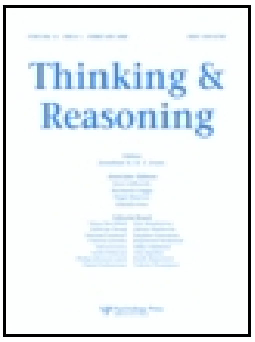

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Effects of context on the rate of conjunctive responses in the probabilistic truth table task

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ABSTRACT
The probabilistic truth table task involves assessing the probability of "*If A then C*" conditional sentences. Previous studies have shown that a majority of participants assess this probability as the conditional probability $P(C|A)$ while a substantial minority responds with the probability of the conjunction *A and C*. In an experiment involving 96 participants, we investigated the impact on the rate of conjunctive responses of the context in which the task is framed. We show that a context intended to lead participants to consider all the possible cases (i.e. the throw of a die known to allow six possibilities) elicited more conjunctive responses than a context assumed not to have this effect (an unfamiliar deck of cards). These results suggest that the step of inferring the probability can distort our assessment of participants' interpretation of conditional sentences. This might compromise the validity of the probabilistic task in studying conditional reasoning.

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KEYWORDS Conditional reasoning; probabilistic truth table task; context effect

Introduction

Traditional approaches in the psychology of reasoning mainly focused on the processes of deduction and truth preservation based on the binary distinction between truth and falsity, favouring inference production tasks (Braine & O'Brien, 1998; Johnson-Laird & Byrne, 1991, 2002; Rips, 1994). Far from these conceptions, several contemporary theories regrouped under the banner of what is called the *new paradigm psychology of reasoning* (Elqayam & Over, 2013; Over, 2009) emphasise the essential connection between reasoning and probability assessment (Baratgin, Over, & Politzer, 2013; Chater & Oaksford, 2008; Evans, 2002, 2012; Oaksford & Chater, 2007, 2009; Pfeifer, 2013; Pfeifer & Kleiter, 2011). While traditional theories considered classical bivalent logic as the basis for rationality, the new paradigm psychology of reasoning uses probability theory as a rationality framework for human reasoning

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(Pfeifer, 2013). For example, in the domain of conditional reasoning, while traditional theories assumed that the meaning of "If A, then C" is captured by either inferential rules (Braine & O'Brien, 1998; Rips, 1994) or a set of mental models representing state of affairs that are possible when the sentence is true (Johnson-Laird & Byrne, 1991, 2002; Johnson-Laird, Khemlani, & Goodwin, 2015), the new psychology of reasoning assumes that this meaning is probabilistic in nature.

Consequently, according to the new paradigm theoreticians, studying probability judgements would tell us more about the psychology of reasoning than assessing the conformity of deductive reasoning with binary extensional logic (Elqayam & Over, 2013, p. 259). One of the most important tasks for studying conditional reasoning within the new paradigm is the probabilistic truth table task introduced by Evans, Handley, and Over (2003) and, the same year, but independently, by Oberauer and Wilhelm (2003). Usually, in this task, participants are given the probabilities of all the truth table cases and asked to infer the probability of a conditional sentence "If A then C". For example, in Evans et al. (2003), participants were informed about a deck containing cards that were either yellow or red, with either a circle or a diamond printed on them. Knowing that the pack contains 1 yellow circle, 4 yellow diamonds, 16 red circles, and 16 red diamonds, participants were asked how likely is the following claim to be true of a card drawn at random from the pack: "If the card is yellow then it has a circle printed on it". This task revealed that a majority of adults estimate the probability of the conditional as the conditional probability in such a way that P(*If A then C*) = P(*C* | *A*), which corresponds to the number of yellow circles divided by the number of yellow cards (i.e., in the example, 1/5). In the following, we will call this response the conditional response. Following Edgington (1995), the new paradigm theoreticians call the equality P(*If A then C*) = P(*C* | *A*) *The equation*. Importantly, Evans et al. (2003) observed virtually no responses matching the material conditional favoured by the standard propositional logic on which the traditional theories of conditional were based. For the material conditional interpretation, the conditional is true for all cases except $A \,\&\, \neg C$. Thus, the probability of the conditional would be $1 - P(A \,\&\, \neg C)$, a response almost never observed by Evans and colleagues. Several studies replicated Evans et al. (2003) and Oberauer and Wilhelm's (2003) findings and reported the predominant estimation of the probability of the conditional as the conditional probability (Barrouillet & Gauffroy, 2015; Douven & Verbrugge, 2010; Fugard, Pfeifer, Mayerhofer, & Kleiter, 2011; Gauffroy & Barrouillet, 2009; Over, Hadjichristidis, Evans, Handley, & Sloman, 2007; Pfeifer, 2013; Politzer, Over, & Baratgin, 2010), although this assessment is subject to some modulations (see Schroyens, Schaeken, & Dieussaert, 2008; Skovgaard-Olsen, Singmann, & Klauer, 2016).

