of belief is not possible for humans. I will investigate in this paper whether this claim is plausible. In the first part of the paper, I will discuss introspective and empirical considerations that suggest that we can reason with degrees of belief. In the second part, I will discuss three different arguments that purport to show that humans cannot reason with degrees of belief. Two of them have been suggested by Harman in *Change in View* (1986), and the last one is based on claims commonly made about reasoning in the literature. I will show why these arguments are flawed, and conclude that, at least as far as these arguments are concerned, it seems like there is no good reason why the topic of reasoning with degrees of belief has received so little attention. Any plausible theory of reasoning should consider degrees of belief as serious candidates for attitudes that can be involved in reasoning processes.

2 The case for reasoning with degrees of belief

It is not my goal in this paper to defend a particular account of reasoning, but I should say a few words about what I take reasoning to be. I am only interested in reasoning of the kind that is done by one person, not reasoning that is done by a group of people. I think I am in agreement with good common sense if I take reasoning to be a mental activity that is directed at forming or revising mental attitudes on the basis of other such attitudes. So, the question I am trying to answer is whether reasoning, so understood, can involve degrees of belief.

Degrees of belief differ from outright beliefs in the following way: the outright belief that p is what you ascribe to some subject S by saying that S believes that p. By contrast, degrees of belief are the kinds of attitudes we mean when we speak about how

[1] For an insightful discussion of the difference between a theory of logic and a theory of reasoning, see Harman (1986, Chaps. 1 and 2). For an argument for the view that subjective Bayesianism is a kind of logical system, see Howson and Urbach (2006).

[2] In the manuscript for his new book *Rationality through Reasoning*, Broome (2013, p. 277) focuses on outright belief, and he begins his very brief discussion of degrees of belief with the remark that he does not know of a worked-out theory of reasoning with degrees of belief. Other authors who have published important work on reasoning in the last 20 years or so also focus on outright belief (e.g. Boghossion 2011 (APA presentation); Streumer 2007; Wedgwood 2006; Grice 2001; Harman 1986; Walker 1985).

confident S is in p, or that S is more confident in p than in q. Degrees of belief are often represented in formal models as numbers between 0 and 1, and I will adopt this practice in some of my examples. By modeling degrees of belief in this way, we can express how confident a person is in a proposition, but it doesn't mean that these numbers are actually present in that person's mind. I won't say much here about how exactly we know what numerical value to assign to a certain degree of confidence, and whether we should model degrees of belief with precise numbers or intervals. In general, people's degrees of confidence manifest themselves in their behavioral dispositions and their decision-making.

It is important not to confuse degrees of belief with outright beliefs about probabilities. The outright belief that the probability of p is 0.7 is not the same attitude as a degree of belief of 0.7 in p. It is possible to have a degree of belief in a proposition without having a corresponding outright belief in the probability of that proposition. No matter how we spell out what we mean by probability—objective probability, evidential probability, frequency etc.—it is always possible for a subject to have a degree of confidence in some proposition p, yet be uncertain what probability to assign to p, and thus to lack the corresponding outright belief.[3]

I will argue that degrees of belief, just like outright beliefs, can function as attitudes that we reason *from* and attitudes we reason *to*. In other words, degrees of belief, just like outright beliefs, are available as starting points and end points of reasoning processes.

I will now consider four different examples of reasoning processes, and I will argue that we can best capture the similarities and differences between these examples if we maintain that degrees of belief can function as premises and conclusions of reasoning processes. The first example is an instance of practical reasoning, in which outright beliefs serve as starting points. Suppose Waltraud is planning a party for her birthday, and she is trying to decide whether to have the party on Friday or on Saturday. It is of utmost importance to her that as many as possible of her three best friends Franz, Hinz and Kunz will be able to attend. Waltraud believes that Franz is unavailable on Friday because he has ballet practice, but is free on Saturday. She also believes that Hinz is unavailable on Friday because he'll be babysitting his daughter, and is free on Saturday. Moreover, she believes that Kunz is free on Friday, but busy with his knitting circle on Saturday. From these beliefs, Waltraud reasons that since only one of her friends is free on Friday, but two of them are free on Saturday, and since she wants as many of them as possible to attend, she should have the party on Saturday.

Compare this case to a second example, with the only difference that degrees of belief are the starting points of the process. Again, Waltraud is deciding between having the party on Friday or on Saturday. She knows that each of her friends is available on 1 of the 2 days, but unavailable on the other. Yet for each particular day, she doesn't have outright beliefs about each of her friends' plans; she only has her degrees of belief to work with. This may be, for example, because her friends were rather vague in giving her information about their schedules, or because she simply doesn't remember exactly what they said. Suppose Waltraud's credence that Franz is free Saturday is 0.7.

[3] See for example: Ross (2006, p. 196), Christensen (2004, p. 19).

