Risky-choice framing and rational decision-making

Sarah A. Fisher, University of Vienna

David R. Mandel, Defence Research and Development Canada

Corresponding author:

Sarah A. Fisher, sarah.fisher@univie.ac.at

Abstract

This article surveys the latest research on risky-choice framing effects, focusing on the implications for rational decision-making. An influential program of psychological research suggests that people's judgements and decisions depend on the way in which information is presented, or 'framed'. In a central choice paradigm, decision-makers seem to adopt different preferences, and different attitudes to risk, depending on whether the options specify the number of people who will be *saved* or the corresponding number who will *die*. It is standardly assumed that such responses violate a foundational tenet of rational decision-making, known as the principle of description invariance. We discuss recent theoretical and empirical research that challenges the dominant 'irrationalist' narrative. These approaches typically pay close attention to how decision-makers represent decision problems (including their interpretation of numerical quantifiers or predicate choice) and they highlight the need for a more robust characterization of the description invariance principle. We conclude by indicating avenues for future research that could bring us closer to a complete – and potentially rationalizing – explanation of framing effects.

Keywords

Framing effects; Rationality; Risk; Decision-making; Prospect theory; Description invariance; Equivalence.

1. Risky-choice framing

In a seminal study, Tversky and Kahneman (1981) presented experimental participants with the following scenario:

Imagine the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume the exact scientific estimates of the consequences are as follows:

Participants in one experimental condition received the following options:

If Program A is adopted, 200 people will be saved.

If Program B is adopted, there is a one-third probability that 600 people will be saved and a two-thirds probability that no people will be saved.

Participants in the other condition received the following:

If Program C is adopted, 400 people will die.

If Program D is adopted, there is a one-third probability that nobody will die and a two-thirds probability that 600 people will die.

In each condition, participants were then asked which option they would favor.

Tversky and Kahneman found that most participants in the first ('saved') condition favored Program A (with 72% selecting this option). In the second ('die') condition, most participants favored Program D (78%).¹ These results present a puzzle. Programs A and C are standardly taken to describe the *same* sure outcome (200 people saved and 400 dying). Likewise, Programs B and D are taken to describe the *same* risky prospect (a one-third probability of 600 people being saved/ none dying, and a two-thirds probability of 600 dying/ none being saved).

Furthermore, note that *within* each framing condition, the sure and risky options have the same expected value (calculated by multiplying the outcome's payoff by the probability of its occurring). Therefore, by choosing a sure option in the 'saved' condition, over a risky alternative with the same expected value, participants seem to exhibit *risk-aversion*. However, they seem to be *risk-seeking* in the 'die' condition, preferring a risky option to a sure option with the same expected value. How can we explain this apparent shift in preference and risk attitude?

Puzzles like the disease problem raise two kinds of question. A descriptive question is: Why is decision-making sensitive to frame? A normative question is: Should it be? Is it consistent with rational behavior, or does it reveal a flaw in human reasoning about risky choices? It is standardly assumed that framing effects are *inconsistent* with rational decision-making. In particular, they are thought to violate a fundamental tenet of rational choice theory, the principle of description invariance.

¹ See also Kahneman & Tversky (1984) and Tversky & Kahneman (1986). A swathe of subsequent research has produced similar results, as surveyed by Kühberger (1998); Kühberger et al. (1999); Levin et al. (1998); Steiger & Kühberger (2018). Effect sizes vary, and preferences do not always undergo wholesale reversals. However, there is robust evidence of a statistically significant shift in the standard direction, i.e., towards the sure option in the 'saved' condition and the risky option in the 'die' condition (see also Maule, 1989 and Wang, 1996).

2. Description invariance

Whatever else one thinks about the nature of rationality and rational decision-making, it is generally assumed that rational agents must exhibit certain basic forms of consistency. For example, they must not prefer A to B and simultaneously prefer B to A (a requirement known as the transitivity of preferences). The principle of description invariance is another such coherence-based principle. Roughly speaking, it states that rational agents' decisions should be unaffected by how choice options are described. Tversky and Kahneman consider this principle to be "so basic that it is tacitly assumed in the characterization of options rather than explicitly stated as a testable axiom" (1986, p. 253). However, it raises some subtle and complex philosophical issues, which are not always acknowledged in the framing literature (see also Bermúdez, 2009, 2018, 2021).