However, a surprising finding revealed by these studies is the substantial rate of adults producing what is considered a conjunctive response in which the probability of the conditional is estimated as the probability of the conjunction of *A* and *C*, such as P(*If A then C*) = P(*A* & *C*), in the example above, 1/37. This rate, sometimes rather modest (12% in Fugard et al., 2011, Exp. 1), can reach very high values (43% in Evans et al., 2003, Exp. 3, 39% in Evans, Handley, Neilens, & Over, 2007, Exp. 3). This finding is surprising because conjunctive interpretations of basic[1] conditionals are frequently observed in school-aged children with other paradigms such as inference production and traditional truth table tasks,[2] but they are rarely encountered in adults (e.g., see Barrouillet & Lecas, 1998; Gauffroy & Barrouillet, 2011). Several explanations have been proposed for this unexpected response. Evans et al. (2003), who were the first to observe the phenomenon, suggested an incomplete reasoning process. The suppositional approach of conditional that these authors favoured assumes that when evaluating a conditional, individuals use a procedure known as the *Ramsey test* (Evans & Over, 2004). They hypothetically add *A* to their stock of knowledge and evaluate their degree of belief in *C* given *A* by comparing the probabilities of *A & C* and *A & ¬C*. Focusing on *A* cases, people disregard the ¬*A* cases that are judged as irrelevant to the truth of the conditional. The conjunctive response would be due to an incomplete Ramsey test, participants cutting short the reasoning process and stopping at the *A & C* cases. Gauffroy and Barrouillet (2009) noted that this explanation is disputable because, when assessing the probability of false conditionals (how likely is the conditional claim to be false), the same conjunctive responders should stop at *A & ¬C* cases. However, this is rarely observed and their responses most often correspond to 1 − P(*A* & *C*) and not to P(*A* & ¬*C*). Another explanation was proposed by Pfeifer (2013) who suggested that the conjunctive response could result from a matching effect, participants only focusing on those cases that match the premise "If A then C". Such an explanation could account for the assessment of the probability of false conditionals, but it does not explain why the conjunctive response pattern in adults is encountered more rarely in traditional truth table tasks than in the probabilistic task. Finally, Pfeifer (2013) also suggested that the conjunctive response could result from a linguistic ambiguity. Many instructions prompt the participant to evaluate the truth of the conditional (this is the case in Evans et al., 2003). If participants understand this instruction as a requirement to find in which cases the conditional is strictly speaking *true*, they will exclusively focus on *A & C* cases because it is known that the conditional is deemed true only for those cases. Thus, Pfeifer argues that such a task cannot differentiate between the conjunctive and what he calls the *conditional event*

[1]According to Johnson-Laird and Byrne (2002), basic conditionals are conditionals in which the antecedent and the consequent have no semantic or referential relations, or relations based on knowledge.

[2]Truth table tasks are tasks in which participants are asked to assess the truth-value of a connective for each logical case.

interpretation, which leads to the conditional response.[3] We will see below that what distinguishes the conditional probability from the conjunctive probability responses is probably not the identification of those cases that make the conditional true, but the way the probability is inferred once these cases have been identified. Overall, what these conjunctive responses say about participants' reasoning and interpretation of the conditional remains uncertain. The intuition that governed the present study is that at least some of the conjunctive responses in the probabilistic truth table task do not reflect genuine conjunctive understanding of basic conditionals in adults (see Evans et al., 2007, for a similar suspicion). If a substantial proportion of adults interpreted conditionals as conjunctions, this would have been previously observed in the other tasks that have been used to study the interpretation of conditionals for decades such as the traditional truth table task. Yet, this is rarely the case.

Pfeifer (2013, p. 333) provides a clear and commonly shared analysis of the probabilistic truth table task when assuming that it "requires, first, the fixing of the interpretation of "If A, then C" and, second, the inferring of the probability", adding that "this task allows for inferring the participants' interpretation of the conditional from the responded probability assessment". This analysis implicitly assumes that the second step of the process, inferring of the probability, introduces minimal noise in the process of identifying participants' interpretation. However, there are reasons to have doubts about the innocuousness of this second step in solving the task, and, consequently, in inferring the interpretation adopted by participants. Our hypothesis is that part of the responses does not reflect participants' interpretation of the conditional, but the way they understand the task of assessing the probability itself. Indeed, in the Evans et al. (2003) task featuring a pack of cards, it is possible that some participants interpret the problem "how likely is the following claim to be true of a card drawn at random from the pack?" as "what is the probability of randomly drawing a card that makes the following claim true?" The former interpretation focuses on the probability for a conditional to be true, which can lead to discard those cards irrelevant for assessing its truth-value (i.e., the $\neg A$ cards). Discarding these cases leads to the conditional response, as Evans et al. (2003) note. By contrast, the latter interpretation focuses on the probability of drawing at random from the pack a certain type of card, the type that makes the conditional true. It has been known for a long time, in truth table tasks in which participants are not restricted to a binary choice between "true" and "false" options (i.e., they are allowed to declare

[3]To circumvent this potential difficulty, Pfeifer (2013) suggests prompting participants to evaluate to what degree the conditional "holds" instead of to what degree it is "true". We did not follow this advice because we found impossible to accurately translate "holds" in French. Moreover, it does not seem that the use of "holds" has a strong impact on the rate of conjunctive responses.

indeterminate the truth value of the conditional or irrelevant the case under study), that most of the adults assume that *A & C* cases are the only cases that make the conditional "If A, then C" true. Thus, if people calculate the probability of drawing at random from the pack a card that makes the conditional true, they will divide the number of *A & C* cards by the number of cards in the pack, thus giving the conjunctive response.

