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Frames, Brains, and Content Domains:

Neural and Behavioral Effects of Descriptive Context on Preferential Choice

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At 7:51 a.m. on Friday, January 12, 2007, a man wearing jeans, a long-sleeve T-shirt, and a Washington Nationals baseball cap began to play his violin at the L'Enfant Plaza metro station in Washington D.C. Over the next 43 minutes that he played, 1,097 people passed him by. Among them, only seven stopped to listen for at least a minute. Twenty-seven gave him money, most without breaking their pace, for a grand total of \$32 and change. Only one person, who gave the man \$20—more than half of what he earned—realized that the “fiddler” was Joshua Bell, one of the world’s most celebrated musicians, who had just played six timeless pieces of music on a violin handcrafted by Stradivari in 1713 and worth an estimated 3.5 million dollars. Two days earlier, Bell had performed at a theater in Boston where merely pretty good seats sold for \$100. This study organized by *The Washington Post* (Weingarten, April 8, 2007) poignantly illustrates the importance of context on subjective valuation. As Weingarten put it, “He [Bell] was, in short, art without a frame.” The Bell demonstration, of course, was not designed to carefully disentangle the possible causal determinants of people’s ostensible indifference toward beauty in a mundane environment, but rather to conjure in our minds the idea that, in two disparate contexts, the *same* man playing the *same* music on the *same* exquisite instrument could be valued and treated so differently.

The argument that context matters hence presupposes that there are certain fundamental similarities to the contrasted events in question that do not change and, moreover, that the attributes that do change are in some sense more superficial than the invariants—sufficiently superficial as not to invalidate the comparison. As we shall see, this notion is fundamental to decision research on the effects of framing and content on judgment and choice. Those features we regard as central and invariant form the so-called

deep structure of an event or problem, whereas those that reflect peripheral or circumstantial features form the so-called *surface structure* (Wagenaar, Keren, & Lichtenstein, 1988). The fact that context does matter is therefore of interest precisely because, for so long, decision theorists had presupposed that it should and would not matter. In this chapter, we extend earlier discussions of this topic both from an analytic perspective and from an empirical perspective, which in the latter case we do by introducing recent behavioral and neuroscientific findings on the effect of two types of contextual factors—namely, framing and content—on judgment and decision making.

Our focus on context is closely related to earlier discussions of content effects on decision making (e.g., Goldstein & Weber, 1997; Rettinger & Hastie, 2001; Wagenaar et al., 1988), but is both broader in the sense that it permits discussion of other effects, such as framing, which we do not, strictly speaking, regard as content effects (cf. Goldstein & Weber, 1997). Our focus also reflects a slightly different centering of intellectual priorities. That is, discussions of content effects in the decision-making literature arise primarily in response to the domain-independent view of decision making captured by early ideas and theories about decision making that had largely set the course for later empirical studies (e.g., Bernoulli, 1738/1954; Savage, 1954; von Neumann & Morgenstern, 1947). In the classical view, all decisions could essentially be represented by a gambling metaphor with only two pertinent variables—degrees of value and degrees of belief—whose product expressed the (subjective) expected utility (or worth) of the gamble. The currency of the gamble (e.g., money earned, lives saved, territory acquired, etc.) was believed to be of no particular consequence, at least not in terms of affecting the process by which decisions were made (Goldstein & Weber, 1997). In other words, the

semantic content of a decision-making problem was treated as immaterial. Theoretical discussions of the importance of content in decision-making problems have thus focused on the incompleteness of the classical view, which given its tenets could not account for more recently revealed content effects.

Our interest in context in contradistinction to content *per se* focuses largely on the discriminative judgment process required to assign certain aspects of a problem or event to its deep structure and other aspects to its surface structure. Within this discussion we treat content effects as an example of the context-dependent nature of judgment and decision making, but it is important to clearly articulate the sense in which we consider variations in content as an example of contextual change. *The New Oxford Dictionary of English* defines *context* as “the circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood and assessed” (2001, p. 396). According to this definition, contextual factors are circumstantial. At first blush, then, one might wonder why the content of a problem would be treated as a contextual factor since it is by no means evident that the former is merely a circumstantial factor. Indeed, the content might seem to constitute a central part of what any given problem is about. For instance, a decision about how to save 600 lives at stake might seem fundamentally (and not merely circumstantially) different than a decision about how to save 600 dollars at risk of being lost. Indeed, one might, quite reasonably, claim that a comparison of the two problems is a classic case of comparing apples to oranges.

To understand why content variations such as these may be regarded as instances of contextual variation, we must on the one hand consider the distinction between deep and surface features and on the other hand consider the theoretical tenets of the domain-

independent view of decision making articulated by the classical theorists. As noted earlier, such theorists viewed all decision problems as reducible to gambles whose currency represents a surface feature of the problem. From this theoretical perspective, content variations *are* circumstantial (i.e., contextual) precisely because they do not—indeed, could not within those theoretical frames—alter the deep-structure representation of the problem. That is, from the perspective of classical decision theory, if the abstract representation of a problem matches another, the comparison is indeed between apple and apple and not apple and orange. Thus, content effects are instances of context effects not in some absolute sense but rather in relation to a particular theoretical and representational vantage point—almost always defined by the researcher in behavioral decision research.