Note first that the principle is often cast in terms of *extensional equivalence*, concerning how reality must be for alternative descriptions to be true of it. Thus, in the disease problem, the corresponding options in each condition are supposed to describe exactly the same possibilities, i.e., the same numbers of people dying or being saved with the same probabilities (this equivalence assumption will be questioned in §5 but let's grant it for now). In general, though, only suitably *knowledgeable* rational agents can be expected to have identical responses to extensionally equivalent statements. Where agents simply fail to *know* that two statements are extensionally equivalent, this is a failure of knowledge and not of rationality.² Tversky and Kahneman appear to recognize this in elaborating the description invariance principle as follows:

Two characterizations *that the decision maker, on reflection, would view as alternative descriptions of the same problem* should lead to the same choice – even without the benefit of such reflection. (Tversky & Kahneman, 1986, p. 253, emphasis added)

On this understanding, decision-making should be impervious to the use of descriptions that decision-makers take to be extensionally equivalent. That precludes mere ignorance from counting as a violation of description invariance since, in the case of ignorance, the descriptions would *not* be recognized as extensionally equivalent, even on reflection.

A question remains as to whether – and when – rational agents should recognize two descriptions to be extensionally equivalent. In considering what counts as adequate reflection, on the part of decision-makers, Tversky and Kahneman give privileged status to their views when *both* versions of a choice problem have been considered. As Kahneman (2000, p. xv) summarizes:

It is the decision maker who should determine, after due consideration of both problems, whether the differences between them are sufficiently consequential to justify different choices. Violations of this lenient form of invariance demonstrate incoherence without a need for any judgement from on high about what is truly equivalent.

The idea, then, is that decision-makers count as recognizing alternative descriptions to be extensionally equivalent 'on reflection' just if they consider them as such in 'joint presentation' mode. In contrast, framing problems are typically presented to experimental participants in 'separate presentation' mode, i.e., one or other problem is presented or, if both, any connection between them is obscured by intervening material.

² The point is familiar from Frege (1948). See also Sher & McKenzie (2006, p. 469, footnote 2) and Bermúdez (2018, p. 183).

It is not clear, though, whether we should accept that agents' views in joint presentation contexts carry across straightforwardly to separate presentation contexts. Below we will review literature on how decision-makers in separate presentation contexts might rationally view the alternative descriptions as *inequivalent*, in turn justifying their systematically different responses to each (whether or not the agents themselves can access the rationale for their behavior).

To conclude this section, an important task facing philosophers and psychologists is to give an adequate characterization of the description invariance principle. This is unlikely to be a straightforward task and, accordingly, demonstrating that the principle is *violated* when framing effects occur may be harder than previously assumed. Before exploring that idea further, we first introduce the dominant 'irrationalist' account of framing effects.

3. Prospect theory

Tversky and Kahneman develop an explanation of risky-choice framing effects that appeals to two phases of cognitive processing. During an initial 'editing' phase, decision-makers form mental representations of the problem. In principle, editing can encompass a wide variety of processes:

The first phase consists of a preliminary analysis of the decision problem, which frames the effective acts, contingencies, and outcomes. Framing is controlled by the manner in which the choice problem is presented as well as by norms, habits, and expectancies of the decision maker. (Tversky & Kahneman, 1986, p. 257)

In practice, though, Tversky and Kahneman's account of framing effects appeals to a single editing operation: the representation of options as *gains* or *losses*. It is hypothesized that, in the positively-worded 'saved' condition, Programs A and B are represented as *gains* (relative to the worst-case scenario of no-one being saved). In contrast, in the negatively-worded 'die' condition, Programs C and D are represented as *losses* (relative to the best-case scenario of nobody dying). This is despite the fact that, on reflection, decision-makers typically believe the alternative descriptions to describe exactly the same options.

During the subsequent 'evaluation' phase the decision-maker assesses and chooses between options. More specifically:

In the second phase, the framed prospects are evaluated, and the prospect of highest value is selected. (Tversky & Kahneman, 1986, p. 257)

Crucially, Tversky and Kahneman hypothesize that evaluation is sensitive to the prior representation of options as gains or losses. This is because of how prospect theory conceptualizes the value a decision-maker attaches to outcomes. In technical terms, value is a concave function of gains (e.g. winning money or saving lives) and a convex function of losses (e.g. losing money or lives). Due to the shape of this 'value function', people tend to be risk-averse when facing gains, but risk-seeking when facing losses (Kahneman & Tversky, 1979).

According to prospect theory, then, risky-choice framing effects involve a double divergence from standard rational choice theory: first, the representation of options as gains or losses is influenced by superficial differences in how they are described.³ Second, the subsequent evaluation of the options is influenced by whether they have been represented as gains or

³ This first feature distinguishes framing effects from mere 'reflection effects', which concern differential responses to *actual* gains or losses, rather than merely *perceived* gains or losses. See Fagley (1993) for further discussion.

losses. The result is that people make risk-averse choices when the options sound like gains, but risk-seeking choices when the options sound like losses. This produces the classic risky-choice framing effect, which has become the poster-child for irrational decision-making. As Kahneman (2000, p. xv) concludes: “the ubiquity of framing effects demonstrates that the human mind is not assigned to achieve coherence”. His claim has been enormously influential, both within academia and beyond (also taking hold in industry, government, and the wider public consciousness). Its impact in philosophy is particularly evident in recent debates about the reliability of moral intuitions – see, for example, Andow (2016; 2018); Demaree-Cotton (2014); McDonald et al. (2021); Nado (2014); Sinnott-Armstrong (2008).

