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On the conjunction fallacy and the meaning of *and*, yet again: A reply to Hertwig, Benz, and Krauss (2008)

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ABSTRACT

In this paper we question the theoretical tenability of Hertwig, Benz, and Krauss's (2008) (HBK) argument that responses commonly taken as manifestations of the conjunction fallacy should be instead considered as reflecting "reasonable pragmatic and semantic inferences" because the meaning of *and* does not always coincide with that of the logical operator \wedge . We also question the relevance of the experimental evidence that HBK provide in support of their argument as well as their account of the pertinent literature. Finally, we report two novel experiments in which we employed HBK's procedure to control for the interpretation of *and*. The results obtained overtly contradict HBK's data and claims. We conclude with a discussion on the alleged feebleness of the conjunction fallacy, and suggest directions that future research on this topic might pursue.

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1. Introduction

Since the early Eighties, about a hundred scientific papers on the conjunction fallacy (CF) have been published. Such wide interest is easy to understand, as the CF has become a key topic in the fervent debate on human rationality. Indeed, from the very beginning the CF phenomenon has been described as a violation of "the simplest and the most basic qualitative law of probability" (Tversky & Kahneman, 1983, p. 293; but already mentioned in Tversky & Kahneman, 1982, p. 90). The law at issue is the *conjunction rule*, a principle whose compelling nature appears unequivocal when stated formally: $\Pr(p \wedge q) \leq \Pr(p)$, i.e., the joint occurrence of a pair of events (p and q) cannot be more probable than the occurrence of anyone of them (e.g., p).

In contrast, what does seem surprising across more than 30 years of research is the recurrence of questions about the validity of CF experiments. A standard line of

argument inspired by the pragmatics of communication has been that violation of the conjunction rule need not be irrational if it results from interpreting the experimental task in ways that rob it of normative relevance. The main sources of misinterpretation considered in the literature include participants' understanding of the isolated conjunct p , the term *probable*, and the connective *and*. Many techniques have been developed to control for each of these possible misinterpretations (see Moro, 2009, for a recent review), but none of them has dissipated the effect.

Nonetheless some concerns turned out to be important and should be credited for having fostered improvements in the experimental procedures by which the CF is investigated. To illustrate, the suspicion that the single conjunct p might be interpreted as p -and-not- q (Adler, 1984; Dulany & Hilton, 1991; Messer & Griggs, 1993; Morier & Borgida, 1984; Polizer & Noveck, 1991; but already discussed in Tversky and Kahneman, 1982, 1983) led to more careful control of stimuli, such as explicitly including the statement p -and-not- q in the judgment task along with p and p -and- q . When this technique is applied (as in Tentori, Bonini, & Osherson, 2004; Wedell & Moro, 2008), the rate

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of violations of the conjunction rule is lower than first reported by Tversky and Kahneman (1982, 1983; the original “Linda” problem) but remains prevalent (e.g., more than 50% for the majority of the scenarios in both studies cited above). Such a pattern makes clear that misunderstanding of the single conjunct cannot be considered the ultimate reason for the occurrence of the CF. However, it also strongly suggests that misunderstanding of the conjunct should indeed be avoided in order to distinguish proper and improper fallacy answers.

In other cases, however, pragmatic factors have been evoked time and again regardless of theoretical remarks and experimental results pointing in the opposite direction. This appears to be the case with the argument advanced by Hertwig, Benz, and Krauss (2008) (hereafter HBK) – previously raised by Ahn and Bailenson (1996), Gigerenzer (1996, 2001, 2005) and Hertwig and Gigerenzer (1999) – that unintended interpretations of the connective *and* may account for (apparent) CF behaviour. As a matter of fact, this concern has been already extensively explored and rejected as unsupported in the literature (see, for example, Bonini, Tentori, & Osherson, 2004; Crandall & Greenfield, 1986; Sides, Osherson, Bonini, & Viale, 2002; Tentori et al., 2004; as well as Moro’s review, 2009, specifically devoted to possible sources of misunderstanding in CF tasks).