Her credence that Kunz is free on Friday is also 0.7. Moreover, her credence that Hinz free on Saturday is 0.6. Again, Waltraud wants as many of her friends as possible to attend her party. She realizes that, given her credences about Franz and Kunz, Friday and Saturday seem equally good, but since she is slightly more confident that Hinz is free on Saturday rather than on Friday, she decides to have the party on Saturday.

It is easy to imagine oneself in each of these predicaments, and each case seems like a paradigmatic case of practical reasoning.

We can produce a similar pair of examples in the realm of theoretical reasoning. Suppose Franz believes that Hinz, Kunz, or Waltraud will soon become his new boss. He also believes that each of them values his work very highly and would offer him a promotion if they were his superior. Thus, Franz comes to believe on the basis of this information that he will soon be promoted. This third example is an instance of theoretical reasoning with outright beliefs.

We can easily construct a fourth example, which is similar except that it results in a degree of belief. Suppose again that Franz believes that either Hinz, Kunz, or Waltraud will soon become his new boss. He also believes that Hinz and Kunz would immediately promote him if they became his boss, but that Waltraud wouldn't. On the basis of these beliefs, Franz forms a degree of belief of 2/3 that he will soon be promoted. Again, we have two very similar deliberation processes, which differ with respect to the mental state that serves as their respective conclusion.

It is certainly uncontroversial that the first and the third example, which only involve only outright beliefs, are instances of reasoning. And given the similarity between the second and the first example, and the similarity between the fourth and third example, it seems very natural to think that the examples involving degrees of belief are instances of reasoning as well.

One might object to my characterization of these examples by arguing that reasoning with degrees of belief is really the same as reasoning with outright beliefs about probabilities. Thus, one might claim that in the last example, Franz' reasoning concludes with the outright belief that the probability that he will be promoted is 2/3, rather than a degree of belief of 2/3 that he will be promoted, and similarly in the second example. This would be a natural view to hold if degrees of belief were nothing over and above outright beliefs of a certain kind. In other words, if degrees of belief were the same thing as outright beliefs about probabilities, then reasoning with degrees of belief would plausibly not be different from reasoning with outright beliefs. However, as I mentioned above, a subject can have a degree of belief in some proposition p without having an outright belief about the probability of p, no matter how we spell out the relevant sense of probability. This is because she may be uncertain about the probability of p, while still having a specific degree of belief in p.

Thus, we can simply assume that my examples of reasoning with degrees of belief are cases in which the agents have degrees of belief, but lack outright beliefs in the probabilities of the relevant propositions. If the examples are specified in this way, the possibility that the subjects in the examples are reasoning with outright beliefs instead of degrees of belief is ruled out.

The claim that degrees of belief play a distinct role in cognitive processing is also vindicated by empirical studies, for example, by some interesting research by Parsons and Osherson (2001). They conducted several experiments in which they

asked subjects to either judge the deductive validity of an argument in premise-conclusion format, or to judge whether they considered a certain conclusion highly likely given a specific set of premises. Meanwhile, researchers were monitoring the subjects' brain activity. They found that non-numerical, credence-based processing involves neural activations that are distinct from the activation patterns observed in deductive reasoning, and they conclude that "the findings confirm that deduction and induction are distinct processes, consistent with psychological theories enforcing their partial separation" (p. 954). The fact that credence-based tasks seem to be executed by the brain in a different way than deductive reasoning tasks lends support to the view that there is a real difference between the outright belief-based and the credence-based reasoning processes that served as examples above.

I conclude based on my arguments that we have strong prima facie reasons to assume that humans can reason with degrees of belief. In the next section, I will discuss different attempts to establish the opposite conclusion.

3 The case against reasoning with degrees of belief

In the second part of my paper, I will discuss three arguments against the possibility of reasoning with degrees of belief. The first two arguments have been given by Harman in his book *Change in View*, and the third argument is constructed from claims about reasoning that have been made in various places in the literature.

3.1 The explicitness argument

The explicitness argument is simple: Harman claims that any attitude that can be part of a reasoning process must be an explicit attitude, and he claims that since degrees of belief are not explicit attitudes, one can't reason with them. I will argue that Harman's premise that degrees of belief are not explicit is false, and that it relies on a flawed account of the nature of degrees of belief. Yet, I accept the first premise of Harman's argument—that only explicit attitudes can enter into reasoning processes.

Harman explains the difference between explicit and implicit attitudes as follows:

> I assume one believes something explicitly if one's belief in that thing involves an explicit mental representation whose content is the content of that belief. On the other hand something is believed only implicitly if it is not explicitly believed, but, for example, is easily inferable from one's explicit beliefs. (Harman 1986, p. 13)[4]

[4] Harman points out that this is not the same as the distinction between conscious and unconscious beliefs, or between occurrent and dispositional beliefs. Unconscious beliefs are not the same as implicit beliefs, because the latter, but not the former, can be easily brought to one's awareness. Conscious beliefs are not the same as explicit beliefs, because it might be that unconscious beliefs involve explicit representations. Furthermore, the distinction between occurrent and dispositional (merely potentially occurrent) beliefs does not map onto the distinction between explicit and implicit beliefs either, because a belief can be explicitly represented in someone's mind without being currently in the focus of awareness (Harman 1986, pp. 13–14).