With the far-reaching implications of the prospect-theoretic account in mind, we will now consider how recent empirical and theoretical research has begun to challenge it.

4. Numerical quantifier interpretation

The question of exactly how decision-makers represent framing problems has come under increased scrutiny in recent years; see Keren (2011); Kühberger (2002); Mandel (2001, 2014); Mandel & Vartanian (2011); Okder (2012); Teigen (2016); Tombu & Mandel (2015). However, even in the early framing literature, it was observed that the sure options in each framing condition of the disease problem are only partially explicated (specifying either the number of people who will be saved, or the number who will die); and it was suggested that participants in each condition might therefore represent the problem in importantly different ways (Berkeley & Humphreys, 1982; Frisch, 1993; Jou et al., 1996; Macdonald, 1986). In this section, we will take a close look at the interpretation of numerical quantifiers (like ‘200’ and ‘400’). In the next section, we will turn to predicate expressions (like ‘saved’ and ‘die’).

One approach to quantifier interpretation is developed and tested by Mandel (2014), drawing on theoretical discussions in philosophy and linguistics, such as Breheny (2008), Carston (1998), Geurts (2006), and Horn (1989), as well as a series of earlier psychological studies by Halberg and Teigen (2009), Teigen (2011), and Teigen & Nikolaisen (2009). Mandel examines the possibility that numerical quantifiers in risky-choice framing problems are interpreted as denoting lower-bounded – minimum – quantities. Thus, Program A would be understood to save *at least* 200 people; and that means fewer than 400 might die. In contrast, Program C could be understood to result in *at least* 400 people dying, meaning that fewer than 200 might be saved. Given these lower-bounded interpretations, Program A offers an objectively better prospect than Program C. This could explain why participants in the ‘saved’ condition have a greater tendency to gravitate towards the sure option than participants in the ‘die’ condition.

Mandel’s experiments suggest that framing effects are indeed driven (at least in part) by lower bounded interpretations of numerical quantifiers.⁴ Importantly, after taking account of participants’ reported interpretations of quantifiers (as lower-bounded, bilateral, or even upper-bounded) most of their subsequent choices proved coherent, reflecting their initial representation of the problem. As Mandel (2014, p. 1193) puts it, “for most people, Options A and C...are descriptions of different events, and not merely re-descriptions of the same event”. Accordingly, participants’ choices may not violate the description invariance principle – at least, not straightforwardly. Those reporting lower-bounded (or upper-bounded) interpretations of the numerical quantifiers arguably did not view the alternative descriptions as extensionally equivalent (describing the *same* problem) but as extensionally inequivalent (describing *different*

⁴ Subsequent studies by Simmons and Nelson (2013) and Chick et al. (2016) suggest that this is unlikely to be the whole story, showing that statistically significant framing effects can arise even under bilateral interpretations of the numerical quantifiers.

problems). On the understanding of the description invariance principle suggested by Tversky and Kahneman, their (ir)rationality will ultimately depend on whether they still consider the problems to be distinct ‘on reflection’. However, as we saw in §2, elaborating and justifying the notion of reflection in play here is likely to prove tricky.⁵

A very different approach to the representation of numerical quantifiers emerges from an account of framing effects based on ‘fuzzy-trace theory’ (FTT). The central claim of FTT is that people simultaneously encode information in precise and ‘gist-like’ ways (Brainerd & Kingma, 1984, 1985). With respect to risky-choice problems, it is argued that the numerical quantifiers activate multiple mental representations, ranging along a continuum of precision (Broniatowski & Reyna, 2018; Chick et al., 2016; Reyna & Brainerd, 1991, 2011; Reyna et al., 2014). At one extreme they are represented precisely (e.g. ‘200’ is represented as ‘exactly 200’). At the other extreme, they are represented in the most gist-like way, merely as ‘some’.⁶

According to FTT, choices are driven by the most gist-like representation compatible with completing the task at hand. As Chick et al. (2016, p. 240) write: “fuzzy-trace theory predicts that individuals base their decision on the lowest level gist representation sufficient to produce a decision”.⁷ In the disease problem, a decision can be produced using the most gist-like representation, ‘some’ (Reyna & Brainerd, 2011, p. 188; Reyna et al., 2014, p. 77). To see why, consider that, in the ‘saved’ condition, this would give us a choice between some people being saved for sure (Program A) and either some or none being saved (Program B). Since an outcome in which some people are saved for sure is preferable to the possibility of none being saved, FTT predicts a preference for Program A. In contrast, in the ‘die’ condition, the choice would be between some people dying for sure (Program C) and either some or none dying (Program D). Here, the possibility of *no* people dying is preferable to the certainty that *some* people will die. Thus, FTT predicts a preference for Program D, in line with the standard framing effect.