We shall return to a discussion of content effects on decision making later in the chapter. However, we first turn our attention to an “intermediate” type of context effect—*framing*, which refers to the manner in which options, acts, or outcomes are described. Like content effects, framing effects are precluded from playing a meaningful role in classical decision theories, but unlike content effects, they are predicted by Kahneman and Tversky’s (1979) influential *prospect theory* to systematically influence decision making. The demonstration of framing effects on choice has played an important role in the debate over the rationality of human decision making, with evidence of such effects usually interpreted as indications that rational choice is quite predictably violated (Stanovich & West, 2000; Tversky & Kahneman, 1981). Although we do not dispute the claim that framing may sometimes have powerful influences on decision making, and that some of those influences may be difficult to justify as rational, we also believe that it

is important to assess those claims carefully. An important part of that task brings us back to the question of how people—including theorists who study framing effects—discriminate deep versus surface structure in decision-making problems.

Finally, to orient the reader, we should note that both sections of the chapter that follow are bounded by two foci. First, we are concerned here with context effects that are descriptive in nature. The studies we review and consider involve manipulations of context that are embedded in linguistic descriptions. In some cases these descriptions pertain to the manner in which options are formulated, while in other cases they pertain to the cover story that establishes the domain in which the decision task “takes place.” There are of course many other ways in which context could be manipulated, such as through changes to actual location (as in our opening example), changes to circumstantial aspects of auditory or visual stimuli, or manipulation of fortuitous “priming” stimuli that are either subliminal or supraliminal, but these topics remain beyond the scope of this chapter. Second, we are concerned here with the effect of context on decision making involving preferential choice under conditions of risk or uncertainty. Once again, there are other areas of research that could have been reviewed. For instance, there is a vast literature on the effect of content on reasoning (Evans, Newstead, & Byrne, 1993), which may alternatively be construed as decisions about the epistemic status of propositions. Our aim here, however, is to build more directly on past work on the effect of descriptive context on preferential or value-based choice (e.g., Goldstein & Weber, 1997; Rettinger & Hastie, 2001; Wagenaar et al., 1988), drawing in a discussion of recent neuroscientific research that sheds new light on the topic.

Framing effects and prospect theory: A foot in the door for context

Like its predecessors, prospect theory is currency neutral, making no positive predictions about potential content effects. However, unlike its predecessors, prospect theory does selectively open the door to context effects by making predictions about the effect of “decision frames” on choice. Tversky and Kahneman (1981) originally conceived of frames as being partly the result of how aspects of a decision problem are described and partly the result of how a decision maker mentally represents those aspects. For instance, optimists, by virtue of their disposition, tend to frame situations involving mixed outcomes (i.e., some good and some bad) as instances of the glass being half full, whereas pessimists would tend to see the same situations in terms of the glass being half empty. However, since dispositions are not subject to experimental manipulation, subsequent research focused on the manner in which information could alternatively be described. For instance, a food product comprised of 10% fat and 90% other non-fat ingredients could be described as “10% fat” or “90% fat-free.” Although the descriptions change, the deep structure presumably does not. That is, both frames denote the same thing, and one should be able from either description to easily infer its counterpart. If you know that the food you are eating is 10% fat you should also know that it is 90% fat free. One frame implies the other.

Rational theories of choice, which subsume the classical decision theories, do not permit surface features of problems, such as the way in which events are formulated, to influence choice. Indeed, the principle of descriptive invariance (Kahneman & Tversky, 1984) states that alternative formulations of the same events should be treated by decision

makers in precisely the same manner if their decisions are to be regarded as internally consistent, coherent, or rational. While prospect theory did not challenge the normative status of the invariance principle, it did offer new predictions regarding how framing would systematically influence choices. An important basis for the prediction is the theory's assumption that the values of prospects (namely, options) are evaluated relative to subjective reference points. Positive changes from the reference point (e.g., current wealth) are coded as gains and negative ones as losses.

The theory further posits that subjective value is a concave function of currency value in the gains domain and a relatively steeper convex function of currency value in the losses domain, giving rise to the well-known S-shaped value function. An important implication of this proposed psychophysical function is that decision makers will tend towards risk aversion in the gains domain and towards risk seeking in the losses domain. For instance, it leads to the prediction that a \$200 gain for sure should be favored more than a 1/3 chance of a \$600 gain (people would prefer the sure thing), whereas a \$200 loss would be disliked more than a 1/3 chance of a \$600 loss. Moreover, in decision-making problems involving mixed outcomes—namely, those comprised of a combination of gains and losses—the frame invoked is proposed to influence the reference point brought to mind in the decision maker.

To illustrate this prediction, consider Tversky and Kahneman's (1981) well-known Asian Disease Problem (ADP). Participants were presented with the following cover story:

Imagine that the US 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 that the exact scientific estimate of the consequences of the program are [sic] as follows:

In the gain-frame condition, participants were asked to choose between the following prospects:

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

If Program B is adopted, there is a $1/3$ probability 600 people will be saved, and $2/3$ probability that no people will be saved.

In comparison, in the loss-frame condition, participants were asked to choose between the following prospects:

If Program C is adopted, 400 people will die.

If Program D is adopted, there is a $1/3$ probability that nobody will die, and $2/3$ probability that 600 people will die.

When the options were framed in terms of lives saved (i.e., gains), 72% chose the certain option (Program A). However, when the options were framed in terms of deaths (i.e., losses), 78% chose the risky option (Program D). Meta-analyses (Kühberger, 1998; Kühberger, Schulte-Mecklenbeck, & Perner, 1999) have indicated that Tversky and Kahneman's (1981) framing effect is greater in magnitude than the mean effect size across other ADP-type studies. Nevertheless, on average, the effect of framing is of moderate magnitude. The effect, therefore, is clearly replicable and, in that sense, "real."