In other words, the conjunctive and conditional responses that are usually seen as revealing two different interpretations of basic conditionals could result from slight variations in the way people interpret the question rather than the conditional. This could explain why Fugard et al. (2011, Exp. 2) observed that, while more than half of their participants produced conjunctive responses at the beginning of the task, most of them changed their mind and adopted what the authors call *conditional event* responses (i.e., giving the conditional probability as a response) when a series of 71 problems were presented. We doubt that the undergraduate students tested by Fugard et al. genuinely shifted from one interpretation of the conditional to another, discovering in the context of a psychology experiment the "correct" meaning of a connector they have heard and used daily for more than fifteen years. It seems more likely that the repetition of trials led them to reinterpret the task and what the experimenter was expecting, moving from "how likely is drawing at random from the pack a card of which the following claim is true?" to "what is the probability of randomly drawing a card that makes the following claim true?"

If part of the conjunctive responses in the probability truth table task is due to the fact that some participants understand the task as requiring the assessment of the probability of occurrence of a case that makes the conditional sentence true, this type of response should increase when the context of the task elicits this reading. The present study tested the effect of two factors that could have such an effect. The first consists in framing the problem in a context that elicits the use of the totality of the potential combinations of antecedent and consequent in computing the probability. Presenting the different logical cases as corresponding to the six sides of a die should meet this requirement. Die throwing is routinely used in mathematics classes for introducing probabilities ("how many chances do you have to get a 3 when throwing a die?"). It can be assumed that any university student has already encountered problems in which probabilities involving dice were to be computed, and he/she knows that these probabilities have to be computed out of the number of sides. Thus, framing the problem in a dice context should lead participants to perform their computations with 6 as a denominator, thus taking into account the entire set of possibilities and producing responses that match what is called a conjunctive interpretation. We compared the dice condition with a context less conducive to the use of all the possible cases in the

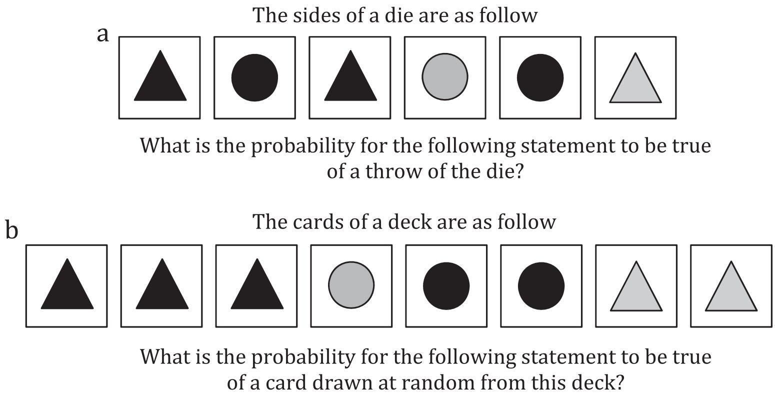

Figure 1. Illustration of a trial of the probability task in the dice context (panel a), here with a mixed presentation, and in the cards context (panel b), here with a grouped presentation, for the conditional sentence "If there is a triangle, then it is blue" (black and grey tones refer to blue and green, respectively).

computation. For this purpose, we used the cards described by Evans et al. (2003), the total number of which varied from one problem to the other, instead of the standard pack of 52 playing cards. Such a context is less likely to trigger the activation of knowledge about the total number of cases on which probabilities must be computed. This should attenuate the tendency to produce conjunctive responses and favour the occurrence of conditional probability responses.

The other factor we manipulated is the way the different truth table cases are displayed. We surmised that presenting these cases grouped in four easily distinguishable sets emphasises the contrast between *A* and ¬*A* cases and could consequently favour the focusing on *A* cases and the resulting conditional response. By contrast, mixing up the four different cases might encourage participants to consider the entire set of possibilities for their computation of probability, thus decreasing the rate of conditional probability responses and increasing the rate of conjunctive responses (Figure 1).

Method

Participants

Ninety-six first-year psychology students (mean age: 21.79 years, $SD = 5.33$) from the University of Geneva participated for partial fulfilment of course requirements. Twenty-four participants were randomly assigned to each of the four conditions resulting from the factorial 2 (context: dice vs. cards) × 2 (positioning: grouped vs. mixed) design.

