The Representation of Judgment Heuristics and the Generality Problem

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Abstract

In his debates with Daniel Kahneman and Amos Tversky, Gerd Gigerenzer puts forward a stricter standard for the proper representation of judgment heuristics. I argue that Gigerenzer's stricter standard contributes to naturalized epistemology in two ways. First, Gigerenzer's standard can be used to winnow away cognitive processes that are inappropriately characterized and should not be used in the epistemic evaluation of belief. Second, Gigerenzer's critique helps to recast the generality problem in naturalized epistemology and cognitive psychology as the *methodological* problem of identifying criteria for the appropriate specification and characterization of cognitive processes in psychological explanations. I conclude that naturalized epistemologists seeking to address the generality problem should turn their focus to methodological questions about the proper characterization of cognitive processes for the purposes of psychological explanation.

Keywords: Naturalized epistemology; relativism; generality problem; heuristics and biases; cognitive algorithms; evolutionary psychology; ecological rationality.

Introduction

Pocket calculators are reliable tools for multiplying numbers represented as Arabic numerals. However, they are unreliable at multiplication when you type in binary numerals expressed as sequences of zeros and ones. There is no important mathematical difference between Arabic and binary numerals: they are mathematically equivalent insofar as they can be mapped onto each other one to one. But, the calculator is good at using Arabic rather than binary numerals because the calculator's multiplication algorithm is *designed* to work on Arabic numerals: the calculator's algorithm is *tuned* to a particular representation of the information. The way in which the numerical information is represented – that is, the *information format* – can have a huge effect on how reliable the calculator's computations are.

Cognitive psychologists Gerd Gigerenzer and Ulrich Hoffrage argue that, like a pocket calculator, the mind is programmed with algorithms designed to work on some representations of information and not others (1995). They propose a stricter standard for the representation of judgment heuristics to capture the connection between algorithms and information formats: in order to be descriptively and explanatorily adequate, judgment heuristics should be characterized in a way that accounts for how they are functionally related to information formats.

Gigerenzer and Hoffrage's stricter standard contributes to naturalized epistemology in two important ways. First, the standard can be used to winnow away cognitive processes that are inappropriately characterized and should not be used in the epistemic evaluation of belief. Second, Gigerenzer's critiques of Daniel Kahneman and Amos Tversky's judgment heuristics help to recast the generality problem in naturalized epistemology in constructive ways.

In the first part of this paper, I will argue that naturalized epistemologists and cognitive psychologists like Gigerenzer have explanatory goals and conundrums in common: in particular, both seek to explain the production and epistemic status of beliefs by referring to the reliable cognitive processes from which they arise; and both face the generality problem in trying to do so. Gigerenzer helps to address the generality problem by proposing a stricter standard for the characterization of cognitive processes. This stricter standard disqualifies some judgment heuristics as candidates for the epistemic evaluation of belief. In what follows, I will defend Gigerenzer's criteria for the explanatory utility of cognitive process types by contrasting his methodology with that of Kahneman and Tversky, and by comparing the utility of the processes to which Gigerenzer adverts, with the judgment heuristics posited by Kahneman and Tversky. I will argue and defend the claim that Gigerenzer constructively recasts the generality problem in cognitive psychology and naturalized epistemology as the *methodological* problem of how cognitive psychologists should characterize cognitive processes for the explanation and epistemic evaluation of beliefs.

Naturalized Epistemology and Cognitive Psychology

Gigerenzer's points about the descriptive and epistemic evaluation of judgment heuristics and beliefs go hand in hand. But, in order to appreciate this, it is important to understand the explanatory goals and problems that naturalized epistemologists and cognitive psychologists have in common.

Shared Explanatory Goals

The central insight reliabilism brings to naturalized epistemology is that the distinguishing feature justified beliefs share is that they are causally initiated or sustained in ways that reliably produce true beliefs. Reliabilism links facts about the causal, functional processes underlying beliefs with the epistemic status of beliefs. This allows the deliverances of a reliabilist theory of justification to be explanatory in two senses. First of all, a belief-warranting cognitive process explains how someone has arrived at a belief by describing the functional procedure responsible for transforming the inputs into the output belief. Second, a belief-warranting cognitive belief-forming process explains the epistemic status of an output-belief by referring to "the underlying source of justificational status:" namely, the reliability of the type of belief-forming process.