The same distinction Harman draws here between individually represented, explicit beliefs, and merely inferable, implicit beliefs has been adopted by cognitive scientists in order to distinguish attitudes than can enter into cognitive processes directly from attitudes that need to be retrieved via some computational process in order to be available for processing. The more complex the process is by which a piece of information must be retrieved, the more implicit is the way it is stored (Harman 1986, p. 22). This distinction between explicit and implicit attitudes is not only applicable to beliefs and reasoning, but to all mental attitudes and cognitive processes. Any mental attitude that participates in a cognitive process must be maximally explicit. As Kirsh explains, "the computational complexity of the process of interpretation determines where on the continuum of explicit to implicit a given representation lies. If the interpretative process […] extracts the content quickly and without substantial involvement of the rest of the cognitive system, then the information it extracts is directly available and hence explicitly encoded" (Kirsh 2003, p. 479).

Thus, if the distinction between explicit and implicit attitudes is made in this way, it becomes a definitional truth that only explicit attitudes can enter into cognitive processes. That is because, by definition, explicit attitudes are those kinds of attitudes that are represented in a format that is directly available for cognitive processing. A piece of information that is implicitly represented cannot be used in processes like reasoning unless it is first retrieved, or—in Harman's words—inferred and thus made explicit, at least temporarily. For example, I might implicitly believe that I don't have 12.546 siblings, because that is implied by my explicit belief that I have exactly 2 siblings, but the mere fact that it is implied by one of my explicit beliefs does not by itself make it ready for entering into a causal process. In order to make this belief ready to participate in cognitive processing, I would have to actually *draw the inference*, so that my belief that I don't have 12.546 siblings is at least temporarily represented in an explicit format that is immediately available as a premise in reasoning.[5]

Based on these considerations I accept Harman's first premise: only explicit attitudes can participate in reasoning. More generally, we have seen that any mental attitude that participates in any cognitive process must be explicit, because that means it is represented in our minds in the right way to enter into such a process.

Footnote 4 continued

I should note here that there is also a different use of the explicit–implicit distinction in the psychological literature. The distinction used in psychology is much closer to the conscious–unconscious distinction than the one proposed by Harman. Schwitzgebel (2010) explains this in more detail in his article on belief in the SOP.

[5] Drawing the distinction between explicit and implicit attitudes also provides a neat solution to a kind of storage problem. In the sibling example, it seems very natural to say that, besides believing that you have exactly two siblings, you also believe that you don't have three siblings, and that you don't have four siblings, and so on. However, given that the mind only has a limited storage capacity, it seems implausible to claim that there is a separate, explicit representation for each of these beliefs. Distinguishing between explicit and implicit beliefs is one strategy for avoiding this problem, because having just one explicit belief about having two siblings makes it unnecessary to waste storage capacities on the countless other beliefs about how many siblings you *don't* have. Those beliefs are implicit, and they can easily be inferred from your explicit belief.

Let us now turn to Harman's second premise: that degrees of belief are implicit attitudes. In light of the considerations in support of the first premise, it is clear that by holding the position that degrees of belief are always implicit, Harman commits himself to claiming that degrees of belief cannot participate in reasoning. If degrees of belief were always implicit, they could never be represented, even temporarily, in a format that makes them accessible as starting points and end points of reasoning processes. And this does not only hold for reasoning processes. I have argued above that for any attitude to participate in any mental process, that attitude must be represented explicitly. Thus, Harman commits himself to the position that degrees of belief cannot participate in any mental process. Yet, this position seems difficult to maintain in light of the introspective and empirical considerations I presented in the first part of the paper. Thus, the burden of proof is on Harman to show that his second premise is correct.

Harman's endorsement of the claim that degrees of belief are implicit stems from a very idiosyncratic view of degrees of belief. He thinks that they are an emergent property of the way our outright beliefs are linked. In *Change in View*, he proposes the following explanation for how beliefs can have varying strengths:

> I am inclined to suppose that these varying strengths are implicit in a system of beliefs one accepts in a yes/no fashion. My guess is that they are to be explained as a kind of epiphenomenon resulting from the operation of rules of revision. For example, it may be that P is believed more strongly than Q if it would be harder to stop believing P than to stop believing Q, perhaps because it would require more of a revision of one's view to stop believing P than to stop believing Q. (Harman 1986, p. 22)

Harman suggests here that degrees of belief can be reduced to outright beliefs. He thinks that the degree of belief that one has in a proposition depends on how robustly embedded the belief is in one's overall web of beliefs. And since he believes that these features of one's explicit beliefs are not themselves explicitly represented in one's belief-box, Harman regards degrees of belief as implicit.