Materials and procedure

The material was inspired by Fugard et al. (2011). In each trial, participants were presented with white squares displayed on screen, each square containing a coloured shape (red, blue, or green circle, triangle, or square). These squares were intended to represent either the sides of a die, their total number being in this case always 6, or the content of a deck of cards, their total number varying from 6 to 9. These squares were accompanied at the bottom of the screen by the question "What is the probability for the following claim to be true of [a throw of the die/a card drawn at random from the deck]?" and a conditional sentence of the form "If there is a [shape], then it is [colour]" (e.g., "if there is a triangle, then it is blue"). In each trial, the sides of the die (or cards) showed the four combinations of two different shapes and two different colours corresponding to the four logical cases ($p\ q$, $p\ \neg q$, $\neg p\ q$, $\neg p\ \neg q$) defined by the accompanying conditional, with 1–3 exemplars of each. The number of exemplars of each case was chosen in such a way that two different interpretations of the conditional (i.e., conjunctive, biconditional, conditional, material implication[4]) never resulted in the same response. Moreover, the sides of the die and the cards were either grouped by categories or randomly mixed depending on the positioning condition (Figure 1).

In each experimental condition, there were 20 experimental trials preceded by 4 training trials without any feedback. Two successive trials always presented a different conditional sentence (a different combination of shape and colour) and a different number of logical cases. In all four experimental conditions, participants studied the same conditional sentences with the same items displayed. The 4 training trials were the same for all the participants who studied the 20 subsequent experimental trials in a different random order. They gave their answers in the "X out of Y chances" format used by Barrouillet and Gauffroy (2015), Fugard et al. (2011), and Gauffroy and Barrouillet (2009) by typing responses on the number pad of the keyboard and validating their answer with Enter.

Results

Overall, the task elicited 61% of conditional responses and 33% of conjunctive responses. The remaining responses (biconditional and defective biconditional, $<0.1\%$, material implication, 0.3%, and unclassifiable responses, 6%) were so rare that we regrouped them in an "other" category (Figure 2). As Figure 2 makes clear, the distribution of the different responses strongly varied as a function of the experimental condition. In order to test the effects of

[4]Biconditional and material implication responses correspond to $P(A \,\&\, C) + P(\neg A \,\&\, \neg C)$ and $P(A \,\&\, C) + P(\neg A \,\&\, \neg C) + P(\neg A \,\&\, C)$, respectively.

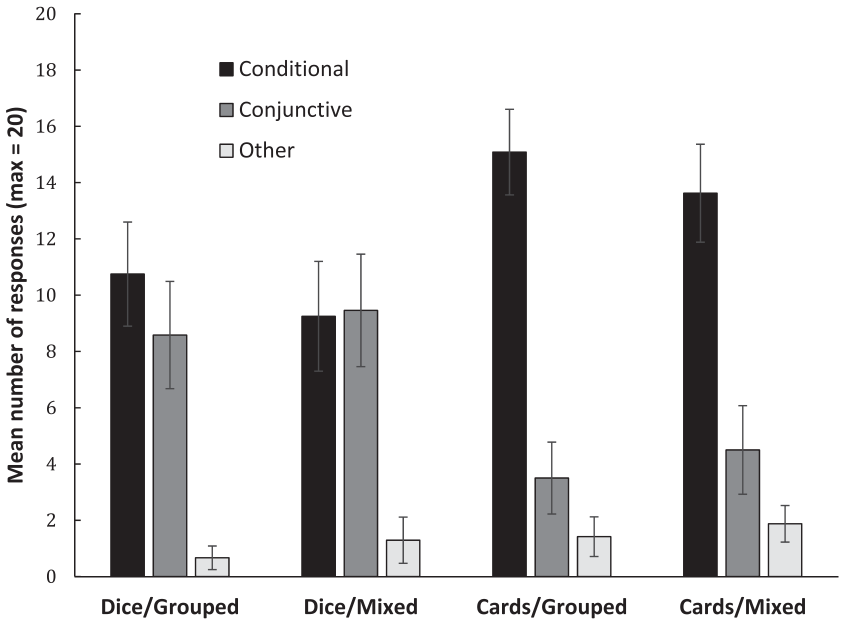

Figure 2. Mean number of conditional, conjunctive, and other responses as a function of the context (dice vs. cards) and the positioning (grouped vs. mixed) of the cases in the probability task.

the context of the task and the way the logical cases were displayed, we performed an analysis of variance (ANOVA) on the number of conjunctive responses (max = 20) as dependent variable with context (dice vs. cards) and positioning (grouped vs. mixed) as between-subjects factors. This analysis revealed a main effect of the context with significantly more conjunctive responses when participants reasoned about dice ($M = 9.02$, $SD = 9.48$) than about cards ($M = 4.00$, $SD = 6.96$), $F(1,92) = 8.58$, $p = 0.004$, $\eta^2_p = 0.085$. Neither the way the cases were displayed (means of 6.04 and 6.98 for grouped and mixed positioning, respectively), $F(1,92) = 0.30$, $p = 0.586$, $\eta^2_p = 0.003$, nor the interaction between the two factors, $F(1,92) = 0.001$, $p = 0.971$, $\eta^2_p < 0.001$, reached significance.