Note that framing effects remain irrational on this account. Like Tversky and Kahneman, the fuzzy-trace theorists assume that decision-makers, on reflection, view alternative frames as extensionally equivalent; it is just that cognitive effort is supposedly conserved by operating with gist-like representations rather than precise ones. Thus, framing behavior is taken to violate the principle of description invariance.

Before moving on, note how far we have departed from Tversky and Kahneman’s narrow appeal to the ‘editing’ process, as discussed in §3. The important issue for them was just the representation of options as gains or losses. Decision-makers were nevertheless assumed to interpret the numerical quantifiers as denoting bilateral quantities (consistent either with a precise, “exactly”, reading, or an imprecise, “about”, reading). In contrast, the further empirical research discussed here points to the importance of considering other kinds of editing behaviors decision-makers might perform. Having explored their interpretations of numerical quantifiers, we now consider the effects of predicate choice.

⁵ For related discussion of the rationality of adopting lower bounded interpretations, see Fisher (2020).

⁶ For more on the precise semantics of the gist-like representation ‘some’ in FTT, and the implications of this for the coherence of the account, see Fisher (2021).

⁷ Reyna et al. (2014, p. 77) propose a sequential process:

[T]he decision-making process begins with the simplest qualitative distinctions (a fuzzy-processing preference); decision makers rely on finer distinctions only if the simplest gist representations of the options are identical.

Later developments of FTT suggest that multiple representations are processed simultaneously (Broniatowski & Reyna, 2018).

5. Choice of predicate

As we saw in §3, Tversky and Kahneman took the use of one or other predicate expression ('saved' vs. 'die') to have the effect of making outcomes sound like gains or losses. A more subtle 'explicated valence account' (EVA) is developed by Tombu and Mandel (2015). They suggest that the use of particular complex predicates (e.g. 'saved', 'not saved', 'die', or 'not die') can make options seem positive or negative to varying degrees.

First, it is observed that there are two distinct kinds of valence-based framing manipulations at play in the disease problem. One pertains to the 'root' expression, 'saved' (positive) or 'die' (negative); Mandel (2001) calls this 'descriptor framing'. The other pertains to whether these root expressions are affirmed or negated, to yield predicates that are positive or negative overall; Mandel calls this 'outcome framing' (Mandel, 2001) or 'explicated outcome framing' (Tombu & Mandel, 2015). For example, '400 people will not be saved' has positive descriptor valence (since it includes the word 'saved') but negative outcome valence (since it states how many people will *not* be saved). A single option can also have 'mixed' outcome valence: for example, the risky option in the 'saved' condition of the disease problem states the probability of 600 people being saved (positive outcome valence) *and* the probability of saving none (negative outcome valence). The risky option in the 'die' condition similarly has mixed outcome valence.

According to EVA, decision-makers tend to maximize positive outcome valence. Note how, in the disease problem, the options within each framing condition differ with respect to their outcome valence: in the 'saved condition', the outcome valence of the sure option is wholly positive (specifying only the number of people who will be saved) while, as noted above, the outcome valence of the risky option is mixed. Thus, the account predicts a preference for the (relatively positive) sure option, Program A. Conversely, in the 'die' condition, the outcome valence of the sure option is wholly negative, while the outcome valence of the risky option remains mixed. Here, then, the account predicts a preference for the (relatively positive) risky option, Program D.

Tombu and Mandel (2015) present a series of experimental results that provide further support for EVA. Interestingly, they also find that participants had broadly stable attitudes to *risk* (pace prospect theory); instead, compared to participants encountering the 'saved' frame, those encountering the 'die' frame were significantly more likely to perceive the sure option as carrying *more risk* than the experimenter-defined risky option. This is an important point because Tversky and Kahneman assumed that decision-makers' risk perceptions would align with the experimental definition of greater or lesser risk. As we saw in §3, that assumption grounds the claim that framing effects involve decision-makers oscillating between risk-averse and risk-seeking behavior. The findings of Tombu and Mandel suggest instead that attitudes to perceived risk are more stable than previously thought.

Nevertheless, it is unclear whether it can be rational for decision-makers' initial *perceptions* of risk to vary with outcome valence. After all, if two descriptions are recognized to be extensionally equivalent, describing the same outcome, why should that outcome be understood to carry differing degrees of risk under each description? (One might appeal at this point to an affective component of risk, along the lines proposed by Loewenstein et al. (2001) or Slovic & Peters (2006); one could then raise the related question of why the same outcome should evoke

different affective responses.) This still seems like a potential violation of the description invariance principle.

