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Guy Politzer, Jean Baratgin

► **To cite this version:**

Guy Politzer, Jean Baratgin. Brief report: What is the chance of winning (or losing) a conditional bet?. BR 1, 2006. <ijn\_00130613>

**HAL Id: ijn\_00130613**

**[https://hal.science/ijn\\_00130613v1](https://hal.science/ijn_00130613v1)**

Submitted on 13 Feb 2007

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**Brief technical report**

What is the chance of winning (or losing) a conditional bet?

Guy Politzer and Jean Baratgin

Institut Jean Nicod

Recent experimental studies have examined lay people's concept of the probability of conditional sentences (Evans, Handley & Over, 2003; Girotto & Johnson-Laird, 2004; Oberauer & Wilhelm, 2003; Over, Hadjichristidis, Evans, Handley, & Sloman, 2007). This question is important because the answer can help evaluate some claims regarding the semantics of conditional sentences made (i) by different authors in philosophical logic (e. g., Stalnaker, 1968; Adams, 1975) and (ii) by the main theories of deductive reasoning (Johnson-Laird & Byrne, 2002 for mental models theory; Brain & O'Brien, 1991, and Rips, 1994 for mental rules; Oaksford, Chater & Larkin, 2000 for the probabilistic approach). These theoretical approaches will not be developed in this brief report. They are expounded in Evans & Over (2004).

The main result of the experiments just mentioned is that when participants are asked the probability that a conditional *if A then C* is true, in the extensional case (e. g., given a pack of cards, *if the card is yellow, then it bears a square*) there are two main answers, namely (i) the conditional probability of the consequent on the antecedent  $\Pr(C/A)$ , and (ii) almost as often, the conjunctive probability  $\Pr(AC)$ ; and in the intensional case (e. g., *if fertility treatment improves then the world population will increase*) only the former answer is observed. The probability of the material conditional,  $\Pr(\text{not-}A \text{ or } B)$ , is hardly ever given.

This result supports the theories that predict the conditional probability response, except for the conjunctive response which requires an explanation. There is one serious problem of comprehension for participants who are asked a question about the probability of the truth of a conditional statement. This is because, on the one hand, supporters of the view that conditionals with false antecedents lack a truth value (e. g. , Adams, 1975) might claim that the question is meaningless and that, consequently, it is re-interpreted in various ways, one of which would give rise to the conjunctive answer; this would take place especially when, as occurs with materials

displaying the logical cases, the AC case is made very salient. On the other hand, there is a possibility that, as claimed by Girotto & Johnson-Laird, in spite of the precautions taken by the investigators, the question is re-interpreted as *if A, what is the probability that C is true*.

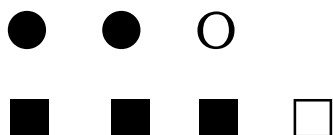
In the present investigation, participants were introduced to a betting situation. Methodologically, this has the advantage that one can replace the somehow awkward and artificial request about "the probability that [the conditional sentence] is true", which may lead to the misunderstanding just mentioned, with a request about "the probability that one wins the bet". In this way, participants should easily represent the probability of the truth of the conditional as the probability of winning the bet. Also, care was taken to keep processing effort in terms of memory or calculation as low as possible. Theoretically, conditional bets were introduced by de Finetti (1938). He distinguished bets that one is only able to win or lose, corresponding to bi-valued events, from conditional bets (*subordinate* in his terminology) corresponding to tri-valued events, whose validity depends on conditions which must be verified. For example, in a race that is to take place tomorrow, the bet on the victory of one of the competitors is of the first type if it is understood that the bet is definitely lost in case this event is not realised, whatever the reason may be; but it is of the second type if it is agreed that the bet is "null and void" in case the race is cancelled or the competitor in question does not participate, etc.

### Participants and method

Participants were 102 first year students of psychology or sports sciences at the University of Aix-Marseille-2. They had not received training in probability theory (except for elementary definitions that some of them had learned in high school). They received a questionnaire (in French) which they answered in small groups. There were three questions, the first two presented in counter-balanced order.

### Instructions and questions

This drawing represents chips.



Pierre chooses a chip at random.

Marie, who has not seen Pierre's choice, says:

***I bet that if the chip is square then it is black***

- 1) What are the chances that Marie wins her bet? (give a numerical value)
- 2) What are the chances that Marie loses her bet? (give a numerical value)
- 3) Suppose Pierre has drawn a round chip: Do you think that Marie has won or lost her bet?

### Results

As the order of the questions had no effect, response frequencies were pooled. These are given in the Table below.

| <u>Response</u> | f         | <u>Betting status of not-A (from question 3)</u> |        |         |
|-----------------|-----------|--|--------|---------|
|                 |           | winning  | losing | neither |
| 3/4, 1/4        | <b>77</b> | 19   | 17     | 41      |
| 3/7, 4/7        | <b>18</b> | 3  | 7      | 8       |
| other           | 7         | 0  | 5      | 2       |
| totals          | 102       | 22   | 29     | 51      |

The conditional probability answer is  $\Pr(\text{win}) = 3/4$ ,  $\Pr(\text{lose}) = 1/4$ . It was given by around 77% of the participants.

The conjunctive response,  $\Pr(\text{win}) = 3/7$ ,  $\Pr(\text{lose}) = 4/7$ , was given by around 18%.

The few remaining responses show a mixture of conditional probability and conjunction (e. g. , 3/4 and 3/7).

### Discussion

The conditional probability response is by far the most frequent, while the conjunctive response is much less frequent than reported by Evans, Handley & Over (2003) and Oberauer & Wilhelm (2003) with abstract materials; however, it has not disappeared.

It is noteworthy that, given the formulation of question 3 in terms of winning or losing, the occurrence of the “neither winning nor losing” response was spontaneous. Moreover, it is the most frequent answer (exactly 50%). Had this option been offered, it is likely that it would have appeared even more often.

For the theories that predict the conditional probability, this response should be linked with the recognition that in case the chip is not square the bet is void, while the conjunctive answer should be linked with the consideration that in that case the bet is lost. There is a corresponding trend in the data but lack of statistical power to conclude with any reliability. Anecdotically, in a pilot group that had an oral debriefing, there was agreement among the conjunctive respondents that if one is to win any money, the chip would have to be square, so that there are only three cases out of seven where one can get some money: In sum, these participants did not consider the not-A case (round chips) as making the bet void, rather this case was viewed as failure to win so that they gave it the same status as the white square. Presumably, in the context of a bet the "voidness" of the not-A case appears more clearly because people are wary of possible unfulfilled conditions for the bet to hold, whereas in a formal artificial situation such cautiousness does not occur.

One could speculate that the betting situation is biased towards winning, so that the not-A case may be considered as failure to win (typically some money) but can hardly count as not losing, except if a scenario was designed to render relevant an escape from losing. One may predict the possibility to observe in this situation a 1/7, 6/7 answer for winning and losing, respectively, because the void bet is now construed as "not-losing", in a similar way as the "not-winning" construal leads to the 3/7, 4/7 answer. In a sense, there is a framing effect in disguise which prevents the 1/7, 6/7 solution to occur.

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