The same analysis performed on the rate of conditional responses confirmed these results. There were more conditional responses when participants reasoned about cards ($M = 14.35$, $SD = 7.96$) than about sides of a die ($M = 10.00$, $SD = 9.25$), $F(1,92) = 6.03$, $p = 0.016$, $\eta^2_p = 0.062$. Neither the way the cases were displayed (means of 12.92 and 11.44 for grouped and mixed positioning, respectively), $F(1,92) = 0.70$, $p = 0.406$, $\eta^2_p = 0.008$, nor the interaction between the two factors, $F(1,92) < 0.001$, $p = 0.990$, $\eta^2_p < 0.001$, reached significance.

Thus, the most favourable condition for conjunctive responses was the dice context with mixed cases ($M = 9.46$, $SD = 9.80$, for conjunctive responses

Table 1. Number of participants (max: 24) who were consistent (at least 14 out of 20) in giving either conjunctive or conditional responses as a function of the context (dice vs. cards) and the positioning (grouped vs. mixed) of the cases in the probability task.

	Dice		Cards	
	Grouped	Mixed	Grouped	Mixed
Conditional	13	11	17	17
Conjunctive	10	11	3	5

to be compared to *M* = 9.25, *SD* = 9.56, for conditional responses), whereas the most favourable condition for conditional responses was the cards context with grouped cases (*M* = 15.08, *SD* = 7.45, for conditional responses to be compared to *M* = 3.50, *SD* = 6.26, for conjunctive responses).

Another way to look at these results was to classify participants as a function of their predominant interpretation. Every participant who was consistent in at least 14 out of the 20 responses in a given interpretation (i.e., more than two-thirds of the cases) was considered as favouring this interpretation and being either a conjunctive or a conditional responder (Table 1). Only 9 participants out of 96 could not be classified this way and were left out of the following analyses. There were 29 conjunctive responders, who gave on average 18.97 conjunctive responses (*SD* = 1.66), and 58 conditional responders, who gave on average 19.09 conditional responses (*SD* = 1.37). A χ^2 test showed a strong dependence between participants' interpretation and context, $\chi^2(1) = 7.45$, $p = 0.006$, with more conditional than conjunctive responders in the cards context (34 and 8 participants, respectively), whereas no such difference appeared with the dice context (24 conditional and 21 conjunctive responders).

Although we were able to classify most of our participants according to a favoured interpretation, several participants shifted from one interpretation to another during the task,[5] as Fugard et al. (2011) observed (Table 2). They reported that these shifts often happened at the very beginning of the task. In line with these observations, we observed frequent shifts in the first trials of the task, including during training trials. Thus, we included these four training trials in the following analyses (the number of analysed trials was consequently 24).

Using the algorithm reported by these authors, we calculated for each participant if he/she shifted toward the conditional interpretation from another interpretation and, if so, at which trial this shift happened. Almost half of our participants (42%) exhibited a conjunctive interpretation at the first trial of the training (54%, 46%, 33%, and 33% in the dice-grouped, dice-mixed, cards-grouped and cards-mixed conditions, respectively). Among these conjunctive

[5]Overall, 28% of our participants shifted toward a conditional interpretation. Among them, 78% exhibited a conjunctive modal response before shifting. Besides, 7% of our participants shifted toward a conjunctive interpretation, 29% of them did so from a conditional modal response.

Table 2. Number of participants who shifted toward a conditional or a conjunctive response during the task as a function of the context (dice vs. cards) and the positioning (grouped vs. mixed) of the cases in the probability task.

	Dice		Cards	
	Grouped	Mixed	Grouped	Mixed
Shift toward the conditional	10	3	9	5
Shift toward the conjunctive	1	2	2	2
No shift	13	19	13	17

responders in the first trial, 48% subsequently shifted toward the conditional response. Moreover, 63% of the shifts toward the conditional response happened during the first four trials (Figure 3). We performed a binary logistic regression to check for the effects of context and cases positioning on whether participants shifted toward a conditional interpretation during the task or not. First, we tested the model including only positioning as predictor of shifting toward the conditional which significantly differed from the constant-only model, $\chi^2(1) = 6.38, p = 0.012$. Neither adding context to our model nor the interaction between positioning and context significantly increased its fit to the data ($\chi^2(1) = 0.06, p = 0.814$; $\chi^2(2) = 0.69, p = 0.707$, respectively). Odds ratio indicated that, according to the model, participants presented with grouped positioning were 2.28 times more likely to shift toward the conditional interpretation than those presented with mixed positioning.

It might be argued that the difference we observed between the dice and cards conditions resulted from the variation in the number of cards across