According to Tversky and Kahneman, the alternative frames of the two prospects are like different visual perspectives of the same scene. In the case of the ADP, the gain frame is proposed to bring to mind a reference point of zero lives saved, from which the sure 200 is more attractive than the $1/3$ chance of 600. In contrast, the loss frame is

proposed to bring to mind a reference point of zero lives lost, from which a sure loss of 400 is more painful than a $2/3$ chance of losing all 600.

Importantly, though, most theorists have accepted the argument that the deep structure of the problem is identical under the two framing conditions. Kahneman and Tversky (1984) in fact claimed that "it is easy to verify that options C and D in Problem 2 are undistinguishable in real terms from options A and B in Problem 1, respectively" (p. 343) and, hence, "the failure of invariance is both pervasive and robust" (p. 343). Although Tversky and Kahneman claimed that the descriptive equivalence of the two sets of options was easily verifiable, it is difficult to see how such verification could be offered. Indeed, no more than an appeal to the reader's intuition was ever offered. Nor does the empirical evidence indicate that people realize the extensional equivalence of the reframed options. Using an ADP isomorph, Mandel (2001) asked participants whether they agreed that the certain option implied the complementary expected outcome that Tversky and Kahneman (1981) proposed (e.g., whether 200 lives saved implied 400 lives lost). Roughly a third of the sample—36 percent for the certain option and 32 percent for the risky option—did not agree with this interpretation.

The descriptive equivalence assumption is also questionable because of an important confound in the experiment—namely, the certain option is always more ambiguous than the risky option it is paired with due to missing information (Kühberger, 1995; Mandel, 2001). With option A, there are 400 lives about which participants are told nothing; with option C, there are 200 such cases. In contrast, participants are informed of all possible outcomes and their associated probabilities in options B and D. A plausible effect of asymmetric ambiguity might be to increase the likelihood of interpreting the

certain option to mean that *at least* 200 will be saved under the gain frame and *at least* 400 will die under the loss frame. Consistent with this hypothesis, Berkeley and Humphreys (1982) noted that option A seems to connote a much stronger sense of agency than option C, which would support the “at least” interpretation of the expected outcomes. Moreover, Macdonald (1986; see also Jou, Shanteau, & Harris, 1996) proposed that people tend to automatically qualify statements about numeric quantity with the modifiers “at least” or “or more.”

If options A and C are interpreted as minimum values and options B and D are interpreted as precise values, then it would be utility maximizing—and quite rational by normative standards—to choose the certain option under the gain frame and the risky option under the loss frame. Two approaches have been used to examine this asymmetric-ambiguity account. First, Kühberger (1995) used an additive method in which the asymmetry in option ambiguity was eliminated by including the missing information in the certain options. Second, Mandel (2001) used a subtractive method in which the asymmetry was eliminated by deleting the second proposition from the risky options. Both investigators replicated the framing effect when the original descriptions of the options were used, but importantly both also demonstrated that the framing effect was eliminated when ambiguity across options was properly controlled.

Mandel (2009) recently conducted a more direct test in which the asymmetry in prospect ambiguity was systematically manipulated independent of gain-loss framing. Replicating Kühberger (1995), the framing effect predicted by prospect theory was found when the sure option was missing information but eliminated when the missing information was provided (see Fig. 1). Importantly, and contrary to the prediction of

prospect theory, a reverse framing effect was found when—contrary to the standard version of the ADP—the sure option had the missing information supplied and the risky option was missing information (see Fig. 1). That is, in the reverse-asymmetry condition, participants in the gain-frame condition were presented with the prospects:

If Program A is adopted, 200 people will be saved and 400 people will not be saved.

If Program B is adopted, there is a $1/3$ probability 600 people will be saved.

And, participants in the loss-frame condition were presented with the prospects:

If Program C is adopted, 400 people will die and 200 people will not die.

If Program D is adopted, there is a $2/3$ probability that 600 people will die.

Under these conditions, participants were actually *more* risk seeking in the gain-frame condition than in the loss-frame condition.

We propose that these findings support a conversational account of framing effects in which the missing information in the description of a prospect invites the interpretation “at least N ” for quantities that are not set at the limit within the context of the problem. Thus, in the reversed-asymmetry condition, the risky option in the gain-frame condition may be read as “there is *at least* a $1/3$ probability that 600 people will be saved,” whereas the risky option in the loss-frame condition may be read as “there is *at least* a $2/3$ probability that 600 people will die.” We suspect that the conversational implicatures drawn represent attempts to resolve linguistic ambiguities in light of the available contextual cues and the representations they evoke, on the one hand, and knowledge of conversational norms, on the other hand.

In terms of the latter, it is normative to be brief and, of course, also to be relevant in communication (Grice, 1975). These injunctions or “maxims,” as Grice called them, can sometime require tradeoffs and/or clever solutions that affect judgment and decision making (Hilton & Slugoski, 2000). For instance, if 200 lives saved implies 400 deaths too, it would be redundant to say both. The Gricean maxim of being brief would dictate truncation to one expression or the other (Reyna & Brainerd, 1991). However, given the uncertain context of the ADP (i.e., emergency response plans to deal with a forecasted epidemic), it might also add value to the communication to choose a frame that in some sense conveyed the anticipated direction or propensity of outcome as part of the subtext, and this would be in keeping with Grice’s *principle of cooperation*, whereby interlocutors structure their utterances to be meaningful, relevant, yet concise. Choosing a gain frame might therefore subtly convey a trend towards saving lives or, as Berkeley and Humphreys (1982) put it, a greater sense of agency, while a loss frame might alternatively convey a trend towards losing lives and having little control. Thus, listeners might be inclined to treat the frame as non-arbitrary but rather chosen for its relevance, with gain framing signaling that *at least* the number specified would be saved, and with loss framing alternatively signaling that *at least* a certain number would die.