In what follows, we question the theoretical tenability of HBK’s argument as well as the relevance of the new experimental evidence they provide in its support. Subsequently, we reinforce our criticism of HBK on the basis of novel empirical data. Finally, we discuss the alleged feebleness of the CF evoked by HBK, and suggest directions that future research on the CF might pursue.

2. The conjunction rule and HBK’s argument

The main point of HBK is that the conjunction rule invokes the logical connective \wedge whereas its experimental test typically relies on natural language conjunctions like English *and*. In contrast to the former, the latter can convey a wide range of relationships between conjuncts (such as *temporal* or *causal* ones) as well as reflect very different set-theoretical operators (such as *union* or *intersection*). HBK argue that depending on which meaning of *and* is assumed, “people may arrive at nearly opposite understandings of a sentence” (p. 741), so that responses commonly taken as manifestations of fallacious reasoning in fact emerge from “reasonable pragmatic inferences” (p. 752). Therefore, HBK conclude, “estimates of the prevalence of genuine conjunction errors in previous studies are quite inflated” (p. 752).

From a theoretical perspective, we find HBK’s argument to be affected by two important flaws.

First, the uncontroversial fact (recognized as such in the CF literature ever since Tversky & Kahneman, 1983, p. 302) that the word *and* can have different interpretations across different sentences does not imply anything about its ambiguity within a given sentence. For example, we agree with HBK that *and* in “Mark invited friends and colleagues

to his party” is unlikely to be interpreted as involving the *intersection* between the set of friends and the set of colleagues. However, this does not entail that people assign to this sentence multiple contrasting interpretations. Indeed, discussing the very same example, Mellers, Hertwig, and Kahneman (2001, p. 270) pointed out that such *and* “implies a *union*, not an *intersection*”, meaning that they do not see any room for equivocation. Should single occurrences of *and* be usually ambiguous, the costs in ordinary conversation would be dramatic, precisely because *and* is “one of the most frequent words in the English language” (HBK, p. 740). As already proved in Tentori et al. (2004), as well as recognized by HBK themselves (pp. 744 and 745), the word *and* in sentences like “Mark has blue eyes and blond hair”, for which large CF effects have been observed, is indeed interpreted by virtually all participants in a way that justifies invoking the conjunction rule as a norm.

The second (and major) flaw in HBK’s argument is omitting that even when the meaning of *and* is not exhausted by \wedge , its interpretation often legitimizes application of the conjunction rule all the same. As explained in Tentori et al. (2004), reference to the conjunction rule does not require logical equivalence between *and* and \wedge , but only that the interpretation of the *and* statement at issue *implies* the corresponding \wedge statement. A relevant example from Levinson (1983), reported by HBK (p. 747) is: “he turned on the switch and the motor started”. Here, the connective *and* may express not only a conjunction between two events but a *temporal* and a *causal* relation that, of course, goes beyond the meaning of \wedge . However, if the reader recognizes that both events “he turned on the switch” and “the motor started” must happen for the sentence “he turned on the switch and the motor started” to be true, then the meaning *s/he* assigns to *and* includes that of the logical operator \wedge in the sense pointed out above. As a consequence, the conjunction rule *can* be properly invoked as a norm.

In this connection, consider Levinson’s (1983) treatment of *and*-conjunctions in the pragmatics of language, approvingly referred to by HBK at various places. Levinson noticed that in many cases the interpretation of a *p*-and-*q* sentence will not be limited to the logical conjunction $p \wedge q$, but will add to it a statement of the strongest non-logical (e.g., *temporal*) connection between the conjuncts which is allowed by the interpreter’s beliefs about the world. In particular, Levinson’s discussion of a conjunction *p*-and-*q* as that reported above involves a series of increasing “informational enrichments” of the purely logical reading of *and*, according to the following pragmatic maxim of interpretation (Levinson, 1983, p. 146; quoted by HBK, p. 747).

Given *p*-and-*q* try interpreting it as:

- (i) *p*-and-then-*q* [he turned on the switch and then the motor started];
if successful try:
- (ii) *p*-and-therefore-*q* [he turned on the switch and therefore the motor started];
if successful try also:

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