Some cognitive psychologists interested in the rationality of judgment adopt a similar explanatory program. Cognitive psychologists explain judgments by characterizing cognitive functions as the processes responsible for transforming inputs to output-beliefs. Gigerenzer's stricter standard for the characterization of judgment heuristics requires that heuristics be specified to account for how the information format of an input is functionally and causally implicated in producing the output belief. The explanatory advantages of his stricter descriptive standard are twofold. On the one hand, cognitive processes so specified can explain why judgment improves and worsens with changes in information format. On the other hand, cognitive processes so specified can provide concrete predictions that can be falsified, thus allowing for the possibility of improving or disproving a psychological explanation.

For cognitive psychologists like Gigerenzer, the epistemic status of a belief is explained by the reliability of the cognitive process involved. In his fast and frugal heuristics research program, Gigerenzer seeks to discover "ecologically rational" heuristics that exploit the information occurring in natural environments to support a disproportionately high frequency of true beliefs (in relation to the total frequency of true and false beliefs) for a given reference class (Goldstein & Gigerenzer, 2002). Gigerenzer aims to vindicate the rationality of human judgment by discovering and promoting ecologically rational heuristics that reliably produce true beliefs. Gigerenzer is a reliabilist in the sense that he invokes reliable cognitive processes to explain both the production and epistemic status of beliefs (Gigerenzer, 2001).

The Generality Problem

Both reliabilists and cognitive psychologists must grapple with the generality problem. For reliabilists, the challenge is to figure out how to classify a belief under the most relevant cognitive belief-forming type. Since a belief-token may be classified under any number of belief-process types, reliabilism leaves us with "no idea which process types are relevant to the evaluation of any particular belief" (Feldman, 1985).

The problem is not simply that there are multiple ways of describing the same process token. The problem is that different process types have different degrees of reliability; and, unless we can identify which process type is the most relevant, we have no way of explaining or determining the epistemic status of a belief-token. This is a "generality" problem because the generality with which one characterizes the cognitive process producing a belief determines that belief's epistemic status. It is a problem because a proposed belief-forming type fails to capture the epistemic status of the beliefs to which it gives rise when characterized at an inappropriate level of generality.

Cognitive psychologists also face the generality problem. For any pattern of judgment, there may be multiple cognitive processes one might invoke to explain that pattern of judgment. For cognitive psychologists like Gigerenzer, the determination of a belief-token's epistemic status depends on the reliability or validity of the underlying cognitive process. However, cognitive psychologists disagree over which cognitive process we should prefer in explaining a pattern of judgment. These competing cognitive processes have different degrees of reliability. Thus, the epistemic status of a belief or pattern of beliefs depends on the explanatory story one adopts: the epistemic status of a pattern of beliefs depends entirely on how the underlying cognitive process gets characterized.

If we can rule out a cognitive process because it fails to meet a crucial standard of descriptive and explanatory adequacy, then we can rule out using it in determining the epistemic status of a token-belief. So, cognitive psychologists can approach the generality problem by identifying criteria that give preference to some characterizations of cognitive processes over others. If a cognitive process is not descriptively or explanatorily adequate, then the supposed reliability or unreliability of that process will not be relevant to the epistemic evaluation of the beliefs in question.

The Representation of Judgment Heuristics

Gigerenzer's account of how judgment heuristics ought to be represented provides a significant criterion that both cognitive psychologists and naturalized epistemologists can use to prefer some cognitive process descriptions to others. Gigerenzer's stricter standard for the proper specification and representation of judgment heuristics is motivated by his frustrations with the judgment heuristics and explanations put forward by Kahneman and Tversky's heuristics and biases research program.

The Representativeness Heuristic

In their canonical work "Judgment Under Uncertainty: Heuristics and Biases," Kahneman and Tversky summarized an ambitious scope of studies demonstrating systematic biases in human judgment. To explain these biases, Kahneman and Tversky proposed three major heuristics, the most debated of which is the representativeness heuristic.

The representativeness heuristic calculates the conditional probability that A is true given B (or vice versa) on the basis of simpler judgments about the degree to which event A is *similar* to event B: when A is judged to be highly similar to B, the conditional probability of A given B is judged to be high (Tversky and Kahneman, 1982). Kahneman and Tversky explain both base rate and conjunction effects by invoking the representativeness heuristic.