The conversational account thus acknowledges that the question of whether two descriptions are perceived as extensionally equivalent by decision makers is an empirical issue. Most research on framing has accepted the theorists’ representation of the problem as valid and, moreover, has assumed that the subject’s performance can be interpreted in relation to that representation as if it were his or her own. By comparison, our view is that in order to define an effect of description on judgment or choice as a strict framing effect

(or what Kahneman & Tversky, 1984, called *formulation effects*) it is incumbent on researchers to show that the subject regards the alternative descriptions as essentially the same. To the extent that the alternative descriptions are not regarded as such, then whatever effect may have been shown does not properly constitute an instance of framing and should not be described as such. One might still question the soundness of an individual's interpretation of the relevant statements. However, that is quite different than claiming that alternative frames can produce incoherence in judgment or choice, and the normative basis of such critiques would be considerably weaker.

The conversational account also implies that other contextual factors, such as content effects, will moderate the effect of alternative descriptions on judgment and choice because conversational implicatures will be drawn in light of such features, which serve as stimuli for constructing representations of events, acts, and contingencies under conditions of interpretational uncertainty. Consistent with Beach's (1990) image theory, we propose that these representations go beyond the mere initial editing of problem features as prospect theory proposes, and will usually trigger considerations of social norms, moral principles, and goals that are appropriate in light of these considerations. Indeed, Wagenaar et al. (1988) have shown that framing manipulations within decision-making problems having the same purported deep structure nevertheless elicit different effects that depend on a complex interaction of content, perspective, and action-inaction effects, for which prospect theory, like earlier psychophysical models based on the gambling metaphor, cannot account.

At present, there are no specific neuroscientific tests of the pragmatic account of framing that we advance here. However, there is much known about the neuroscience of

language comprehension that can guide future research. For instance, considerable evidence demonstrates that the left hemisphere is sufficient for information processing when the task is symbolic and its relevant features are available for extraction. This has led Gazzaniga (1989, 2000) to propose his influential “left hemisphere interpreter” hypothesis, according to which the left hemisphere is viewed to be dominant for inference making. However, recent evidence suggests that the right hemisphere is engaged when the problem space is underdetermined, allowing for interpretational uncertainty (Goel, Stollstorff, Nakic, Knutson, & Grafman, in press; Goel et al., 2007). If the framing effect in ADP-type problems is a function of conversational implicatures, one might expect to find the right hemisphere playing an important role in this task.

Specifically, on the basis of the research just cited, we would predict that deliberation in the ADP-type problems would result in more right hemisphere activation when the prospects were worded using Mandel’s (2001) subtractive method in which there was missing information than using Kühberger’s (1995) additive method in which the missing information was filled in for both prospects. Moreover, we would predict that “framing effects” in ADP-type problems would be attenuated in persons with right hemispheric lesions that impede their ability to draw conversational implicatures.

An alternative hypothesis is suggested by Pylkkanen and McElree’s (2007) magnetoencephalography (MEG) study, which found that coercing a meaning out of ambiguous sentences such as “The journalist *began* the article before his coffee break.” activates the ventromedial prefrontal cortex (VMPFC), whereas doing so for less ambiguous sentences such as “The journalist *wrote* the article before his coffee break.” does not activate this region. The VMPFC has been implicated in social cognition

(Damasio & Van Hoesen, 1983; Gallagher & Frith, 2003), and Pylkkanen and McElree's (2007) findings suggest that resolution of ambiguity involving human agents activates this region. Thus, we might expect a similar pattern of activation in ADP-type problems where the prospects that imply some form of human agency are relatively ambiguous.

Although such neuroscientific hypothesis tests await future research, there has been one neuroscientific study that has directly examined the framing effect. De Martino, Kumaran, Seymour, and Dolan (2006) investigated the neural underpinnings of the framing effect using functional Magnetic Resonance Imaging (fMRI). On each task trial, subjects were shown a message indicating the amount of money that they would initially receive (e.g., "You receive £50"). Subjects then had to choose between a sure option and a risky option. In gain-frame trials, the sure option was formulated as the amount of money kept from the initial amount (e.g., keep £20); whereas in loss-frame trials, the sure option was formulated as the amount lost from the initial amount (e.g., lose £30). The risky option was always represented as a pie chart depicting a 40% chance of keeping the full amount and a 60% chance of losing the full amount.

Analysis of the behavioral results revealed that subjects were risk averse in the gain frame and risk seeking in the loss frame, as predicted by prospect theory. At the neural level, bilateral amygdala activation was significantly greater on trials where subjects made "frame-congruent" choices (i.e., choosing the sure option in the gain frame and the risky option in the loss frame) than on trials where they made frame-incongruent choices (i.e., choosing the risky option in the gain frame and the sure option in the loss frame). By contrast, frame-incongruent choices produced significantly greater activation in the anterior cingulate cortex (ACC). Finally, significant negative correlations were

found between the degree to which subjects were susceptible to the framing effect and activation in right orbitofrontal cortex (R-OFC) ($r = -0.8$) and also the VMPFC ($r = -.75$).