It might be concluded that the sensitivity of risk perception to superficial differences in linguistic valence cannot be given a rational explanation.⁸ Alternatively, it might be argued that frames with differing outcome valence pragmatically convey distinct information. This idea builds on the work of McKenzie, Sher and others in the related domain of ‘attribute framing’ (Leong et al., 2017; McKenzie & Nelson, 2003; Sher & McKenzie, 2006, 2008, 2011). For example, explicit focus on the number of people who will be saved might convey that the speaker considers the option to be a relatively *good* one, or that it will save relatively *many* people, compared to prior expectations or alternative courses of action. Conversely, focusing on the number of people who will die might convey exactly the opposite.⁹ Decision-makers who infer such information may no longer view the alternatively framed descriptions as informationally equivalent (since each makes different sets of background facts more likely to obtain) even if they view them as extensionally equivalent (being strictly true/ false in the same sets of circumstances). This approach raises questions about how much background information should be taken into account when deciding whether or not alternative descriptions are viewed as descriptions of the same problem; and, relatedly, whether the description invariance principle concerns *informational* or merely *extensional* equivalence.

A potential competitor to EVA is a nascent approach based on ‘query theory’. On this view, outcome valence operates only indirectly on decision-making, by influencing the order in which decision-makers consider arguments for or against the options available to them (Wall et al., 2020).¹⁰ Based on experiments that probe participants’ internal argumentative processes, Wall et al. argue that participants focus on arguments in favor of the option that is framed in the most positive way. For example, in the ‘saved’ frame of the disease problem, participants are expected to consider arguments for the sure option, Program A, earlier and more often relative to the risky option. In the ‘die’ frame it is the other way around, explaining the characteristic pattern of choices. Here too, however, the question would remain as to whether the effect is ultimately amenable to rational explanation, or whether it inevitably violates description invariance.

As we have seen, the renewed focus on editing behaviour discussed in the last two sections takes inspiration from foundational philosophical questions about the nature of meaning and the role of context in communication, while simultaneously bringing these questions into sharper focus. For example: To what extent do alternative frames have the same or different meanings? Which aspects of their meanings should be classified as semantic or pragmatic? And how should we conceptualize norms governing the use and interpretation of frames? These and related questions open up many avenues for further exploration in philosophy, psychology, linguistics, and beyond.

Before concluding, we briefly consider a final – and much more radical – approach to framing effects, which argues for contextual restrictions on the description invariance principle itself.

⁸ Perhaps there is some kind of associative mechanism at work here, along the lines proposed by Levin and others in their explanations of ‘attribute framing’ paradigms (Levin, 1987; Levin & Gaeth, 1988; Levin et al., 1986; Levin, Johnson, Russo, & Deldin, 1985; Levin et al., 1998).

⁹ Clearly, this explanation is only applicable to decision-makers in separate presentation contexts. In joint presentation contexts, the additional information should be blocked on pain of contradiction. For further related discussion, see van Buiten & Keren (2009).

¹⁰ A similar proposal is developed by Gold and List (2004).

6. Scope of description invariance

Bermúdez (2021) argues that the description invariance principle applies only in some contexts. In particular, he identifies a category of ‘ultraintensional contexts’ in which agents can rationally evaluate something differently under different descriptions, even while recognizing these descriptions to be extensionally equivalent.¹¹

Crucially, Bermúdez argues that ultraintensional contexts arise only when alternative descriptions concern distinct dimensions of a complex decision problem. In his central example, inspired by the eponymous Greek play, Agamemnon faces the prospect of sacrificing his daughter, Iphigenia, to the goddess Artemis, in order to save the innocents at Troy.

Agamemnon’s act of killing Iphigenia could be framed as *following Artemis’s will* or as *murdering his daughter*. Each frame brings into play distinct reasons for acting in one way or the other. On this basis, Bermúdez argues that Agamemnon can prefer following Artemis’s will to murdering his daughter, even while recognizing this is one and the same act.

In standard risky-choice paradigms like the disease problem, the alternative descriptions concern only a single dimension, e.g. the lives of the 600 people at risk. Therefore, Bermúdez does not seek to provide a rational explanation of the framing effects that arise in response to this problem. Nevertheless, his approach opens up a new question for theories of rational decision-making to address: in which contexts does the principle of description invariance apply? This is importantly different from the question of what exactly the principle requires, as discussed in §2. As such, it indicates another way of challenging the apparent irrationality of certain kinds of framing effects.