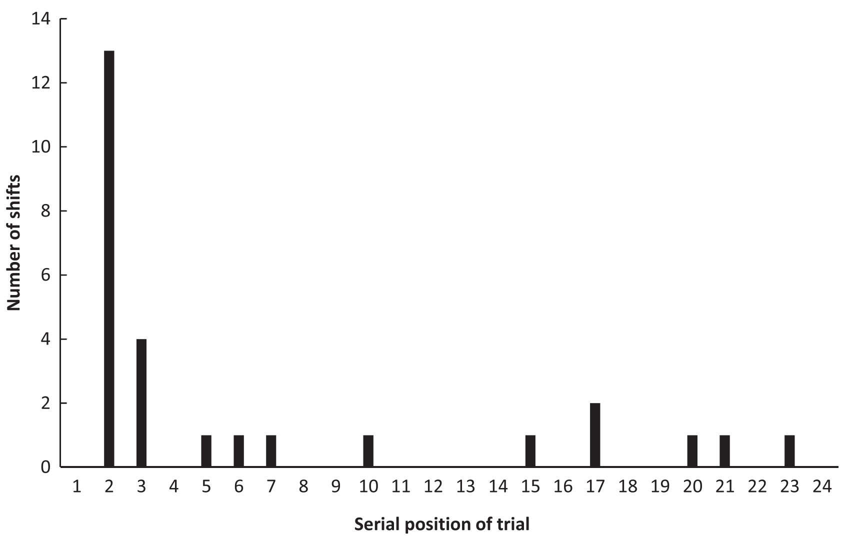

Figure 3. Number of participants who shifted towards the conditional interpretation as a function of the serial position of the trial in the probability task.

trials (6, 7, 8, or 9 cards) whereas the number of sides of the dice remained constant (6 sides). The varying number of cards could have kept the participants alert to think more carefully, leading them to go beyond the conjunctive response elicited by the dice condition.[6] However, if the difference between the two conditions resulted only from the varying number of cards, the two conditions should not differ in the very first trial. Instead, the difference should appear over the trials with more frequent shifts in responses in the cards condition. In fact, the difference between the two conditions was significant from the very first training trial onwards in which the dice condition already elicited more conjunctive responses than the cards conditions (24 and 16, respectively) and less conditional responses (15 and 25, respectively), $\chi^2 = 4.05$, $p < 0.05$. Thus, the variation in the number of cards while the number of sides of the dice remained constant cannot explain the results we observed. Moreover, it can be seen in Table 2 that the cards conditions did not elicit significantly more shifts toward the conditional response than the dice condition (14 and 13, respectively).

Discussion

The results of this experiment revealed that individuals' responses to the probabilistic truth table task can strongly vary with small changes in the way the task is contextualised and in the way the material is presented. As we surmised, framing the task as the throw of a die induced the tendency in participants to base their assessment of probabilities on the entire set of possibilities (the six sides), resulting in an increase in the frequency of what is described as conjunctive responses. By contrast, when the problems were presented as referring to a pack of cards, conjunctive responses were less frequent and conditional responses predominated. Moreover, shifts toward responses that only take the *A* cases into account, which result in what is described as conditional interpretations, were more often observed when the different cases were displayed in separated and easily identifiable groups. We assume that by facilitating the distinction between different cases and the identification of $\neg A$ categories, this positioning made conjunctive responders realise, through the successive trials, that it is possible to assess the probability in another way. As a result, the cards-grouped condition elicited the highest rate of conditional responses, whereas the dice-mixed condition elicited the highest rate of conjunctive responses that predominated in this condition.

This does not mean that individual differences in the probabilistic truth table task cannot reflect genuine differences in the interpretation of the conditional itself, as they could result for example from individual differences in

[6]We thank an anonymous reviewer for making us aware of this possibility.

intelligence (Evans et al., 2007). However, the present findings support our hypothesis that the responses to the probabilistic truth table task do not entirely depend on the interpretation of the conditional, but also on the second step identified by Pfeifer (2013) of inferring the probability. It is worth noting that when variability in this second step is taken into account, a same interpretation can lead to different responses. This variety of responses for a same interpretation was evoked by Fugard et al. (2011, p. 637) who noted that "a conjunction response may also result from a mapping of the natural language if-then to a conditional event, but with the task of inferring when the conditional receives the truth value *true*". They took the example of a die thrown randomly, the sides of which show either a square or a circle that can be either black or white with the conditional sentence "If the side shows a square, then the side shows black". Fugard et al. explained that asking about the probability that this conditional is true can be interpreted as asking the probability that both the antecedent and consequent are true. Indeed, the conditional is exactly true when both the antecedent and the consequent are verified (i.e., black squares). This corresponds to our analysis of the processes leading to a conjunctive response if participants interpret the question of the probability task as "what is the probability of randomly drawing a card that makes the following claim true?" In other words, what Fugard et al. (2011) suggested is that depending on the reading of the task, the interpretation they call conditional event can lead to either a conditional or a conjunctive response. Surprisingly, they nonetheless assumed that probability tasks "allow the experimenter to infer how the participants interpret the conditional", something reflected in the way they reported the results of Evans et al. (2003) and Oberauer and Wilhelm (2003): "Just over half of participants responded with the conditional event interpretation and the remainder responded with a conjunction interpretation" (Fugard et al., 2011, p. 637).