Whereas the amygdala is involved in emotional processing and reward-related learning (LeDoux, 1996; see also O'Doherty, current volume; Pizzagalli, Dillon, Bogdan, & Holmes, current volume), the ACC is involved in cognitive conflict and error monitoring (van Veen & Carter, 1996). As De Martino et al. propose (see also Kahneman & Frederick, 2007), the greater activation of the amygdala in frame-congruent choices and of the ACC in frame-incongruent choices indicates opponency between two neural systems. Specifically, their findings suggest that ACC activation on frame-incongruent choices reflects the detection of conflict between response tendencies based on an emotional system and an analytic system. The observed correlations between susceptibility to the framing effect and regions of the orbital and medial prefrontal cortex (OMPFC), but not the amygdala per se, further suggest that susceptibility to framing is not merely due to a more emotional response, but rather to how emotional cues provided by the amygdala are integrated into a mental representation of the alternatives. Furthermore, the OMPFC and amygdala are known to have strong reciprocal connections, with the former playing a key role in the representation of emotional stimuli necessary for the predictive value of outcomes to be properly assessed (Dolan, 2007). The notion that violations of normative principles such as descriptive invariance are attributable to activation of neural regions that play a role in the representation of value may lend support to recent cognitive accounts that emphasize the role of outcome representations in the manifestation of such biases (Mandel, 2008).

Of course, in light of our earlier discussion of the role of conversational implicature in the manifestation of framing effects, it is fair to ask whether the alternative frames in De Martino et al.'s (2006) study share the same deep structure. That is, did subjects understand the sure prospect in the gain frame to mean *precisely* £20 of the initial £50 would be kept and, conversely, did they understand that prospect in the loss frame to mean *precisely* £30 of the initial £50 would be lost? Notwithstanding the findings of past research that cast doubt on the equivalence of frames in ADP-type problems (e.g., Kuhberger, 1995; Mandel, 2001, 2009), we suspected that in the context of De Martino's et al.'s study the majority of subjects would regard these frames as equal in meaning. That is, they would interpret the quantities as exact values rather than minimum values (e.g., "at least £20 would be kept"). Unlike the ADP, the game-show-like context used in De Martino et al.'s study is consistent with drawing an implicature that the values are precise and under the full control of whoever is responsible for establishing the "game."

We put this hypothesis to the test, asking 21 subjects to choose an option in the gain frame and in the loss frame (with the order of frames counterbalanced across subjects). After each choice, we also asked subjects to indicate whether they thought the sure option (i.e., "Keep £20" or "Lose £30") meant (a) "keep/lose at least N ," "keep/lose precisely N ," or "keep/lose at most N ." The two versions of the problem were presented on separate pages. As predicted, we found that 17 (81%) indicated "precisely" in both frames. We also found that 16 of these 17 subjects (94%) showed no framing effect. Specifically, 50% chose the sure option in both conditions and the other 50% chose the risky option in both conditions. These findings are consistent with the earlier

conversational account we proposed and the findings of Mandel (2009), in particular. Of course, it is unclear why our findings and De Martino et al.'s differ. It is possible that the difference in the effect of framing across these two studies is owing to differences in characteristics of the samples. About half of our subjects had a graduate degree in the sciences, though none claimed to recognize the aim of the task.

Thus, it remains a lingering question whether De Martino et al.'s (2006) subjects who demonstrated a framing effect tended to interpret the values presented in the sure option as precise values or lower bounds. Answering this question is important in order to clarify the descriptive and prescriptive implications of their findings. For instance, if their subjects who exhibited a framing effect tended to interpret the value expressed in the sure option as a lower bound, then the activation of the amygdala would not be in response to merely descriptive attributes of mixed outcomes that are fundamentally the same but rather to the coding of distinct outcomes that do indeed vary in reward value (i.e., losing at least £30 is objectively worse than keeping at least £20). Moreover, "inconsistent" preferences under such circumstances would be quite rational—arguably more rational than ostensibly consistent choices would be. An intriguing hypothesis is that activation of OMPFC would not only predict susceptibility to framing, but also a tendency to interpret the values presented as precise values rather than upper or lower bounds. This hypothesis is consistent with our current understanding of OMPFC's role in representing value-laden stimuli. It is also consistent with Pylkkanen and McElree's (2007) findings that the VMPFC is activated in problems requiring the interpretation of ambiguous agentic actions.

As the title of this section suggests, prospect theory offered a foot in the door for context to influence decision making. However, the manner in which framing was proposed to influence decision making was highly constrained, following mainly from purported psychophysical properties of valuation (and, though not discussed here, also psychophysical properties of decision weighting). Recent behavioral findings indicate a much broader role of context, and also call into question some of the most fundamental assumptions underlying the literature on framing. These findings suggest that alternative descriptions thought to share the same deep structure may be perceived as having different deep structures by a significant proportion of individuals. In instances where such is the case, one might wonder whether it is even appropriate to call the variations in description “contextual” factors since they apparently do change something fundamental about the target of evaluation, and not merely its circumstantial features.

Yet, the conversational account proposed here also suggests that contextual information in conjunction with pragmatic conversational inferences plays a key role in the resolution of ambiguity, and that it is precisely this process of resolving ambiguity that leads to the perceived differences in deep structure, which in turn shape the nature of choices. That contextual information appears to draw heavily on the *content* of decision problems, from which inferences that help shape representations of acts, outcomes, and contingencies may be drawn. Accordingly, we now turn our attention directly to the effect of content on decision-making processes.

Content effects on decision processes: Context moves center stage

Given its longstanding commitment to psychophysical models of choice that assumed context independence, behavioral decision theory has been slow to appreciate

the significance of content effects on decision processes. As Goldstein and Weber (1997) describe, the field can be characterized as having gone through a series of stages whereby, with each transition, its awareness of the significance of content has been progressively broadened. In the first stage, behavior was thought to be content independent. In the second stage, it was occasionally acknowledged that behavior was content-dependent but the reasons for such effects were thought to be of little or no theoretical interest. In the third stage, behavior was thought to be content-dependent for reasons that are somewhat interesting but still not a core part of theory. And, finally, in the fourth stage, context-dependence is seen as central to theory and as something that cannot be ignored without incurring a severe loss of explanatory completeness.