To do Kahneman and Tversky's heuristic the most justice, I turn to the paper and Tom W. study they recently identified as providing the strongest evidence for the representativeness heuristic" (Kahneman & Tversky, 1996). In the experiment, the researchers use two control groups. The *similarity* group was presented with a personality description of Tom W. – a description resembling a stereotypical engineer – and was asked to judge how *similar* Tom W.'s personality description was to the typical graduate student in nine different fields of graduate school specialization (Kahneman & Tversky, 1982). The *base-rate* group, was asked to rank the relative probability with which a graduate student (with no personality description) would be specializing one of those nine fields. The experimental group, the *prediction* group, was given the personality description of Tom W. and instructed to rank the fields of graduate specialization by the probability that Tom W. is a student of those specializations.

Kahneman and Tversky found that over 95% of graduate students judged that Tom W. is more likely to study computer science than humanities or education, *even though* "they were surely aware of the fact that there are many more graduate students in the latter field." Because Kahneman and Tversky found the correlation between judged likelihood and similarity to be 0.97, and the correlation between judged likelihood and estimated base rate to be -0.65, they concluded, "judgments of likelihood essentially coincide with judgments of similarity and are quite unlike the estimates of base rates." They took this result as providing "a direct confirmation of the hypothesis that people predict by representativeness, or similarity" rather than by base rates.

Kahneman and Tversky invoke other heuristics to explain different cases of quantitative judgments under uncertainty. Their *availability heuristic* is supposed to explain how subjects calculate the size of a class of events or the probability of an event according to the degree of ease with which instances or occurrences of those event-types can be brought to mind: "[f]or example, one may assess the risk of heart attack among middle-aged people by recalling such occurrences among one's acquaintances." And, their *anchoring heuristic* is supposed to explain how subjects calculate a value along some criterion on the basis of an initial value or starting point suggested in the formulation of a problem: for example, subjects seemed to use arbitrary numbers provided in the wording of an experimental task to estimate the percentage of African countries in the United Nations (Tversky & Kahneman, 1974).

Heuristics and Biases: Heuristic Explanations

The problem with Kahneman and Tversky's heuristics, as Gigerenzer sees it, is that they are too vague to provide legitimate psychological explanations: the heuristics are vague with respect to the kind of inputs and information formats required by the heuristics. As a result, the heuristics "at once explain too little and too much." They explain too much because "post hoc, one of them can be fitted to almost any experimental result. For example, base-rate neglect is commonly attributed to representativeness. However, the opposite result, overweighting of base rates (*conservatism*), is as easily "explained" by saying the process is anchoring (on the base rate)" (Gigerenzer, 1996). Because Kahneman and Tversky's heuristics are underspecified, they can be selectively invoked to explain nearly any kind of judgment: if one heuristic fails to account for an observed pattern of judgment, another can be invoked to save the day. As a result, theorists have plenty of flexibility to selectively invoke heuristics in ways that "resist attempts to prove, disprove, or even improve them" (Gigerenzer, 1996).

Kahneman and Tversky's heuristics explain "[t]oo little because we do not know when these heuristics work and how" (Gigerenzer, 1996). In particular, they say nothing about how heuristic processes are functionally and causally tuned to specific representations of information. Thus, they lend no help in explaining why judgments vary across information formats.

Gigerenzer seeks a new level of specificity and explanatory power for heuristics proposed in contemporary psychological theorizing. The stricter standard looks something like this: psychological explanations should invoke process models of cognition that specify how the processes functionally relate to the representation of information (i.e., information formats).

This stricter standard accommodates important insights Gigerenzer brings to bear on the relationship between the representation of judgment heuristics and psychological explanation (Feynman, 1967). The primary lesson Gigerenzer draws is this: two judgment heuristics or algorithms may be mathematically or computationally equivalent, yet be psychologically different. The cognitive psychologists' task, then, is to discover which (if any) of these algorithms can be found in the human mind.