7. Conclusion

It is standardly assumed that risky-choice framing effects involve violation of the rational choice principle of description invariance. In particular, according to prospect theory, decision-makers represent options as gains or losses just because the options are described using positive or negative language; and their decisions end up being risk-averse or risk-seeking as a result. This article has surveyed various theoretical and empirical challenges to this picture. We have considered how decision-makers’ representations of the choice problem could be more complex than is standardly acknowledged; and how their subsequent choices could become amenable to rational explanation. In doing so, we have questioned what the principle of description invariance really requires of rational agents, and whether prototypical experimental tasks like the disease problem enable valid tests of departures from that principle. As we have sought to emphasize, the current state of the field clearly calls for further constructive research, both to clarify the role and content of the description invariance principle, and to develop the theoretical and empirical bases of a robust and comprehensive account of framing effects.

References

- Andow, J. (2016). Reliable but not home free? What framing effects mean for moral intuitions, *Philosophical Psychology*, 29(6), 904–911, doi: 10.1080/09515089.2016.1168794
- Andow, J. (2018). Are Intuitions About Moral Relevance Susceptible to Framing Effects? *Review of Philosophical Psychology*, 9, 115–141. doi: 10.1007/s13164-017-0352-5

¹¹ ‘Ultraintensional’ contexts are thus unlike standard ‘intensional’ contexts, in which the failure of substitutivity of extensionally equivalent descriptions depends on a mere lack of *knowledge*.

- Berkeley, D., & Humphreys, P. (1982). Structuring decision problems and the 'bias heuristic'. *Acta Psychologica*, 50, 201-252. doi:10.1016/0001-6918(82)90042-7
- Bermúdez, J. L. (2009). The second challenge: Individuating outcomes. In J. L. Bermúdez (Ed.), *Decision theory and rationality* (pp. 77-107). Oxford: Oxford University Press.
- Bermúdez, J. L. (2018). Frames, rationality, and self-control. In J. L. Bermúdez (Ed.), *Self-control, decision theory, and rationality* (pp. 179-203). Cambridge: Cambridge University Press.
- Bermúdez, J. L. (2021). *Frame it again: New tools for rational decision-making*. Cambridge: Cambridge University Press.
- Brainerd, C. J., & Kingma, J. (1984). Do children have to remember to reason? A fuzzy-trace theory of transitivity development. *Developmental Review*, 4, 311-377. doi: 10.1016/0273-2297(84)90021-2
- Brainerd, C. J., & Kingma, J. (1985). On the independence of short-term memory and working memory in cognitive development. *Cognitive Psychology*, 17, 210-247. doi: 10.1016/0010-0285(85)90008-8
- Breheny, R. (2008). A New Look at the Semantics and Pragmatics of Numerically Quantified Noun Phrases. *Journal of Semantics*, 25(2), 93-139. doi: 10.1093/jos/ffm016
- Broniatowski, D. A., & Reyna, V. F. (2018). A formal model of fuzzy-trace theory: Variations on framing effects and the Allais paradox. *Decision*, 5(4), 205-252. doi:10.1037/dec0000083
- Carston, R. (1998). Informativeness, relevance and scalar implicature. In R. Carston & S. Uchida (Eds.), *Relevance theory: Applications and implications* (pp. 179-236). Amsterdam: Benjamins.
- Chick, C. F., Reyna, V. F., & Corbin, J. C. (2016). Framing effects are robust to linguistic disambiguation: A critical test of contemporary theory. *Journal of Experimental Psychology: Learning Memory and Cognition*, 42(2), 238-256. doi:10.1037/xlm0000158
- Demaree-Cotton, J. (2016). Do framing effects make moral intuitions unreliable? *Philosophical Psychology*, 29(1), 1-22. doi: 10.1080/09515089.2014.989967
- Fagley, N. S. (1993). A note concerning reflection effects versus framing effects. *Psychological Bulletin*, 113(3), 451-452. doi:10.1037/0033-2909.113.3.451
- Fisher, S. A. (2020). Rationalising framing effects: At least one task for empirically informed philosophy. *Crítica, Revista Hispanoamericana de Filosofía*.
- Fisher, S. A. (2021). Framing effects and fuzzy traces: 'Some' observations.
- Frege, G. (1948). Sense and reference. *The Philosophical Review*, 57, 209-230. doi: 10.2307/2181485
- Frisch, D. (1993). Reasons for framing effects. *Organizational Behavior and Human Decision Processes*, 54(3), 399-429. doi:10.1006/obhd.1993.1017
- Geurts, B. (2006). Take "five": The meaning and use of a number word. In S. Vogelee & L. Tasmowski (Eds.), *Non-definiteness and plurality* (pp. 311-329). Philadelphia, PA: Benjamins.
- Gold, N., & List, C. (2004). Framing as path-dependence. *Economics and Philosophy*, 20, 253-277. doi: 10.1017/S0266267104000203
- Halberg, A.-M., & Teigen, K. H. (2009). Framing of imprecise quantities: When are lower interval bounds preferred to upper bounds? *Journal of Behavioral Decision Making*, 22(5), 490-509. doi:10.1002/bdm.635
- Horn, L. (1989). *A Natural History of Negation*. Chicago: University of Chicago Press.
- Jou, J., Shanteau, J., & Harris, R. J. (1996). An information processing view of framing effects: The role of causal schemas in decision making. *Memory and Cognition*, 24(1), 1-15. doi:10.3758/BF03197268
- Kahneman, D. (2000). Preface. In D. Kahneman & A. Tversky (Eds.), *Choices, values, and frames*. Cambridge: Cambridge University Press.
- Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2), 263-291. doi: 10.2307/1914185
- Kahneman, D., & Tversky, A. (1984). Choices, values, and frames. *American Psychologist*, 39(4), 341-350. doi:10.1037//0003-066X.39.4.341