An important insight prompting the shift to the last stage was that content effects not only affected decision outcomes, they also had predictable effects on the selection of decision strategies (e.g., Goldstein & Weber, 1997). For example, Rettinger and Hastie (2001) found that among decision problems that had the same formal characteristics but different content not only did risk attitudes vary, but the type of strategy invoked in order to arrive at a choice also varied by content. For instance, subjects' process reports revealed that a decision problem set in a legal context was much more likely to rely on narrative strategies than a decision problem set in a monetary gambling context. Notably, these differences in risk tolerance and decision strategy emerged even though content did not have an effect on the subjective values of the option being considered. Thus, the effect of content on decision strategy could not be attributed to changes in valuation.

Variations in content can also affect decisions by changing people's perspectives on what their decisions are fundamentally about. For instance, Mandel (2006) showed

that, whereas the endowment effect (i.e., the tendency to sell a commodity in one's possession for more than one would be willing to pay to purchase it; e.g., see Kahneman, Knetsch, & Thaler, 1990) was evident in a case described in a purely economic context (namely, between you and a second-hand CD dealer), when the context was changed such that the other person was described as an acquaintance the endowment effect was eliminated, and when the other individual was described as a friend the endowment effect was actually reversed, contrary to the prediction of prospect theory. Mandel (2006) proposed that the relational context of the exchange changed the social norms that subjects judged as applicable under the circumstances. With acquaintances, reciprocity or fairness is likely to be perceived as normative, leading to pressures for equality in buying and selling offers. With friends, by comparison, generosity is more likely to be viewed as normative, especially for sellers, leading to selling offers that are lower than buying offers (i.e., a reversal of the endowment effect).

In a recent fMRI study, we (Vartanian, Mandel, & Duncan, 2009) examined how changes in descriptive content influenced preferential choice in a case of decision making under conditions of uncertainty. In particular, we sought to examine whether a decision task involving saving human lives produced a different pattern of neural activation than a comparable task involving saving money. We reasoned that the life problem would invoke moral considerations that would be absent in the cash problem, and that such considerations would not only effect risk tolerance, they would also manifest in different neural activation patterns. For example, Mandel and Vartanian (2008) recently showed that moral dilemmas that involved choices where humans would have been harmed regardless of the action taken—an example of what Tetlock, Kristel, Elson, and Lerner

(2000) have referred to as *tragic tradeoffs*—generated a stronger sense of moral conflict and a reduced sense of confidence in subjects than moral dilemmas that involved choices where harm to humans could have been avoided by diverting the danger to a priceless commodity, even though in both conditions subjects exhibited similar choices.

Specifically, we reasoned that human-life problems may make subjects more sensitive to the prospect of failure to save lives. We predicted that choices to save lives would consequently be characterized by greater risk aversion than choices to earn cash. Neurologically, we predicted that the dorsal striatum, by virtue of its sensitivity to motivational context and goal-directed action to increase reward (Delgado, Stenger, & Fiez, 2004; O’Doherty et al., 2004), would be activated more in life decisions, consistent with a view of the decision maker as “motivated actor.” In contrast, we predicted that the insula, given its role in risk prediction and probability signaling (Carlsson et al., 2006; Clark et al., 2008), would be activated more in decisions about cash, consistent with a view of the decision maker in this domain as “financial risk analyst.”

Subjects in our experiment were instructed to complete a series of gambles between two options (decks) of identical expected utility, where one option was paired with a certain outcome on each trial (e.g., saving \$400 out of \$1200 at risk of loss or saving 4 lives out of 12 at risk of death) and the other option was paired with a variable, uncertain outcome (e.g., saving either \$0 or \$1200 in the cash problem and saving either 0 or 12 lives in the life problem) (see Fig. 2). Content was manipulated within subjects across blocks. After each trial, subjects received feedback on the outcome of their chosen deck as well as the other deck, following which they were presented with a fixation stimulus before moving on to the next trial.

Consistent with previous results involving decisions with outcome feedback (Barron & Erev, 2003), overall, participants were risk averse, choosing the sure option on 59% of trials. However, as predicted, subjects were more risk averse and more sensitive to loss in the life than cash domain. When choices from the uncertain deck were followed by negative feedback (i.e., selecting from the certain deck would have yielded a better outcome), they exhibited a tendency to switch to the certain deck on the subsequent trial, but only in the life domain. Stated differently, subjects were more likely to employ a *win-stay-lose-shift strategy* (e.g., Messick, 1967; Nowak & Sigmund, 1993) in the life domain than in the cash domain, staying with the risky option if it yielded a positive result on the previous trial and shifting to the sure option if it did not. Moreover, when choices of the uncertain deck were followed by negative feedback, response latencies were longer on the subsequent trial in the life domain, but shorter in the cash domain. In combination, the behavioural data strongly suggest that decision making in the life domain was mired with more conflict than decision making in the cash domain.

Regarding the neural findings, as predicted, a direct contrast at the time point when choices were made (Fig. 2) revealed relatively higher activation in the anterior caudate nucleus in the life domain than in the cash domain (see Fig. 3), consistent with the responsiveness of this region to motivational context and goal-directed action to increase reward. In contrast, there was relatively higher activation in the posterior insula in the cash domain than in the life domain (see Fig. 3), consistent with its role in assessing the predictability of stimuli and probability signaling, a critical component of risk prediction. We also found distinct neural patterns of activation in response to negative feedback as a function of content. Specifically, there was relatively higher

activation in the subgenual anterior cingulate when participants received negative feedback in the life domain than when they received negative feedback in the cash domain (see Fig. 4). This is consistent with this region's sensitivity to negative feedback that occurs specifically in contexts involving humans (see van den Bos, McClure, Harris, Fiske, & Cohen, 2007). Furthermore, choosing the uncertain deck on trial n following negative feedback on the uncertain deck on trial $n-1$ was associated with relatively higher activation in the dorsal hippocampus (bordering on posterior amygdala) in the life domain than in the cash domain (see Fig. 5), consistent with the role of the hippocampus in context-driven memory in relation to cognitive representations of potential dangers (Hasler et al., 2007).