However, both Fugard et al.'s thoughts and our results suggest that it might be risky to derive interpretations from responses to the probability task and to infer from conjunctive responses that individuals favour a conjunctive interpretation. Superficial characteristics of the task such as the context in which it is framed or the positioning of the material seem to affect the way individuals understand the probability question and consequently their response. It is difficult to imagine that the interpretation people have of a conditional introducing an artificial relation between a shape and a colour might be modified by a scenario indicating that the conditional rule describes the sides of a die instead of cards in a pack. Although it has been shown that the context of enunciation of a conditional can affect its interpretation (e.g., Barrouillet & Lecas, 2002), the conditional rules used here had the same content and were intended to describe identical sets of coloured shapes. It seems more probable, as we hypothesised, that our manipulations affected the way participants understand the question and the way the probability was inferred. It might be noted that both the conjunctive and the conditional interpretations share the same identification of the set that must provide the numerator of the fraction, the *A & C* cases that are assumed to make the conditional true. The two interpretations only differ on the identification of the basis on which the probability must be computed. Our results show that this choice is not totally determined by interpretative processes, but also by the activation of knowledge about probabilities (e.g., the knowledge that probabilities concerning dice must be computed on the basis of 6 possible cases). This means that the probabilistic truth table task involves knowledge and abilities that are unrelated to the interpretation of conditional sentences. Consequently, it is possible that this task provides us with an insight of how individuals understand "if … then" sentences that might be less reliable than usually assumed. Thus, two questions arise. First, does the probabilistic truth table task tell us something more than the traditional truth table task? Second, how should we interpret the responses observed in this task?

Concerning the first question, we have already noted that conditional and conjunctive responders agree on the cases they consider as making the conditional true, the *A & C* cases. The predominance of conditional response also makes clear that a majority of participants deem ¬*A* cases as irrelevant for assessing the truth value of the conditional. However, these findings have been known for a long time, long before the emergence of the *new paradigm psychology of reasoning*. Traditional truth table tasks in which participants are offered the response option "irrelevant" along with "true" and "false" reveal that the "true" responses are mainly concentrated on *A & C* cases, while ¬*A* cases are considered by a majority of adult participants as irrelevant for the truth value of the conditional (Evans & Newstead, 1977; Johnson-Laird & Tagart, 1969). This response pattern was known as the *defective truth table* before being renamed de Finetti truth table. By contrast, as we noted in our introduction, conjunctive responses in the three-valued traditional truth table task are very rare (e.g., Gauffroy & Barrouillet, 2009) and do not occur at all in some studies (e.g., Gauffroy & Barrouillet, 2011). This means that it almost never occurs that adult participants deem the conditional false for both ¬*A & C* and ¬*A &* ¬*C* cases. This is especially true for ¬*A &* ¬*C* cases, for which the response "false" in traditional truth table tasks is very rare (e.g., 10% of occurrences in Barrouillet, Gauffroy, & Lecas, 2008; 3% in Gauffroy & Barrouillet, 2009; 6% in Evans et al., 2007, for "if p then q" conditionals; 4% in Gauffroy & Barrouillet, 2011). It is thus very unlikely that participants in probability tasks, including those who produce conjunctive responses, consider ¬*A &* ¬*C* cases as making the conditional false. However, conjunctive responders do not consider ¬*A &* ¬*C* cases as making the conditional true either, as their responses make clear. If this were the case, they would add the ¬*A &* ¬*C* cases to the *A & C* cases in computing the numerator of the fraction, something that never happened in our study. In other words, although conjunctive responders include ¬*A cases* in their assessment of the probability of the conditional, this inclusion cannot result from a deliberate and thoughtful assessment of the relevance of these cases for the truth value of the conditional. Consequently, at least for a substantial minority of participants, the probability task does not seem to deliver reliable hints about the information they find relevant or not for assessing the truth value of conditionals. In this respect, this task appears less informative than the traditional truth table task when it comes to the way people understand and interpret conditionals.

Let us now turn to the question of the interpretation of the responses to the probability task. Although we observed as predicted that these responses strongly vary with slight changes in the task context, it is important to note that our results replicate the findings observed in the previous studies, with a majority of responses matching the conditional probability P(*C* | *A*). This predominance of conditional probability responses has usually been interpreted as favouring probabilistic theories of the conditional such as the Bayesian approach favoured by Oaksford and Chater (2007, 2009), the suppositional theory of Evans and Over (2004), the conditional event advocated by Fugard et al. (2011) or the probabilistic account proposed by Oberauer and Wilhelm (2003). Because, according to Fugard et al. (2011) analysis and as suggested by our results, a part of conjunctive responses probably result from the same interpretation that underpins conditional responses, it could be argued that a vast majority of adults endorse the conditional event interpretation of the conditional.

However, it is worth noting that the predominant conditional responses observed in the probability task do not necessarily support a probabilistic view of the conditional, because mental model accounts can also provide simple explanations of this response pattern. For example, although Oberauer and Wilhelm (2003) argued that the results of the probability task support a probabilistic theory of the psychological meaning of conditionals, they also noted that a revised mental model theory would be able to account for the observed responses. Evans et al. (2003) argued that the mental models theory (Johnson-Laird, 2001) and its principle of truth cannot incorporate the Ramsey test because this test involves representing *A* & ¬*C* cases. Because the model *A* & ¬*C* corresponds to cases for which the conditional is false, it cannot be part of the representation in the mental model theory. However, Oberauer and Wilhelm (2003) suggested that there is no need to explicitly represent *A* & ¬*C* cases to perform the Ramsey test. An estimate of the conditional probability could be obtained by estimating the frequency of *A* & *C* cases from the initial model and relate it to an estimated frequency of *A* cases using an incomplete model of *A* that disregards the variable *C* (such incomplete models are for example part of the initial representation of the disjunction in Johnson-Laird's mental model theory). In the same way, Oberauer and Wilhelm (2003) suggested that this explanation could account for the conjunctive responses by assuming that participants fail to focus on the *A* cases only and base their estimate on the whole sample.