The second, connected insight is that two different representations of numerical or statistical information may be equivalent, yet be psychologically different. If the mind has an algorithm tuned to a particular information format, then human judgment might make good use of one representation of the information and not the other (Gigerenzer, 1996). For example, numerical information can be represented in Roman, Arabic, and binary systems. Although these representations are mathematically equivalent, they are not psychologically equivalent: we have learned to calculate arithmetic algorithms under only particular representations of numerical information. To underscore this point, Gigerenzer and Hoffrage ask the reader to "[c]ontemplate for a moment long division in Roman numerals" (1995).

In order to be properly specified, cognitive algorithms and judgment heuristics must be characterized so that they are tuned to specific representations of information in the way that algorithms in a pocket calculator are tuned to Arabic numerals. Cognitive algorithms specified in this way provide legitimate explanations because they do not explain too much or too little. They do not explain "too much" because their specific conditions of use cannot be fitted to any experimental result. Nor do they explain "too little:" they provide detailed conditions of use that explain when the heuristic process can be used and how the heuristic process transforms input-information into output-judgments.

The Frequency Algorithm

Gigerenzer and Hoffrage's proposed judgment heuristic meets this stricter standard for the representation of judgment heuristics and psychological explanation. As a result, their judgment heuristic is capable of doing something Kahneman and Tversky's representativeness heuristic could not: viz., explain why probability judgments vary with different kinds of information formats.

The fact that Kahneman and Tversky demonstrated base rate and conjunction effects with a particular kind of information format does not imply that the human mind has *no* judgment heuristics capable of performing conditional probability calculations. In order to discover whether humans have cognitive algorithms that carry out conditional probability judgments, Gigerenzer and Hoffrage surmise that the kind of probabilistic information to which cognitive algorithms could be tuned were not single-event probabilities or percentages, but the "sequential encoding and updating of event frequencies without access or reference to the base rate" (Gigerenzer & Hoffrage, 1995).

To illustrate, they ask the reader to suppose there is a physician in an illiterate society who has discovered a symptom that signals a severe disease that has begun to afflict her people: In her lifetime, she has seen 1,000 people, 10 of whom had the disease. Of those 10, 8 showed the symptom; of the 990 not afflicted, 95 did. A new patient appears. He has the symptom. What is the probability that he actually has the disease? To calculate the conditional probability that the patient has the disease given the symptom, all she needs is the number of cases that had both the symptom and disease (8) and the number of symptom cases (8 + 95):

The Bayesian algorithm for computing the posterior probability $p(H|E)$ from the frequency format involves solving the equation:

$$p(H \mid E) = \frac{e \,\&\, h}{(e \,\&\, h) + (e \,\&\, -h)} = \frac{8}{8+95}$$

where e & h (*e*vidence and *h*ypothesis) is the number of cases with symptom and disease, and e & –h is the number of cases having the symptom but lacking the disease. This algorithm is formally equivalent to Bayes Rule in the sense that it produces the same conditional probability solutions (population statistics) for fixed samples. However, the algorithm is computationally simpler and does not require explicit reference to base rate information.

If humans have a judgment heuristic like the frequency algorithm and not like the traditional formulation of Bayes' law, then we would expect conditional probability judgments to improve when probability problems are stated in terms of frequencies of *e*, *h*, and -*h* rather than in terms of single-event probabilities or percentages that include explicit base rate information. Gigerenzer and Hoffrage discovered that correct conditional probability judgments jumped from 16% to 50% when conditional probability tasks were stated in terms of frequencies rather than percentages.

Gigerenzer's frequency algorithm is preferable over Kahneman and Tversky's representativeness heuristic because it is descriptively and explanatorily more adequate. It does not explain "too much:" it cannot be fitted to any experimental result because it has specific conditions of use (statistical information must be represented in terms of frequencies for the frequency algorithm to work). Nor does the algorithm explain "too little:" it provides detailed conditions of use that explain when the heuristic process gets used (i.e., when the right frequency information is provided). Finally, Gigerenzer and Hoffrage's judgment heuristic predicts and explains why probability judgments improve when probability information is represented as frequencies rather than single-event probabilities. In contrast, the representativeness heuristic cannot explain this information format effect on probability judgment. Gigerenzer and Hoffrage's cognitive process, which conforms to the stricter standard they propose, has the explanatory advantage of being able to account for information format effects.