Taken together, our results suggest that whether the content of a gamble includes the presence or absence of lives can function as a strong contextual variable, influencing choice (i.e., greater risk aversion), decision strategy (i.e., greater reliance on a win-stay-lose switch strategy), response latency (i.e., longer response times following negative feedback on risky choices), and their neural correlates as just mentioned. Let us now consider the latter in greater detail, beginning with the observed activation in the anterior caudate nucleus when subjects made choices in the life domain. We interpret this finding in terms of O'Doherty's (2004, O'Doherty et al., 2004) "actor-critic" model, which dissociates between the functions of the ventral and dorsal striatum. According to the model, whereas the ventral striatum ("the critic") is involved in the formation of predictions about expected future rewards (see also Delgado & Tricomi, current volume), the dorsal striatum ("the actor") acts on those learned predictions to maximize long-term reward by selecting better options more frequently. This model is supported by data

showing that the dorsal striatum is sensitive to variations in contextual cues, given that such cues provide signals to the dorsal striatum for action selection (Delgado, Stenger, & Fiez, 2004). The greater activation of the anterior caudate nucleus (located within the dorsal striatum) in the life domain than in the cash domain indicates that the problems involving saving lives (even hypothetical lives!) engage neural regions associated with selection of actions to maximize long-term reward. These findings would seem to suggest, then, that context can influence the subject's motivations and, potentially, the subject's subsequent decision.

Whereas the activation in the anterior caudate nucleus was related to the time point when choices were made, context also affected the neural signal when the outcomes of subjects' choices were revealed. Specifically, the subgenual anterior cingulate was activated more when subjects received negative feedback in the life domain than when they received negative feedback in the cash domain (Fig. 4). As mentioned earlier, our findings are consistent with van den Bos et al. (2007), who have shown that this region is sensitive to receiving negative feedback that occurs in a "social" context—namely, one involving interactions between two humans rather than a human and a computer. In fact, our results extend earlier findings by demonstrating that the mental representations of humans may be sufficient for activating the subgenual anterior cingulate in the face of negative feedback. In part, the involvement of the subgenual anterior cingulate in receiving negative feedback in the life domain may be due to the role that this region plays in the experience of emotion, more generally.

There are two lines of clinical evidence that support this interpretation. First, lesions to the subgenual cingulate cause an inability to experience emotion in relation to

concepts that normally evoke emotion (Damasio, Tranel, & Damasio, 1990). Second, regional cerebral blood flow is reduced in the subgenual cingulate in depressed patients (Drevets et al., 1997), consistent with the generally reduced emotional responsiveness observed in this population. The results suggest that the context in which negative feedback occurs can modulate the activation of regions that respond to emotion, thus extending the neural signatures of context effects to responses to outcomes as well as choice.

Finally, having demonstrated that context affects the neural signatures of choice and outcome processing, our results also suggest that it may affect the interplay between those two processes. Specifically, we investigated the neural response when subjects made choices on trial n as a function of type of choice and outcome on trial $n - 1$. Our results showed that when risk-seeking choices received negative feedback, opting to return to the risky option was associated with relatively higher activation in the dorsal hippocampus in the life domain than in the cash domain (Fig. 5). Reinforcement learning paradigms have shown that there is functional dissociation between the amygdala and hippocampus in fear conditioning. The amygdala is activated in encoding stimulus-response contingencies as a function of outcome. This is consistent with data showing that in fear conditioning paradigms the amygdala is activated more in the early phase of conditioning as it encodes stimulus-outcome contingencies, after which it disengages and other regions take over to direct action as a function of encoded associations (Marschner, Kalisch, Vervliet, Vansteenwegen, & Büchel, 2008).

In contrast, rather than encoding contingencies early on, the hippocampus is involved in the formation of context-dependent memories about stimulus-outcome

associations (Hasler et al., 2007). In fact, in fear conditioning and extinction paradigms activation in the hippocampus has been shown to be correlated positively with the magnitude of extinction memory, $r = .71$ (Milad et al., 2007). The results of our experiment suggest that context affects the link between decision outcomes and subsequent decisions, as risk-seeking choices following negative outcomes in the life domain are associated with relatively higher activation in the hippocampal system. Stated differently, it appears that the human brain is poised to remember instances of risk taking involving human life that led to failure, and to activate those memory representations on subsequent decisions.

The multiple effects of content on centers of neural activation are especially remarkable if we consider that the manipulations undertaken here were merely descriptive and that the “decision-making context” was in fact purely hypothetical. That is, these differences emerged simply in response to *imagining* being in a situation where one had to save lives or money at risk of loss and to *imagining* the described consequences of their choices. We can only expect that the effects of content on both behavioral and neural measures would be even more pronounced if the decision-making problems and their consequences had been real, although we do not assume a straightforward extrapolation of our findings to the real world. If the literature on context effects has taught us anything, it is not to take changes in circumstance for granted. Obviously, a shift from decision making in hypothetical situations to decision making in real situations would constitute more than a “mere” circumstantial modification.