Barrouillet et al. (2008) and Gauffroy and Barrouillet, 2009 (see also Barrouillet, 2011) proposed a modified version of the mental model theory that accounts for both the conjunctive and conditional responses in the probability task as well as for the frequent shifts from the former to the latter. What the probability task makes clear is that virtually all the participants who produce consistent responses (either conditional or conjunctive) deem the conditional true for *A & C* cases. These cases match the content of the initial model that people construct, according to the mental model theory (Johnson-Laird & Byrne, 1991, 2002), when they understand a conditional sentence. Indeed, this theory assumes that when interpreting an "If A then C" conditional, people construct an initial model representing the co-occurrence of *A* and *C* along with an implicit model indicating that other possibilities do exist, but have not yet been made explicit. The complete representation of the conditional requires a fleshing out of this initial model and the construction of two additional models of the form ¬*A & C* and ¬*A &* ¬*C*. Barrouillet (2011) and Gauffroy and Barrouillet (2009) suggested that the production of the initial *A & C* model depends on a Type 1 heuristic process. Coming spontaneously and automatically to mind, this initial model appears as the core meaning of the conditional, what makes it true. Fleshing out this initial representation and constructing the ¬*A & C* and ¬*A &* ¬*C* models would require the intervention of a Type 2 resource-dependent analytic system. It is assumed that those cases that match the models constructed through fleshing out are not conceived by reasoners as making the conditional true because they do not belong to the initial representation, but at the same time they do not falsify it as *A &* ¬*C* cases do. Consequently, the truth-value of the conditional remains psychologically indeterminate for those cases that match models constructed through fleshing out.

As far as the probability task is concerned, Gauffroy and Barrouillet (2009) assumed that people assess the probability of the conditional by dividing the number of cases that make the conditional true by the number of cases for which the conditional has a determined truth-value. Participants who construct the alternative models ¬*A & C* and ¬*A &* ¬*C* through fleshing out deem the cases that match these models as irrelevant for the truth value of the conditional. Consequently, these reasoners disregard ¬*A* cases and compute the probability of the conditional by dividing the number of cases that make the conditional true (i.e., *A & C*) by the number of cases for which this conditional has a truth-value (i.e., *A & C* and *A &* ¬*C*, these latter falsifying the conditional). This corresponds to the conditional response. Conjunctive responses in adults could result from participants who do not go beyond the automatic heuristic processes. These participants would not flesh out the initial model, remaining with the single *A & C* model. When asked to assess the probability of the conditional, these participants would focus on the *A & C* cases that make the conditional true and calculate the probability to find these cases in the whole sample.

Assuming that conditional responses occur in participants who flesh out the initial model helps us to understand our observation that the grouped presentation induced shifts towards the conditional response, because this way of presenting facilitates the identification of ¬*A* cases that trigger the fleshing out of the initial representation. The tendency to identify relevant and irrelevant cases through fleshing out would be counteracted by the routine of computing chances out of 6 when the problem is framed as a die throw. According to this view, instead of two different interpretations, the conjunctive and conditional responses would reflect two levels of a dual processing, with a conjunctive response supported by heuristic processes and a conditional response resulting from the intervention of analytic processes. Moreover, Barrouillet (2011) favoured a default interventionist approach. This helps understand that the conjunctive response resulting from the default representation often precedes the conditional response which requires the intervention of the analytic system. This explains why shifts from the conjunctive to the conditional responses are far more frequent than the opposite.

Overall, the results of the present study warn us about the fact that the probabilistic truth table task involves a processing step that goes beyond a mere interpretative process of the "if … then" conditional. The requirement to estimate the probability for the conditional to be true "of a card drawn at random from the deck" introduces an undesirable noise in what the task is intended to measure. Thus, it remains uncertain whether this task constitutes a privileged access to how people understand the meaning of conditional sentences, as it appears less informative than the traditional truth table task. It is likely that the use of a task asking for the computation of probabilities has helped in increasing the verisimilitude of the idea that the meaning of the conditional is probabilistic in nature. However, we have shown that these results can be accounted for by the extensional approach favoured by the mental model theory (Barrouillet, 2011; Barrouillet et al., 2008; Gauffroy & Barrouillet, 2009). The fact that simple manipulations can modify the relative frequency of the two main responses usually observed suggests that these responses do not reveal profoundly diverging interpretations. Instead, it appears that these two main responses reflect two different levels of elaboration of a same interpretation. A modified mental models theory accounts for the ease with which some individuals can adopt one type of response or the other.

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