Judgment Heuristics and Naturalized Epistemology

Gigerenzer proposes a stricter standard for what counts as explanatorily adequate cognitive processes, and thus provides a criterion we can use in winnowing away descriptions of cognitive process types relevant to the epistemic evaluation of belief. Because the representativeness heuristic fails to meet the appropriate descriptive and explanatory standard put forward by Gigerenzer, it fails to stand as a candidate cognitive process type in the epistemic evaluation of belief.

Ruling out the representativeness heuristic in this way suggests a more general strategy for coping with the generality problem in cognitive psychology and naturalized epistemology: cognitive psychologists can decide what cognitive processes are most relevant in the epistemic evaluation of belief by creating stricter standards for what counts as a legitimate or adequate cognitive process from an explanatory point of view. This would make methodological debates about how cognitive processes ought to be specified directly relevant to naturalized epistemologists' questions about the epistemic evaluation of cognitive processes and beliefs.

Reliability versus Content-Blind Norms

Some might object that the normative appropriateness of using the frequency algorithm in the experimental tasks is grounded, not on the reliability of the frequency algorithm, but on the judgment's conformance to Bayes Rule.

In response, I would argue that there is nothing about the functional characterization of the frequency algorithm *by itself* that guarantees that one's acquired sample data appropriately or reliably grounds statistical claims about a new sample.

The normativity of the frequency algorithm is not built into the algorithm itself, but gets determined, in part, by its fit with the environment or context of use. I agree with Gigerenzer that *a priori* rules of probability and statistics should not be applied to concrete situations in a content-blind way since doing so disregards the relevant structural properties of the given situation. Instead, norms need to be constructed and justified for a specific class of situations (Gigerenzer, 2001).

I think that the more pressing epistemic question to ask is this: what is the nature of the normative "fit" between the frequency algorithm and the experimental task's context of use? For Gigerenzer, the normative appropriateness of the "fit" between the frequency algorithm and the experimental task could be construed in either of two ways.

On the one hand, the "fit" between the frequency algorithm and the experimental task could have to do with the *statistical validity* of using Bayes Rule in the task's context of use (Gigerenzer, 2001). Subjects were presented a mammography problem asking them to calculate the relative frequency with which "a new representative sample" of forty year old women will have cancer on the basis of the following acquired sample of forty year old women: 103 out of every 1,000 women had a positive mammography, but only 8 of these women actually turned out to have breast cancer (Gigerenzer & Hoffrage, 1995). The problem is set in a medical context where the reference class is clearly specified and the samples (it is reasonable to presume) were randomly selected and sufficiently large for the purpose of making predictions about new cases. So, Gigerenzer might suggest that the normative appropriateness of using Bayes Rule here has to do with the concrete specification of reference classes in the experimental task, the representativeness of the new sample, and the quality of the samples involved (Gigerenzer, 2001).[1]

On the other hand, Gigerenzer could construe the frequency algorithm's "fit" with the environment or context as an *ecologically rational* one. Ecologically rational heuristics manipulate the information structure in the environment to support a disproportionately high frequency of true beliefs in relation to the total frequency of true and false beliefs for a given reference class (Goldstein & Gigerenzer 2002). The ecological rationality of a heuristic is not determined *a priori* but is contingent upon its accuracy for the information environment in which it operates (Todd & Gigerenzer, 2000).

Ecologically rational cognitive processes reliably produce true beliefs. And, a reliabilist account of justification would prefer ecological rationality's way of characterizing the normativity and fit of the frequency algorithm with the experimental tasks involved. There are empirical and epistemic advantages to this position. Modeling the algorithm's ecological rationality for different contents and contexts of reasoning might provide surprising predictions about the conditions in which the reliability of judgment improves or degrades in different environments (Todd & Gigerenzer, 2000). Such work would open up the possibility of discovering contents and contexts for which the reliability of the frequency algorithm does not improve or degrade with changes in sample size or sampling technique due to features of the reference class objects or the environment's information structure.

Is Gigerenzer's Standard Too Strict?

It might be objected that the explanatory standard Gigerenzer proposes is too strong for psychological theorizing. Kahneman and Tversky's heuristics are couched at a level of generality common in psychology. Consider, for example, psychological explanations for cognitive dissonance and stereotype threat. The cognitive dissonance literature explains the resistance to adopt a belief in terms of the degree to which that belief is dissonant or psychologically uncomfortable for a person given her beliefs and actions (Festinger, 1957). But, how it is that cognitive dissonance is triggered in the mind is left unspecified. More recently, in the stereotype threat literature, psychologists have proposed that the implicit activation of a sociocultural stereotype influences the performance of the stereotyped individual (Shih, Pittinsky & Ambady, 1999). How the sociocultural stereotype gets activated within the mind is left unspecified.