Concluding remarks

Our examination of the effect of descriptive context on preferential choice has highlighted the importance of taking into consideration the decision maker's representation of aspects of the decision problem. In this regard, our argument might be seen as falling into what Jungermann (2000) labeled the optimist's camp, focusing in particular on what he termed "the structure argument" (e.g., see Berkeley & Humphreys, 1982; Hogarth, 1981; Phillips, 1983). That is, we have raised concerns about the assumptions that theorists have made regarding the parsing of deep and surface structure in decision problems; concerns that, in turn, call into question whether decisions are really as incoherent as they have been portrayed by the pessimist's camp.

These questions, we believe, strike at the heart of any reasoned discussion of context because in the absence of sound criteria for deciding what manipulations are fundamental (i.e., not "merely" context) or circumstantial (i.e., "merely" context) there is no principled basis to proceed. Our view on this issue is that the structure argument *per se* neither reflects optimism nor pessimism regarding human performance.

Acknowledging the importance of taking the decision maker's representation of a problem into account does not make an *a priori* case for the quality of their decision in light of their representations. There is certainly still the opportunity for incoherence to present itself even when choices are assessed in relation to the decision maker's understanding. Indeed, it is possible that seemingly coherent choices might be found to be incoherent upon such analysis. That is an empirical question, the answer to which should not be presupposed or biased by para-theoretical camp allegiances.

We would say, though, that our objection over "theorist-centricity" points mainly to the analytical and theoretical inadequacies of relying solely on the theorists'

interpretation, and the logical difficulties, which that approach presents for drawing sound inferences about the coherence of people's decisions. Although taking steps to measure decision makers' representations surely adds a level of complexity to the design of behavioral research, we believe it is well worth the effort—especially in an area so often characterized by evaluative conclusions regarding human performance.

The meta-theoretical orientation we thus advocate is similar to Dennett's (1991) *heterophenomenology*—namely, phenomenology of another, not oneself. Dennett regards heterophenomenology as an attempt to overcome what he called "lone-wolf autophenomenology"—the traditional (Cartesian) phenomenological view that accepts the individual's self-reports as being authoritative. In general, behavioral decision theorists have had little difficulty rejecting that perspective, being well aware that subjects often are willing to "tell more than they can know" (Nisbett & Wilson, 1977). But behavioral decision theorists have been more susceptible to a similarly Cartesian view in which the subjects' representation is ignored, denied, or treated as irrelevant, while the theorist's representation is elevated to the status of reality or proof. Our focus on the triad of the subjects' representation or phenomenology, the subjects' behavior (e.g., choices, response times, and reactions to feedback), and the subjects' neural behavior is thus part of a meta-theoretical orientation that seeks to triangulate the totality of the subjects' responses in order to formulate a more accurate view of human performance in light of human experience and the biological underpinnings of both performance and experience.

This approach, we believe, is particularly important at this juncture since the neuroscience of judgment and decision making offers many new lines of evidence that

could be brought to bear on theory generation and theory testing. We have endeavored to show how manipulations of content not only affect behavioral measures such as risk attitude, response time, and decision strategies following outcome feedback, but also how such manipulations affect the neural signatures accompanying those behavioral responses. It is difficult to dismiss the effects of context on decision making when the effects manifest themselves not only in terms of choices and decision strategies but also in terms of the regions of the brain that are differentially activated.

The findings we presented in the section on content effects foreshadow theoretical developments in which contextual stimuli are understood to influence decision making, at least in part, through their activation of specific neural regions that in turn increase the probabilities of certain decision strategies, response tendencies, and experiences while decreasing the probabilities of alternative strategies, response tendencies, and experiences. We have little doubt that the emerging body of neuroscientific studies on judgment and decision making, which is still in its infancy, will play an important role not only in buttressing acceptance of what Goldstein and Weber (1997) described as the “fourth stage” in which context dependence is regarded as fundamental to decision theory, but also in shaping and constraining the theories that develop within that meta-theoretical perspective through entirely new lines of evidence. More generally, it is difficult to imagine how neuroscience’s newfound abilities to peer into the brain will not have a significant transformative effect on our fundamental understanding of how people make judgments and decide.

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Figure Captions

Figure 1. Mean risk seeking as a function of frame and missing information.

Note. From Mandel (2009). Mean risk seeking is calculated by coding preferences of the sure-thing option -1 and preferences of the risky option +1, and then multiplying these values by subjects strength of preference judgments—namely, the extent to which they viewed their chosen alternative as superior to the non-chosen alternative.

Figure 2. Trial structure.

Note. From Vartanian, Mandel, and Duncan (2009). Each session (life, cash) involved two blocks of 24 trials of identical structure. The figure represents the first trial from a life block involving selection from the certain deck followed by feedback. The length of each trial was 10s. Following the termination of all 24 trials a slide was presented for 2s indicating the total savings/earnings from that block.

Figure 3. Neural activation for choice as a function of context.

Note. From Vartanian, Mandel, and Duncan (2009). The anterior caudate nucleus was activated more when subjects made choices in life problems (a). The posterior insula was activated more when subjects made choices in cash problems (b).

Figure 4. Neural activation as a function of negative feedback and context.

Note. From Vartanian, Mandel, and Duncan (2009). The subgenual anterior cingulate was activated more when subjects received negative feedback in life domain than when they received negative feedback in the cash domain.

Figure 5. Neural activation as a function of negative feedback, subsequent choice, and context.

Note. From Vartanian, Mandel, and Duncan (2009). The dorsal hippocampus (bordering on posterior amygdala) was activated more in the life than cash domain when subjects opted to return to the uncertain deck on trial n following negative feedback on trial $n - 1$.