As Keith Frankish argues in his book *Mind and Supermind*, Harman's view requires that one have an outright belief in every proposition that one has a degree of belief in. But that seems absurd. Say I am at the horse races, and I am watching a race with five horses. I have a credence of 0.5 that 'Darwin's Pride' will win. In this situation, I certainly have neither an outright belief that 'Darwin's Pride' will win, nor that it won't win. But according to Harman, I cannot have a degree of belief in this proposition unless I have an outright belief in it. Harman's account conflicts with the possibility of such middling degrees of belief (Frankish 2004, p. 18)

Moreover, it is implausible to claim that the degree to which one believes a given proposition varies with the degree to which it would be difficult for one to give up one's outright belief in this proposition. Harman's view implies that if I have a credence of 0.9 in some proposition p and a credence of 0.95 in another proposition q, then it would be more difficult to revise my belief that q than to revise my belief that p, because a higher degree of belief reflects a stronger connection to other beliefs. However, as the following example shows, a lower credence can in certain cases be more robust than a higher credence.

Say there is a big jar full of red and black marbles, but you don't know the ratio between the numbers of red and black marbles. In each case, you know that you will draw a sequence of two million marbles, with replacement. In case A, so far you have drawn twenty marbles, 19 black and one red. As a result, your credence that the last marble you draw will be black is 0.95. In case B, you have drawn a million marbles, 900,000 of which have been black. As a result, your credence that the last marble you draw will be black is 0.9. Your rational credence in case A is higher than your rational credence in case B, but it is much less robust. In case A, if you were to go on to draw a sequence of twenty red marbles, you would cease to be confident that the last marble you draw will be black, but in case B, drawing a sequence of twenty red marbles would have virtually no effect on your confidence that the last marble will be black.

These two arguments show that Harman's thesis that degrees of belief are implicit because they are an emergent property of full beliefs is flawed, since his claim is based on an extremely implausible conception of degrees of belief.

Moreover, it should be noted that even if Harman were correct, and degrees of belief were implicit in the way he suggests, namely by being an epiphenomenon of the way our explicit beliefs are related, it still does not follow immediately that they cannot somehow be made explicit and thus be used in cognitive processing. What Harman seems to have in mind is that we cannot "easily infer" degrees of belief, and thus make them explicit, because they are a structural feature of our web of explicit beliefs. Yet, in order for his argument to go through, he would have to show that this view completely precludes that we can access our degrees of belief in a way that would make them usable in cognitive processes. He provides no argument to this effect, but since I have already shown that his basic conception of degrees of belief is problematic, I won't pursue this line of reasoning any further. I thus conclude that the explicitness argument fails to show that reasoning with degrees of belief is impossible.

3.2 The complexity argument

After presenting the explicitness argument, Harman considers whether it would even be possible for us to reason with degrees of belief if we had them explicitly. He argues that even if we tried to reason with explicit degrees of belief, we wouldn't be able to do so, because it would be too complicated (p. 22). His basic argument has the following structure:

(1) For any being *S*, if *S* reasons with degrees of belief, *S* makes extensive use of updating by conditionalization.
(2) Humans can't make extensive use of updating by conditionalization, because it is too complicated for them.
(3) Therefore, humans don't reason with degrees of belief.

Harman does not explicitly argue for the first premise of his argument, only for the second one. Here's what he says:

> One can use conditionalization to get a new probability for P only if one has assigned a prior probability not only to E [the evidence proposition], but to P & E. If one is to be prepared for various possible conditionalizations, then for

> every proposition P one wants to update, one must already have assigned probabilities to various conjunctions of P together with one or more of the possible evidence propositions and/or their denials. Unhappily, this leads to a combinatorial explosion, since the number of such conjunctions is an exponential function of the number of possibly relevant evidence propositions. In other words, to be prepared for coming to accept or reject any of ten evidence propositions, one would have to record probabilities of over a thousand such conjunctions for each proposition one is interested in updating. (Harman 1986, pp. 25–26)

Thus, the idea behind premise 2 is that a reasoner would need to assign degrees of belief to far too many conjunctions of propositions in order to be prepared to employ conditionalization as an updating rule, which is supposed to show that reasoning with degrees of belief wouldn't be manageable for humans even if they had explicit degrees of belief.[6] I will argue that we should reject this premise, as well as the first premise of the argument.