Indeed, even Gigerenzer's fast and frugal heuristics suffer from these forms of underspecification. For example, the recognition heuristic, "the most frugal" of all the fast and frugal heuristics, directs one to choose the recognized object when one of a set of objects is recognized, while the others are not (Goldstein & Gigerenzer, 2002). However, the conditions under which the recognition heuristic or recognition memory gets "triggered" remains undefined. Until the recognition heuristic becomes more refined, we have no way of explaining why individuals do not use recognition to decide which German city has the larger handball team or lies farther West.[2] Nor do we have an explanation for why individuals use the recognition heuristic rather than some other fast and frugal heuristic in the "adaptive toolbox" for a specific judgment or task (Cooper, 2000).

Gigerenzer recognizes the value of these somewhat vague, yet informative, psychological explanations. With respect to heuristics proposed in the heuristics and biases research program, he says, "[i]t is understandable that when heuristics were first proposed as the underlying cognitive processes in the early 1970s, they were only loosely characterized." His complaint is that "25 years and many experiments later, explanatory notions such as *representativeness* remain vague, undefined, and

[1] If the frequency algorithm refers to an existing cognitive process that is tuned to frequency representations of probabilistic information, then we should also expect subjects to rely on the frequency algorithm in *statistically inappropriate* contexts. Thanks to Jay Garfield for pointing out this empirical implication.

[2] Thanks to Norbert Schwarz and Hilary Kornblith respectively for these examples.

unspecified with respect both to the antecedent conditions that elicit (or suppress) them and also to the cognitive processes that underlie them" (Gigerenzer, 1996).

Gigerenzer's critique, then, is not that psychological explanations invoking underspecified cognitive processes are not useful in the course of theoretical development and progress. Rather, the concern is that researchers should – in the design of their experimental tasks – aim to meet a stricter standard in the specification of cognitive processes for the sake of achieving determinate, falsifiable psychological explanations.

Conclusions

Naturalized epistemologists and cognitive psychologists share explanatory goals that intimately tie together the explanation and epistemic evaluation of belief. And, in explaining the production and epistemic status of beliefs, naturalized epistemologists and cognitive psychologists both face the generality problem. I have argued that naturalized epistemologists and cognitive psychologists need to address the generality problem by focusing on the methodological question of how cognitive processes should be characterized for the sake of psychological explanation. I analyzed how Gigerenzer and Hoffrage rule out the representativeness heuristic's relevance to the epistemic evaluation of belief by invoking a stricter standard for the representation of judgment heuristics. And, I defended Gigerenzer and Hoffrage's stricter standard by contrasting the utility of processes proposed by Gigerenzer to those proposed by Kahneman and Tversky.

Evolutionary psychologists like Gigerenzer have called for a return to seeing humans as good intuitive statisticians (Cosmides & Tooby, 1996; Gigerenzer, 1991). Gigerenzer has been especially vociferous in arguing for a shift in the disciplinary focus towards rational cognitive processes: he suggests that "after 40 years of toying with the notion of bounded rationality, it is time to overcome the opposition between the rational and the psychological and to reunite the two" (Gigerenzer & Goldstein, 1996). The shift towards identifying conditions and cognitive processes underlying rational (rather than irrational) judgment is a boon for naturalized epistemologists interested in identifying reliable strategies of reasoning.

However, Gigerenzer's work also brings with it new conundrums. Gigerenzer and Daniel Goldstein provide an interesting model to measure the ecological rationality or reliability of the recognition heuristic for different contexts of reasoning. However, as I argued above, the recognition heuristic is not sufficiently specified to provide a determinate psychological explanation – at least, not according to Gigerenzer's stricter standard.

This inconsistency in approach raises many questions. What are we doing when we seek to evaluate the epistemic status of a cognitive process that is not yet adequately specified from an explanatory point of view? What does it mean to have a sufficiently specified cognitive process or a determinate explanation in cognitive psychology? And, how should we decide such matters? For reliabilists, these are intriguing and crucial questions to attend to.

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