



# Using forced choice to test belief bias in syllogistic reasoning



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## ABSTRACT

In deductive reasoning, believable conclusions are more likely to be accepted regardless of their validity. Although many theories argue that this *belief bias* reflects a change in the quality of reasoning, distinguishing qualitative changes from simple response biases can be difficult (Dube, Rotello, & Heit, 2010). We introduced a novel procedure that controls for response bias. In Experiments 1 and 2, the task required judging which of two simultaneously presented syllogisms was valid. Surprisingly, there was no evidence for belief bias with this forced choice procedure. In Experiment 3, the procedure was modified so that only one set of premises was viewable at a time. An effect of beliefs emerged: unbelievable conclusions were judged more accurately, supporting the claim that beliefs affect the quality of reasoning. Experiments 4 and 5 replicated and extended this finding, showing that the effect was mediated by individual differences in cognitive ability and analytic cognitive style. Although the positive findings of Experiments 3–5 are most relevant to the debate about the mechanisms underlying belief bias, the null findings of Experiments 1 and 2 offer insight into how the presentation of an argument influences the manner in which people reason.

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## 1. Introduction

An argument is logically valid if its conclusion necessarily follows from its premises. From a normative standpoint, the logical status of an argument is determined exclusively by its structure. Nevertheless, it is well known that other factors routinely influence peoples' judgments of argument validity. One of the most important of these is the extent to which the conclusion of an argument conforms with a person's pre-existing view of the world. People tend to be easily persuaded by invalid arguments that fit their beliefs yet are likely to resist valid arguments that oppose their beliefs. This phenomenon is known as belief bias (Wilkins, 1928).

Numerous psychological theories have been developed to account for belief bias in syllogistic reasoning (e.g., Evans, Barston, & Pollard, 1983; Quayle & Ball, 2000; Thompson, Striemer, Reikoff, Gunter, & Campbell, 2003). Mental model theory (MMT; Oakhill, Johnson-Laird, & Garnham, 1989) holds that people construct mental models to simulate the components of an argument. When faced with unbelievable conclusions, they engage in a more thorough search for alternative models, improving the likelihood of arriving at the normatively correct conclusion. Selective processing theory (SPT; Evans, Handley, & Harper, 2001; Klauer, Musch, & Naumer, 2000) posits that reasoning strategy depends on conclusion believability: people attempt to confirm believable conclusions but disconfirm unbelievable ones. According to dual process theories like those described by Evans (2007), unbelievable conclusions may recruit additional, reflective processing. All of these theories suggest that conclusion believability can influence the quality of reasoning. However, it is also

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generally accepted that believability may exert an influence independent of reasoning quality in the form of a heuristic tendency to accept believable and reject unbelievable conclusions. Such a tendency is a response bias that affects the pattern of validity judgments without altering their overall accuracy. Of course, a simple alternative to the theories described above is that the effect of beliefs is purely one of response bias. Recent work by [Dube, Rotello, and Heit \(2010\)](#) suggests that this alternative view of belief bias is not only viable but one that traditional methods of analysis make difficult to rule out.

In a typical belief bias experiment, participants judge the logical validity of conclusions that vary in their congruence with prior belief. Analysis has traditionally focused on three aspects of these endorsement rates (e.g., [Evans & Curtis-Holmes, 2005](#)). The main effect of logic, the tendency to endorse valid over invalid conclusions, indicates deductive reasoning capacity. The main effect of belief, the tendency to endorse believable over unbelievable conclusions, is thought to be driven by a belief-based heuristic. Finally, a logic  $\times$  belief interaction is taken as evidence for a qualitative effect of beliefs on reasoning that goes beyond response bias. Although it might seem intuitively reasonable, this manner of interpreting the data has been the subject of recent critical attention. In particular, the conclusion that a logic  $\times$  belief interaction necessarily signifies a change in the quality of reasoning requires assumptions about the nature of the underlying processes that may not be justified ([Dube et al., 2010](#); [Klauer et al., 2000](#)). This is a serious issue given that much of the theoretical debate surrounding belief bias has centered on evidence for this interaction.

