

## REJOINDER

## Differential Framing Effects: 11 More Ways to Study Them

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We appreciate the comments that Mandel and Reyna provided to the target article. Already, the target article discussed a multitude of angles to the framing effect. In their contributions, Mandel and Reyna have highlighted several aspects that may fruitfully be investigated in future studies, we suggest 11 ways to do so. We hope that these future studies will continue to employ formal modeling approaches, as they offer the opportunity to compare theories and make assumptions and interpretations explicit.

*Keywords:* formal models, framing effects, Bayesian hierarchical mixture analysis, development, lexicographic theory

The commentaries on the target article (Huizenga et al., 2023) focus on the importance of meaning (Mandel, 2023) and of gist (Reyna, 2023) in the study of framing effects. Below we elaborate on

how these comments may inspire new questions on differential framing effects related to task, individual, and developmental differences. Moreover, we suggest experimental designs, dependent variables, and modeling approaches to study these new questions. In doing so, we focus on novel ideas (numbered by I1, I2, etc.) and do not repeat suggestions for future work already included in the target article.

Mandel defines strict framing effects as those that occur in problems in which the experimenter can demonstrate that the frames have equivalent meaning. For example, if decision-makers interpret the sure option as a lower bound and not as an exact number, frames do not have equivalent meaning, and thus, the resulting framing effects are not strict framing effects according to Mandel's definition. We agree on the importance of meaning and that it is most interesting to investigate its role in framing effects. However, we are less sure about the necessity to make a distinction between strict and nonstrict framing effects. That

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is, we see meaning as one of several important sources of subjectivity, just as those proposed by cumulative prospect, dual-process, fuzzy-trace, and hybrid theories (CPT, DPT, FTT, HT). In our opinion, accordingly, an interesting scientific task is to determine which of these subjectivity types, including that of meaning, best describe differential framing effects. Thus, instead of treating meaning as separate, we would rather include it among the various potential contributors to framing effects, on an equal theoretical footing as the other mechanisms. Accordingly, the concept of subjective meaning may inspire future studies, as is outlined next.

Mandel, Reyna, and others already showed how one can assess such subjective meaning, see the general discussion of the target article. We see several additional possibilities. First, (I1) one may include various items, and formal modeling of responses to them, to estimate the subjective lower bound interpretation of the sure option, as has been done before for other ambiguous stimuli (Palminteri et al., 2016; Ramotowska et al., 2023; Tymula et al., 2012). Second, (I2) each individual may be probed in an open-ended way for subjective meaning as has been done in other fields (Umanath & Coane, 2020). Third, (I3) it may be considered whether indices derived from functional Magnetic Resonance Imaging or Electro-Encephalography are useful to assess subjective meaning, which has been proven informative in other fields (Blake & Logothetis, 2002; Kilian-Hütten et al., 2011). Given such indices of subjective meaning, it (I4) may be tested whether individual differences in subjective meaning are related to the magnitude of the framing effect. Moreover, it (I5) may be tested whether developmental differences in subjective meaning mediate the typical age-related increase in framing effects. More generally, the comment of Mandel highlights that (I6) it is in every field important to test whether individual and developmental differences are partly due to differences in subjective meaning of instructions or stimuli.

The comment by Reyna contains several important points, of which we highlight two. First, it states that one conclusion from the target article is that “mental representations of the gist of decisions, along with probability of gains, explains most individuals’ preferences.” We agree, although not completely,<sup>1</sup> and would like to stress that the results from the target article

suggest that an absence of a framing effect is due to decision-makers basing their decisions on probability of gains, and not on expected value as was predicted by CPT, DPT, and FTT. Accordingly, the findings from the target article contradict FTT’s prediction of an age-related increase from reliance<sup>2</sup> on “quantitative,” that is, expected-value processing to gist-based processing. The latter insight may (I7) inspire an adapted FTT explanation of differential framing effects in which expected-value processing is replaced by the processing of the single-attribute gain probability. To test this adaptation, one (I8) may go back to data from previous studies and test in individuals that do not exhibit a framing effect whether the percentage of risky choices equaled 50% in both frames (original FTT prediction) or a different, though still frame-invariant, percentage (adapted FTT prediction). Another idea (I9) is to apply the formal modeling procedure of the target article to data from such studies, to determine whether participants could be better described by standard FTT or adapted FTT, or by one of the other theories described in the target article.

The second point is that we assessed whether a theory can describe framing effects, and task, individual, and developmental differences therein, but that we did not assess for all theories whether they included theoretical predictions for each of the differential effects. We agree, but do not see it as problematic. For example, CPT does not include any theoretical prediction of formulation effects, but the clever experiments of Reyna et al. showed that CPT cannot describe these effects, thereby showing that CPT in its current form is not an adequate theory of framing effects. We would like to add that we do see problems in another line of reasoning (which just to avoid any misunderstandings was not brought up in any of the comments), namely that if a theory can

<sup>1</sup> We would reformulate this as: The *absence* of the framing effect is due to decision-makers using a heuristic based on subjective evaluation of the probability of gains. The *presence* of the framing effect is due to decision-makers relying on gist, although only if the difference between sure and risky gain probabilities is low. In addition to that, some decision-makers show a framing effect because they base their decisions on CPT’s subjective utility.

<sup>2</sup> Note that according to FTT, strategies are coded in parallel by all individuals, yet there are age-related differences in reliance on each strategy.

describe effects, it is a good theory. We again take CPT as a case in point: In the target article, we showed that although CPT described 22% of the sample best, the fitted choice patterns were very variable including reverse, no, and regular framing effects. As a good theory constrains possible outcomes (Roberts & Pashler, 2000), this may be taken to suggest that CPT in its current form is not a good theory of the framing effect. It may therefore be worthwhile (I10) to consider whether CPT can be further restricted by constraining the range of its parameters; several approaches can be used to do this in an informed manner (Lee & Vanpaemel, 2018).

Last, we would like to clarify that HT's descriptions are based both on empirical findings and on theoretical considerations. HT states that probability of gains is the first attribute to be considered.<sup>3</sup> There is ample *empirical* evidence for the importance of this probability attribute (see references in the target article). HT also states that if the difference between sure and risky gain probabilities becomes small, decision-makers may consider a second attribute, gist. This will result in framing effects increasing with risky gain probabilities, which we coined the probability effect. The idea that decision-makers consider a second attribute if differences on a first attribute are small is based on *theoretical* predictions derived from Lexicographic Theory. Note, we observed the probability effect in a set of items in which we unconfounded sure versus risky differences in gain probability on the one hand and gain differences and loss differences on the other hand (see Table 2 in the target article). Note, however, that the probability effect was not observed in two studies in which these confounds were not removed (Reyna & Ellis, 1994; Reyna et al., 2011), but where sure versus gain probability differences were unconfounded with the expected value of sure and thus risky options. A new study (I11) including both item sets and formal modeling of these sets separately may test whether similar or different strategies are used to answer these two sets.

To conclude, we appreciate the comments that Mandel and Reyna provided to the target article. Already, the target article discussed a multitude of angles to the framing effect, and in their contributions, Mandel and Reyna have highlighted several additional aspects that may fruitfully be investigated in future studies. We hope that future studies will continue to employ formal modeling

approaches, as they offer the opportunity to compare theories and make assumptions and interpretations explicit.

<sup>3</sup> This attribute is subjectively evaluated, consequently some decision-makers may increase, whereas other may decrease their risky choices with increasing probabilities. See the target article, Supplementary Online Materials, Figure S6, or the individual fits on Open Science Framework (Huizenga et al., n.d.).

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