The first premise of the argument assumes that if we reasoned with degrees of belief, we would have to make extensive use of the conditionalization rule, i.e. we would update our degrees of belief in the ideally rational manner. Harman is correct in pointing out that depending on the particular situation, conditionalization can be a process of considerable mathematical complexity. However, Harman does not seem to consider that our minds might use certain shortcuts or heuristics, i.e. procedures that are less complex than the ideal procedures, but that yield outcomes that are "good enough" most of the time. There is a large literature in psychology that investigates these kinds of heuristics, and it has produced credible evidence that our mind cuts corners in order to produce outcomes efficiently with the limited capacities it has.[7] Thus, even if ideal reasoning with degrees of belief requires updating by conditionalization, it does not follow that anyone who reasons with degrees of belief must always employ the conditionalization rule, or even employ it most of the time. A heuristic or simplified rule might be used instead.

Moreover, the first premise also neglects the fact that much reasoning with degrees of belief is done without taking into account new evidence, so conditionalization is irrelevant in these cases. These are cases in which the reasoner forms a new credence on the basis of her existing credences, in combination with the rules of probability. Such cases surely count as reasoning, and they don't require employing conditionalization.[8] We can conclude from this and the previous argument that the first premise should be rejected.

The second premise of the argument states that making extensive use of conditionalization as an updating rule is too complicated for humans. As the passage I cite earlier shows, Harman believes that (a) the amount of data required to update by

[6] Harman assumes here that conditional probabilities are defined by the ratio formula: $P(p|q) = P(p \,\&\, q)/P(q)$.

[7] One of the classic collections of papers in this topic is Kahnemann et al. (1982). Another one is Gilovich et al. (2002). There is some controversy about whether the heuristics people reason by produce bad results or results that are "good enough". For our discussion, it doesn't matter which perspective on this issue is more plausible.

[8] Thanks to Alan Hájek for pointing this out.

conditionalization is too large for humans to cope with, and (b) the reason why there is so much data to be handled is that reasoners must be prepared for all sorts of incoming evidence, which means that they must have vast numbers of different conditional degrees of belief. I will argue that both of these assumptions are questionable.

Harman claims that reasoning with degrees of belief, and more specifically updating by conditionalization, would be too complicated for a normal human mind. Yet he never makes explicit what level of complexity he thinks the human mind can handle, and to what extent this level is exceeded by reasoning with degrees of belief. In the context of the principles he proposes as feasible, he appears to hold that the reasoning processes we actually employ cannot outstrip the capacities of our conscious reasoning and working memory (cf. Harman 1986, Chaps. 2, 4) However, not all cognitive processes that may be employed in reasoning are of the conscious, working-memory-based kind. There is a broad consensus in psychology that humans have two very different kinds of cognitive processing levels, or systems, which play a role in reasoning, decision-making, and social cognition. One type of processing is fast, effortless, automatic, and non-conscious. The other type is slow, effortful, controlled, and conscious. Both types of processing can tackle the same kinds of tasks, and sometimes deliver conflicting results. The automatic, non-conscious processing mechanisms are sometimes referred to as *System 1*, the controlled, conscious mechanisms as *System 2*. There is some controversy among psychologists as to whether they are actually two different cognitive systems in the mind that execute those different kinds of processing, or whether they are different modes of operation of the same underlying mental architecture, but those details don't really matter here.[9] What matters for this argument is the fact that human beings have processing capacities that are independent of working memory, and can handle vastly more data than the conscious, controlled System 2 processes. System 1 processes can operate on the attitudes we have and generate new attitudes without our conscious involvement. This is what happens when we infer a conclusion or make a decision without consciously applying any particular rule to the attitudes that constitute the starting points of our reasoning. Rather, our mind "spits out" a conclusion that we become aware of, but the generation of the conclusion happens automatically, and the reasoner is unaware of the exact process by which she reaches the conclusion.[10] Moreover, System 1 processes don't require that we consciously call to mind every single attitude that is used as a starting point of reasoning.

Thus, Harman might be right that we are bad at conscious, System 2-based probability math, because it requires too much working memory. However, that does not disqualify degrees of belief from playing an essential part in System 1 reasoning, because it can handle vastly more data (cf. Evans and Over 1996, p. 50).

Harman also argues for the second premise by claiming that conditionalization requires the reasoner to be prepared for various kinds of incoming evidence, which

[9] See, for example, Frankish (2009), Evans (2008), Oaksford and Chater (2007), Sloman (1996).

