Overview and evaluation of conjunction fallacy

Conjunction fallacy is a well-known cognitive fallacy, happening if the probability of two events simultaneously occur is presumed to be larger than the probability for one single event to happen. This contradicts one of the most fundamental rule in probability theory: a conjunction's probability (P(A and B)) cannot top the probabilities of its constituents (P(A) or P(B)). Because of its ground-breaking implications, conjunction fallacy has been a key topic for debates on the rationality issue (Gigerenzer, 1996; Stein, 1996). Interestingly, some even argue that it might not even be a real fallacy afterall (Hertwig & Gigerenzer, 1999). Surprisingly, after all these years, there is still opportunities for further research due to lack of commonly accepted explanations, exposed by Nilsson, et al.(2009) . The most often-cited illustration of conjuction fallacy, found by Tversky & Kahneman (1983), is the case of Linda, which in this particular paper, we would go into detail. In an instance where Linda was constructed to be representatitive of an active feminist (F) (a 31-year old, outspoken, single, very bright, graduated in Philosophy, etc) and unrepresentative of a bank teller (T), 85% of subjects thought that " Linda is a bank teller and is active in the feminist movement" is more likely to occur than " Linda is a bank teller". This directly contrasted the classical probability theory and can be seen as " content prevailing over form".

In their almost-complete investigation, Tversky & Kahneman proposes several explanations for this abnormaly, including representativeness and availability heuristics. As Rieger (2012) observes, conjunction fallacy typically occurs when one of the conjoint events are much more likely to happen, which works with Linda' case. Because instinct of

representativeness and classic mathematical measurements are completely opposite, the fact that Linda is much more likely to be a feminist clouds the subjects' judgement. In fact, Shafir, et al. (1990) confirmed a positive relationship between the impact of conjunction (including the typicaly) and conjunction fallacy(including the probability). In Linda's case, " typical ratings", a phrase proposed by Shafir, et al (1990) proved to be accurate indicators of the conjunction fallacy effect. However, the representative heuristic does have some flaws: Yates & Carlson (1986) demonstrated that conjuncation fallacy may occur even when the two events are conceptually irrelevant. In fact, Tversky & Kahneman themselves did not advocate representativeness as a general justification for the fallacy effects. Tentori, et al. (2013) added that representativeness explanation have an " informal and fuzzy characterization" and it is not sharp enough to be empirically tested in an accurate manner.

Another competitor to representativeness explanation of conjunction fallacy is the use of averaging models. The more complexing probability combination models, using weighted averaging models, claim that the conjunction probability of two events is made up of convex combination of probabilities of the single events. Meanwhile, the simpler models apply belief strengths, not configural weighting of probabilities. The shortcomings of these models, as pointed out by Tversky and Kahneman themselves, are the inability to accommodate double conjunction errors that were observed and the wrongly forecast that a single conjunction error always occurs, which might not necessarily be the case (Franco, 2009). In my notation, these

probability combination models should be ad hoc adjusted so that they can fit case by case analysis.

With their use of confirmation – theoretic framework approach for conjunction fallacy, Tentori, et al. (2013) proved that a certain perceived degree of confirmation for the added conjunct functions better than its perceived probability as a predictor in the incident and dominance of conjuction fallacy. In their study, it was pointed out that the existance of a conjunction fallacy regarding h1^h2 crucially relies on inductive confirmation in terms of the added conjunct h2. This result is consistently correct in their four experiments, including different experimental design (between and within subjects) and distinct classes of problems (the M–Avs A–B paradigm). Last but not least, they identify a set of confirmation- theoretic basis for conjunction fallacy, indicating a full standing of this cognitive fallacy might be close.

Interestingly, conjunction fallacy has also attracted a certain amount of criticisms in literature, some of them deny the existence of this reasoning fallacy at all. Hertwig, et al. (2001) argued that the word “ probable” can have different meanings and are perceived in different ways. However, when debriefed, subjects do not often defend their answers and object the results on the basis that “ probability” can have an alternative meaning (Crupi, et al., 2008). Instead, they usually admit they made an error in judgement. This might be one of the reason why conjunction fallacy is considered to be a hallmark of cognitive illusions. The word “ and” is also the subject of argument, thought to mislead through “ polysemous” meanings. However, none of these research actually denies the existance of conjunction effect.

Additionally, people’s preferrence of a conjunction over a single conjuct is well-documented under bettings instructions, whereby the mathematical chance of victory is the benchmark for rational behaviour and yet mentioning of the term “ probable” is not even common (Crupi, et al., 2008). Oechssler, et al. (2009) shown with their empirical study that the conjunction fallacy effect was much reduced with those blessed with greater cognitive ability. Cognitive ability was then measured by cognitive reflection test, introduced by Frederick (2005), which confirmed that biases like conjunction fallacy is much more asserted among low cognitive individuals. As Kahneman summarised in his paper, the outcome of the conflict is the result of combination of factors, consisted of nature of evidence, the question’s formulae, the heuristic’s appeal, sophistification of subjects, etc.. The extent to which conjunction rule applies relies on the balance of mentioned factors. Franco (2009) even predicted a reversed conjunction fallacy, where probability of a conjunction is unreasonably inferior to the probabilities of its constituents.

A test of conjunction fallacy is a direct contradiction between intuitive concept against a fundamental law of probability. The equation: $P(a_i)P(b_j \mid a_i) = P(b_j)P(a_i \mid b_j) = P(a_i, b_j)$ (Franco, 2009)is one of the most important in classical probability theory, linking the joint probabilities of A and B to each conditional respective probability. However, conjunction fallacy proves to be a straight violation of the equation, threating the descriptive stature of classical probability in cognitive decision making. The fact that people’s buying the conjunction rule in the abstract form but questioning it in concrete examples is baffling for researchers. On the one

hand, we stand by logical judgements underlying most academic conceptions of probability. On the other hand, we have the natural judgement that dictate our actions and belief. This contrast is expressed with exceptional clarity with the conjunction error. In the past, there used to be a rather subtle relationship between the two perceptions, proved in different fields such as behavior finance (Rieger, 2012).

This is an intriguing issue for which more extensive investigation is required. Time will tell whether we would have a complete understanding of conjunction fallacy's significance for human reasoning.

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