- Keren, G. (2011). On the definition and possible underpinnings of framing effects: A brief review and a critical evaluation. In G. Keren (Ed.), *Perspectives on framing* (pp. 3-33). Abingdon, Oxfordshire; New York: Psychology Press.
- Kühberger, A. (1998). The influence of framing on risky decisions: A meta-analysis. *Organizational Behavior and Human Decision Processes*, 75(1), 23-55. doi:10.1006/obhd.1998.2781
- Kühberger, A. (2002). The rationality of risky decisions: A changing message. *Theory & Psychology*, 12(4), 427-452. doi:10.1177/0959354302012004293
- Kühberger, A., Schulte-Mecklenbeck, M., & Perner, J. (1999). The effects of framing, reflection, probability, and payoff on risk preference in choice tasks. *Organizational Behavior and Human Decision Processes*, 78(3), 204-231. doi:10.1006/obhd.1999.2830
- Leong, L. M., McKenzie, C. R. M., Sher, S., & Müller-Trede, J. (2017). The role of inference in attribute framing effects. *Journal of Behavioral Decision Making*, 30(5), 1147-1156. doi:10.1002/bdm.2030
- Levin, I. P. (1987). Associative effects of information framing. *Bulletin of the Psychonomic Society*, 25(2), 85-86. doi: 10.3758/BF03330291
- Levin, I. P., & Gaeth, G. J. (1988). How consumers are affected by the framing of attribute info. *Journal of Consumer Research*, 15(3), 374. doi: 10.1086/209174
- Levin, I. P., Johnson, R. D., Deldin, P. J., Carstens, L. M., Cressey, L. J., & Davis, C. R. (1986). Framing effects in decisions with completely and incompletely described alternatives. *Organizational Behavior and Human Decision Processes*, 38, 48-64. doi: 10.1016/0749-5978(86)90025-7
- Levin, I. P., Johnson, R. D., Russo, C. P., & Deldin, P. J. (1985). Framing effects in judgment tasks with varying amounts of information. *Organizational Behavior and Human Decision Processes*, 36, 362-377. doi: 10.1016/0749-5978(85)90005-6
- Levin, I. P., Schneider, S. L., & Gaeth, G. J. (1998). Not all frames are created equal: A typology and critical analysis of framing effects. *Organizational Behavior and Human Decision Processes*, 76(2), 149-188. doi:10.1006/obhd.1998.2804
- Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin*, 127(2), 267-86. doi: 10.1037/0033-2909.127.2.267
- Macdonald, R. R. (1986). Credible conceptions and implausible probabilities. *The British journal of mathematical and statistical psychology*, 39(1), 15-27. doi:10.1111/j.2044-8317.1986.tb00842.x
- Mandel, D. R. (2001). Gain-loss framing and choice: Separating outcome formulations from descriptor formulations. *Organizational Behavior and Human Decision Processes*, 85(1), 56-76. doi:10.1006/obhd.2000.2932
- Mandel, D. R. (2014). Do framing effects reveal irrational choice? *Journal of experimental psychology. General*, 143(3), 1185-1198. doi:10.1037/a0034207
- Mandel, D. R., & Vartanian, O. (2011). Frames, brains, and content domains: Neural and behavioral effects of descriptive context on preferential choice. In O. Vartanian & D. R. Mandel (Eds.), *Neuroscience of decision making* (pp. 45-70). New York: Psychology Press.
- Maule, A. J. (1989). Positive and negative decision frames: A verbal protocol analysis of the Asian Disease problem of Tversky and Kahneman. In H. Montgomery & O. Svenson (Eds.), *Process and structure in human decision making*. Chichester, UK: Wiley.
- McDonald, K., Graves, R., Yin, S., Weese, T., & Sinnott-Armstrong, W. (2021). Valence framing effects on moral judgments: A meta-analysis, *Cognition*, 212, doi: 10.1016/j.cognition.2021.104703.
- McKenzie, C. R. M., & Nelson, J. D. (2003). What a speaker's choice of frame reveals: Reference points, frame selection, and framing effects. *Psychonomic Bulletin & Review: A Journal of the Psychonomic Society, Inc*, 10(3), 596. doi: 10.3758/BF03196520
- Nado, J. (2014). Philosophical Expertise. *Philosophy Compass*, 9, 631-641. doi: 10.1111/phc3.12154