[10] To give another example of this, consider language processing. When we understand an utterance, we are usually not aware of the semantic and pragmatic norms by which we infer what the speaker meant. Also, this kind of processing happens very quickly, and would be much slower, and probably not even feasible, if we had to consciously walk ourselves through applying Grice's maxims in order to find out what our interlocutor was trying to communicate with her utterance.

means she would need to have assigned degrees of belief to a very large number of different conjunctions of evidence propositions in order to have the corresponding conditional credences. The point I made earlier about System 1 having large processing capacities independently of our working memory applies here, but furthermore, it is not clear why we need to be "prepared" for various kinds of incoming evidence. Harman is right that in order to update one's credence in a proposition p by conditionalization, one needs to have a credence in the proposition conditional on relevant piece of evidence. However, it is not clear why Harman assumes that we need to have these credences *before* we even encounter the evidence. It would cut down the complexity of the task if we could just generate the relevant conditional credences on the fly as we encounter pieces of evidence that we need to update on. If this were the case, it would not be necessary to have stored degrees of belief for all possible types of evidence we might encounter.[11] As long as we come up with an explicit degree of belief when it is needed, there isn't a problem.[12]

We can illustrate this idea with a toy example. Suppose I am about to watch a horse race, and there are four horses competing that are named Aristotle, Bacon, Confucius, and Descartes. I am about to place my bets, and I have a degree of belief of 0.4 that Aristotle will win, a degree of belief of 0.3 that Bacon will win, a degree of belief of 0.15 that Confucius will win, and a degree of belief of 0.15 that Descartes will win. Then I learn from a trustworthy source that Aristotle definitely won't win the race. Upon learning this, I need to update my degrees of belief accordingly, which means that for each horse, I need a conditional degree of belief that this horse will win, given that Aristotle won't win, which is determined by the ratio formula. For example, my conditional degree of belief that Bacon will win given that Aristotle won't win is Cr(Bacon wins & Aristotle doesn't win)/Cr(Aristotle doesn't win) = 0.3/0.6 = 1/2, and similarly for the other horses. Equivalently, I might realize that conditionalization requires that my updated degrees of belief must sum to 1 while preserving their relative weights before updating, which would also lead me to the correct updated credences of Cr(Bacon wins) = 0.5, Cr(Confucius wins) = 0.25, and Cr(Descartes wins) = 0.25.

If Harman were right, then I would have needed to have the relevant conditional credences all along in order to be able to update my credences in this way, even before I had even considered the possibility of Aristotle definitely not winning. Yet it seems very implausible that I had these conditional credences all along. Moreover, it is also implausible that I needed to have these credences all along in order to be able to update my credences by conditionalization. As the example shows, I can simply generate the credences I need for updating once I encounter the relevant evidence.

[11] In their paper "On the provenance of judgments of conditional probability", Zhao et al. (2009) elicit judgments of conditional probability from subjects in different kinds of experiments. One way they do this is by making subjects directly estimate the conditional probability of some unfamiliar event. Given that the subjects in their experiments seem to be readily able to do this, it seems not unreasonable to think that people can generate conditional credences 'on the fly' when they are needed for updating.

[12] As Alan Hájek has pointed out to me, coming up with the relevant conjunctions of propositions that figure in the ratio formula for conditional probability might often be a lot simpler than Harman assumes, for example when they can be determined by applying some kind of indifference principle. This further undermines his claim that employing conditionalization in reasoning is too complicated for human beings.

While this is an example in which the unconditional probabilities logically determine the conditional probabilities, there could also be cases in which this is not so. Suppose I am watching a Formula 1 race, which is currently in the 34th round, and, based on the drivers' current performance and positions, I have some specific credence distribution regarding the places in which each driver will finish. Then I hear that Jenson Button, who is currently in second place, is warned by his team that he must slow down lest he will run out of fuel. Prior to receiving this information, I had a 0.8 credence that he would finish in second place. Yet, upon learning about his fuel problems, my credence that he will finish in second place drops to 0.05. If Harman were right, then I would have needed to have the relevant conditional credence all along in order to be able to update my credences in this way. Even before I considered the possibility of Button's fuel problems, I would have needed to have a conditional credence of 0.05 that Button would finish in second place given that he had to slow down from the 34th round on because of a fuel shortage. And I would have had to have analogous conditional credences for all the other drivers and possible problems they might encounter. Yet, it seems very implausible to assume that I already had all the relevant credences. Moreover, there seems to be no reason to deny that I can make up the needed conditional credences on the fly once I learn that Jenson Button has fuel problems. However, the relevant conditional credences might not be so straightforwardly logically determined by my unconditional credences as they were in the previous example. Yet, I can come up with the relevant credences by drawing on some very general information about how Formula 1 racing works, from which I can easily reason to the relevant conditional credences once I need them for updating. Given that I know how many rounds the race has left, that the race cars behind Button will have a speed advantage over him, that it is unlikely that all drivers behind him will have to give up, and that it is unlikely that the race will be finished behind the safety car (which would prohibit anybody from overtaking), I can easily see that my confidence that Button will finish in second place given his fuel problems should be very low. In order to come to this conclusion, I certainly need some kind of capacity to apply general knowledge to a particular case, but since it is hard to deny that humans possess this skill, it seems unproblematic to appeal to it in my argument.[13]