Are there alternative ways of determining whether a change in the pattern of endorsement rates is the result of a change in the quality of reasoning, as the major theories of belief bias suggest, rather than a change in response bias? Although making the distinction is theoretically critical, it is not straightforward. Some recent studies of syllogistic reasoning have turned to signal detection theory (SDT; [Macmillan & Creelman, 2005](#)) in order to model the effect of beliefs on accuracy and response bias ([Dube et al., 2010](#); [Heit & Rotello, 2014](#); [Trippas, Handley, & Verde, 2013, 2014](#)). In the SDT model, the reasoning process yields evidence of validity that is represented as a continuous strength variable. Valid and invalid arguments are described by distributions of evidence strength. People judge validity by setting a criterion which evidence must exceed if an argument is to be endorsed as “valid.” The endorsement rates are determined by the proportions of the distributions that exceed the criterion. Accuracy depends on the overlap of the evidence distributions. When a change in the reasoning process brings about separation of the distributions, this alters the pattern of endorsement rates and, more importantly, improves accuracy. A shift in response bias that makes the criterion more liberal or conservative also alters the pattern of endorsement rates but will not affect accuracy. An effect on judgment accuracy indicates that something other than response bias is at work.

A commonly used SDT tool for examining movement in evidence distributions is the receiver operating

characteristic (ROC) which plots the ratio of hits and false alarms at several levels of confidence, allowing inferences to be made about the distributions. [Dube et al.’s \(2010\)](#) analysis of ROCs in syllogistic reasoning showed no effect of conclusion believability on accuracy, a result consistent with a pure response bias account of belief bias. [Dube et al.](#) also pointed out that the shape of empirical ROCs argues against the validity of drawing conclusions about accuracy based on a logic  $\times$  belief interaction in endorsement rates. According to the SDT model, such an interaction could come about entirely as a result of response bias. In a follow-up study using similar methods, [Trippas et al. \(2013\)](#) partly replicated their findings but found that under some conditions, such as with higher cognitive ability and relatively complex problem types, effects of beliefs on reasoning quality did emerge.

The ROC findings offer somewhat inconsistent support for theories of belief bias that posit qualitative effects on reasoning. The ROC method also has several potential shortcomings. One is practicality. The method requires capturing performance over a range of criterion levels. This can be achieved by collecting confidence ratings alongside validity judgments or by manipulating response bias across multiple groups. Either method is data-intensive and time consuming, and the subsequent analysis is more complex than dealing with a single set of endorsement rates. Collecting confidence ratings is the more popular of the two methods because it allows a within-subjects treatment. However, the source of confidence in syllogistic reasoning has not been extensively studied. There is evidence for alignment between normative responding and confidence-type judgements (e.g., [De Neys, 2012](#); [Morsanyi & Handley, 2012](#)), but confidence may not always be related to accuracy ([Shynkaruk & Thompson, 2006](#)). Finally, there is ongoing debate about whether SDT provides the optimum model for empirical ROCs ([Dube, Rotello, & Heit, 2011](#); [Klauer & Kellen, 2011](#)).

### 1.1. The forced choice method

Forced choice is a procedure commonly used in domains such as perception and memory. Although it has not to our knowledge been applied to the study of syllogistic reasoning, its properties make it ideal for investigating belief bias. In the traditional single-probe procedure, participants are presented with individual syllogisms and must decide whether the conclusion is valid or invalid. In the forced choice procedure which we introduce here, two syllogisms are presented side by side and the participant must decide which of the two has the valid conclusion. The procedure is not much more complex than the traditional one, and the dependent measure, proportion correct, is simple and straightforward to interpret. Most importantly, forced choice offers a means of isolating changes in reasoning from changes in response bias by removing the latter from the decision process. This is done by equating the believability of competing conclusions.<sup>1</sup>

<sup>1</sup> The procedure does allow one form of bias: participants could show an arbitrary preference for the right or left display position. Spatial position bias was examined in our analysis.

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