- Okder, H. (2012). The illusion of the framing effect in risky decision making. *Journal of Behavioral Decision Making*, 25(1), 63-73. doi:10.1002/bdm.715
- Reyna, V. F., & Brainerd, C. J. (1991). Fuzzy-trace theory and framing effects in choice: Gist extraction, truncation, and conversion. *Journal of Behavioral Decision Making*, 4(4), 249-262. doi:10.1002/bdm.3960040403
- Reyna, V. F., & Brainerd, C. J. (2011). Dual processes in decision making and developmental neuroscience: A fuzzy-trace model. *Developmental Review*, 31(2), 180-206. doi:10.1016/j.dr.2011.07.004
- Reyna, V. F., Chick, C. F., Corbin, J. C., & Hsia, A. N. (2014). Developmental reversals in risky decision making: Intelligence agents show larger decision biases than college students. *Psychological Science*, 25(1), 76-84. doi:10.1177/0956797613497022
- Sher, S., & McKenzie, C. R. M. (2006). Information leakage from logically equivalent frames. *Cognition*, 101(3), 467-494. doi:10.1016/j.cognition.2005.11.001
- Sher, S., & McKenzie, C. R. M. (2008). Framing effects and rationality. In N. Chater & M. Oaksford (Eds.), *The probabilistic mind: Prospects for Bayesian cognitive science* (pp. 79-96). Oxford: Oxford University Press.
- Sher, S., & McKenzie, C. R. M. (2011). Levels of information: A framing hierarchy. In G. Keren (Ed.), *Perspectives on framing* (pp. 35-63). Abingdon, Oxfordshire; New York: Psychology Press.
- Simmons, J., & Nelson, L. (2013). "Exactly": The most famous framing effect is robust to precise wording. Retrieved from <http://datacolada.org/11>.
- Sinnott-Armstrong, W. (2008). *Framing moral intuitions*. In W. Sinnott-Armstrong (Ed.), *Moral psychology, Vol. 2. The cognitive science of morality: Intuition and diversity* (p. 47-76). Cambridge MA: MIT Press.
- Slovic P., & Peters, E. (2006). Risk Perception and Affect. *Current Directions in Psychological Science*, 15(6), 322-325. doi:[10.1111/j.1467-8721.2006.00461.x](https://doi.org/10.1111/j.1467-8721.2006.00461.x)
- Steiger, A., & Kühberger, A. (2018). A meta-analytic re-appraisal of the framing effect. *Zeitschrift für Psychologie*, 226(1), 45-55. doi:10.1027/2151-2604/a000321
- Teigen, K. H. (2011). When frames meet realities: On the perceived correctness of inaccurate estimates. In G. Keren (Ed.), *Perspectives on framing* (pp. 197-217). Abingdon, Oxfordshire; New York: Psychology Press.
- Teigen, K. H. (2016). Framing of numerical quantities. In G. Keren & G. Wu (Eds.), *The Wiley Blackwell handbook of judgement and decision making* (pp. 568-589). Chichester, UK: John Wiley & Sons, Ltd.
- Teigen, K. H., & Nikolaisen, M. I. (2009). Incorrect estimates and false reports: How framing modifies truth. *Thinking & Reasoning*, 15(3), 268-293. doi:10.1080/13546780903020999
- Tombu, M., & Mandel, D. R. (2015). When does framing influence preferences, risk perceptions, and risk attitudes? The explicated valence account. *Journal of Behavioral Decision Making*, 28(5), 464-476. doi:10.1002/bdm.1863
- Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, 211(4481), 453-458. doi:10.1126/science.7455683
- Tversky, A., & Kahneman, D. (1986). Rational choice and the framing of decisions. *The Journal of Business*, 59(4), S251-S278. Retrieved from <https://www.jstor.org/stable/2352759>
- van Buiten, M., & Keren, G. (2009) Speaker-listener incompatibility: Joint and separate processing in risky choice framing. *Organizational Behavior and Human Decision Processes*, 108, 106-115. doi: 10.1016/j.obhdp.2008.03.002
- Wang, X. T. (1996). Framing effects: Dynamics and task domains. *Organizational Behavior and Human Decision Processes*, 68, 145-157. 10.1006/obhd.1996.0095