This is not so say that it is always possible to generate a conditional credence on the fly when it is needed. There might be cases in which a reasoner simply lacks the relevant knowledge needed to figure out the appropriate conditional credence for the predicament she is in. Yet, the recognition that figuring out conditional credences on the fly might not produce ideal results in every case does not tell against the idea that this could be the strategy humans often employ when they update their degrees of belief. This is of course also not to say that we *always* have to generate conditional credences on the fly. My argument does not preclude the possibility that people are prepared for certain kinds of evidence in Harman's sense. Rather, I claim that it is

[13] As an anonymous reviewer points out, it is not entirely clear whether this is a case in which we make up conditional credences on the fly, or a case in which we make up the posterior (i.e. updated) credences on the fly. Yet, since the agent would have to reason from her general knowledge about car racing to the relevant credences in either case, I don't need to take a stand on whether such reasoning proceeds always in one of these ways rather than the other.

possible for reasoners to generate conditional credences on the fly, which means that we should not accept Harman's preparedness assumption, which is his main support for the second premise of the complexity argument. I have shown that there is a way in which humans could update their degrees of belief via conditionalization that does not require the vast numbers of representations that Harman thinks we need.

We have seen that both premises of Harman's complexity argument are problematic. His first premise, which states that subjects who reason with degrees of belief would have to make extensive use of conditionalization, does not take into account that humans who reason with degrees of belief might do so by employing heuristics and shortcuts instead of the conditionalization rule. It also fails to acknowledge the possibility of reasoning with degrees of belief that doesn't appeal to conditionalization because it is not based on new evidence. His second premise, which claims that making extensive use of conditionalization would be too complicated for humans, rests on at least two problematic assumptions: the assumption about computational capacity and the assumption about being 'prepared' for conditional updating. My discussion has shown that our resources for computation are not as limited as Harman assumes, because System 1 processes can operate with degrees of belief in ways that are not constricted by the limits of our working memory. Furthermore, even if we had to use the conditionalization rule in updating, this would not be as problematic as Harman assumes, because we could generate the relevant credences on the fly, rather than carrying them around with us all the time in order to be prepared for all sorts of possible incoming evidence. Thus, even though we can concede to Harman that human agents don't have the cognitive capacities necessary to reason with degrees of belief in an ideally rational manner, this does not mean that degrees of belief cannot play a role in human reasoning at all.

3.3 The intentionality argument

In the previous section, I argued that we should not underestimate the ability of the mind to execute complex reasoning processes. I pointed out that human cognitive processing can either operate in a conscious, controlled way (System 2), or in an unconscious, automatic manner that is not constricted by working memory (System 1). The latter mode of processing can handle vastly more data than the former, and has the capacities needed for processing degrees of belief. However, some philosophers think that anything carried out by System 1 should not be dignified with the name *reasoning*. A number of philosophers who have offered accounts of reasoning claim that it is an intentional, active process (e.g. Grice 2001; Broome 2013; Raz 2010). For example, Grice holds a view of reasoning according to which the reasoner intends the production of the conclusion to be based on her premises in some particular rule-governed way:

> […]reasoning is typically an activity, with goals and purposes, notably the solution of problems. […] we may think of the reasoner as intending his production of the conclusion to be the production of something which is an informal consequence of his premiss (premisses), a state of affairs which is evidently

> distinguishable from merely thinking that a certain proposition is, somehow or other, informally derivable from a given set of propositions. (Grice 2001, p. 27)

A relevantly similar view of reasoning is defended by Broome in his book manuscript *Rationality through Reasoning*. He rejects what he calls the "jogging model" of reasoning, because he thinks that it is incompatible with his view that reasoning is an active process. According to the jogging model, one can call some premise-attitudes to mind, which then sets off an automatic process that produces a conclusion. He states that if reasoning worked like this, it "would scarcely be an act of yours. Most of it would not be done by you, all you would do is call the premises to mind. Reasoning would mostly be a passive process, which sometimes needs a jog. But intuitively there is more to reasoning than that" (Broome 2013, p. 232). Instead, he endorses a view of reasoning according to which it is "[…] a process in which you say to yourself the contents of your premise-attitudes, you operate on them by applying a rule to construct a conclusion, which is the content of a new attitude of yours that you acquire in the process" (2013, p. 290, my emphasis, see also a slightly different version of the definition on p. 241).

It is evident that both of these views of reasoning require that reasoning is an active process in which the reasoner intends to produce a particular conclusion in a particular way. However, this is hardly compatible with System 1 processing, since mental processes that work in this way don't need to be intentionally initiated by the subject, and the subject does not monitor or have access to the way the conclusion is generated. We can capture Grice's and Broome's line of thinking in the following argument:

(1) Genuine reasoning is an active, intentional process.
(2) If so-called "reasoning with degrees of belief" were carried out by System 1, it would not be an active, intentional process.
(3) Therefore, if so-called "reasoning with degrees of belief" were carried out by System 1, it would not constitute genuine reasoning.

I will argue that there are strong reasons to reject both premises of this argument. The problem with the first premise is that it is not plausible that all reasoning is an active, intentional process, if we mean by this that it can't be automatic. There are simply too many examples that we would intuitively classify as cases of reasoning, but that would be excluded by the account in question. It often happens that we learn something new, for example by testimony or by observation, and we automatically infer certain new beliefs from what we've just learned without intending to draw, or initiating these inferences. Here's just one case involving outright beliefs to illustrate this type of case:

Suppose you just spoke to your friend Waltraud, who told you that her fiancé Gottlob is out of town for a business trip for a few days. The next day you happen to talk to your mutual friend Franz on the phone, who mentions in passing that he saw Gottlob the night before with a woman who wasn't Waltraud in a dingy little restaurant a few hours outside the city. Based on your friend's testimony, you form the belief that Gottlob was at the restaurant with another woman, and you immediately infer from this that he is lying to Waltraud. You also infer that the

"business trip" was just an excuse Gottlob made up to spend time with the other woman.

It seems very natural to think that your inferences constitute reasoning. You start out from an initial belief—that Gottlob was at the restaurant with another woman—and the beliefs you form subsequently are inferred from it and some other background information. However, the actual inferences were drawn automatically. Upon acquiring the initial belief based on testimony, your mind simply "spat out" the inferred beliefs. It seems wrong to say that your inferences were intentional activities in the sense employed in the first premise. You drew these inferences automatically, without monitoring or initiating the application of some inference rule or strategy. There is no sense in which you "set out" to draw these inferences from your original belief, and you didn't form the intention to do so. That your friend's fiancé is lying was just a natural thing to conclude when you came to believe that he was at the restaurant with another woman, but the inference was not something you needed to initiate. This example illustrates the more general observation that it often happens that we learn some proposition p from observation or testimony, and we infer some proposition q from p (or p and some background beliefs) without ever asking ourselves whether q, or intending to infer q from p.

Yet, according to the view that all reasoning is an active, intentional process, the mental processes in the example don't constitute reasoning, and neither do any other inferences that work similar to those in the example. On this view, reasoning is something we rarely do, because it is an active process in which the reasoner intends to produce a particular conclusion in a particular way. But this latter view is in conflict with our ordinary views of what reasoning is, and moreover, it leaves us with the puzzle of how to classify those ubiquitous automatic inferences that surely look like cases of reasoning, but aren't reasoning according to this view.

This is not to say that reasoning is never an active, intentional process. For example, I might be executing a proof in a new proof system whose rules I have just learned, and in drawing each inference, I deliberately set out to apply a certain rule of the system to reach a particular conclusion. The important point here is that not all reasoning processes are intentional in the relevant sense, because some of them involve inferences that are drawn automatically. Claiming that none of these automatic processes constitute reasoning leads to an untenable view according to which we very rarely engage in reasoning processes. It is therefore implausible to characterize reasoning as an active, intentional process in the sense that it can't be an automatic process.

The second premise of the argument is questionable as well. The authors mentioned above endorse the second premise of the argument because they have a very specific view of what it means to be an active, intentional process. They think that automatic processes of the kind executed by System 1 don't fit this description. However, it is not clear that this is the correct way of understanding what it means for a process to be active and intentional. For example, it seems very natural to describe speaking and driving as active, intentional processes. Yet, when we speak and drive, much of what we do is executed automatically, and does not need to be initiated by forming a particular intention. In order to be able to describe these processes as intentional activities, we could plausibly adopt a wider conception of what an active, intentional process is. Then we could have an account of reasoning according to which reasoning

can be both automatic and intentional, which would be compatible with the possibility of reasoning with degrees of belief. I am sympathetic to this view, but I won't defend it here.

4 Conclusion

I started my paper by pointing out that currently there is no worked-out theory of reasoning with degrees of belief to be found in the philosophical literature. Such an absence would make sense if reasoning simply couldn't involve degrees of belief. After presenting the case in favor of the possibility of reasoning with degrees of belief, I discussed several arguments for the conclusion that degrees of belief cannot play a role in reasoning. Harman's explicitness argument turned out to be flawed because it relies on an implausible account of the nature of degrees of belief. His complexity argument is based on three assumptions: (1) the no-heuristics assumption, (2) the computational capacity assumption, and (3) the 'preparedness' assumption about updating. None of these assumptions turned out to be plausible. The intentionality argument, which was supposed to show that automatic (System 1) processes involving degrees of belief can't be genuine reasoning, turned out to rest on an implausible notion of what constitutes an active, intentional process. Moreover, even granted this notion, the argument failed to correctly capture certain processes that intuitively constitute reasoning. Thus, at least as far as these arguments are concerned, it seems like there is no good reason why the topic of reasoning with degrees of belief has received so little attention. Any plausible theory of reasoning needs to include degrees of belief among the attitudes that can be involved in reasoning processes, and it needs to explain which principles govern reasoning with degrees of belief.

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