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Response mode, compatibility, and dual-processes in the evaluation of simple gambles: An eye-tracking investigation

Enrico Rubaltelli* Stephan Dickert† Paul Slovic‡

Abstract

We employed simple gambles to investigate information processing in relation to the compatibility effect. Subjects should be more likely to engage in a deliberative thinking strategy when completing a pricing task rather than a rating task. We used eye-tracking methodology to measure information acquisition and processing in order to test the above hypothesis as well as to show that losses and alternatives with uncertain outcomes are more likely than gains and alternatives with sure outcomes to be processed through a deliberative thinking process. Results showed that pupil dilations, fixation duration and number of fixations increased when subjects evaluated the gambles with a pricing task. Additionally, the number of fixations increased as the gamble outcome became increasingly negative and when the outcome was uncertain (vs. sure). Fixations were also predictive of subjects' final evaluations of the gambles. We discuss our results in light of the cognitive processes underlying different response modes in economic preferences.

Keywords: compatibility effect, dual-process theory, gambles, risk, loss aversion, uncertainty.

1 Introduction

Both psychologists and economists have traditionally been interested in understanding how people make decisions under uncertainty and how they deal with economic risks. However, whereas the latter have conventionally been more concerned with delineating the conditions under which decisions follow rational norms and expectations (Von Neumann & Morgenstern, 1947), psychologists have focused on analyzing the cognitive processes underlying decisions and preferences (Simon, 1976, 1978). An early laboratory study showed that people pay more selective attention to probabilities or payoffs depending on the response mode of the presented task (e.g., choice versus judgment; Slovic & Lichtenstein, 1968). For instance, when asked to specify a price to sell a simple gamble offering a probability p to win an amount x, individuals are more likely to base their judgment on the gamble payoff (x). However, when people are asked to make a choice between two or more gambles they are more likely to base the decision on the probability (p) of obtaining a positive outcome.

Subsequent research by Lichtenstein and Slovic (1971, 1973) demonstrated, both in the laboratory and in a Las Vegas casino, that with a particular set of paired gambles it is possible to reverse people's preferences simply by asking them to choose among gambles or to set a price for each of them. Each pair of gambles included one gamble that offered a large payoff but with low probability (labeled $-bet) and another gamble that offered a small payoff but with high probability (labeled P-bet). In this way it was possible to assess which dimension was more influential in each task and to determine whether their effects on people's preferences were big enough to induce preference reversals. Consistent with the above reasoning, results showed that , many people chose the P-bet because it offered the highest chance to win, but then placed a higher selling price on the $-bet ,which offered the possibility of winning a larger amount of money. Research on preference reversals suggests that this phenomenon is mainly induced by an overpricing of the $-bet in the pricing condition when this gamble offers a larger payoff compared with the P-bet (Tversky, Slovic, & Kahneman, 1990). This result has been replicated many times (Lindman, 1971; Grether & Plott, 1979; Hamm, 1979; Goldstein & Einhorn, 1987; Karni & Safra, 1987; Schkade & Johnson, 1989; Tversky, Slovic, & Kahneman, 1990; Chapman & Johnson, 1995), no doubt because it offers a particular challenge for economic theories of choice which assume stable preferences.

Several explanations have been suggested to account for preference reversals like these (Seidl, 2002), of which the compatibility effect is probably the most prominent (Tversky, Sattath, & Slovic, 1988). Compatibility effects between task and response have been shown in several

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*University of Padova, Department of Developmental and Socialization Psychology, Via Venezia, 8–35131 Padova, Italy. Email: enrico.rubaltelli@unipd.it.

†Max Planck Institute for Research on Collective Goods.

‡Decision Research & University of Oregon.

research domains in cognitive psychology (e.g., Simon effect; see Simon, 1990). Tversky, Sattath and Slovic (1988) suggested a similar explanation to account for the different degree of attention given to specific attributes depending on the method used to elicit preferences. In particular, these authors postulated that, when attributes are compatible with the response scale, they are assigned greater weight because they are most easily mapped onto the response. For instance, when subjects are asked to set a price for a gamble this task is compatible with the information about the gamble payoff, which is also expressed in monetary values (e.g., dollars). Conversely, when the task requires a choice the payoff information is not easily mapped onto the response anymore and loses some of its salience. In fact, Slovic, Griffin, and Tversky (1990) could show that using non-monetary outcomes attenuates preference reversals when no compatibility between the pricing task and the outcome attribute was possible.

An assumption of the compatibility effect is that response modes compatible with specific characteristics of the options (e.g., payoffs) draw attention to them. Attentional deployment to these characteristics, in turn, increases the weight given to them in the construction of preferences (Willemsen, Böckenholt, & Johnson, 2011). Research on attentional processes underlying choices and preference reversals supports the role of attention in the compatibility effect (Schkade & Johnson, 1989). Using the Mouselab computer-based process-tracing system, Schkade and Johnson were able to force subjects to view components of each gamble sequentially one at a time. Results showed that the percentage of time spent looking at payoffs was significantly greater in a pricing task than in a rating task, therefore supporting the hypothesis that people attend to information differently depending on the answer they are required to provide. The process tracing methodology used by Schkade and Johnson allowed them to considerably improve the understanding of the processes behind the compatibility effect. Ratings of attractiveness required less time than the generation of a price. Additionally, in the pricing task, the information search pattern was significantly more dimensional than in the ratings task (transitions between two outcomes or two probabilities within the same gamble as opposed to transitions between a payoff and its probability). Finally, there were differences in how people generated their answers in the two tasks. When generating a price, subjects spent one third of the time adjusting their evaluation on the response scale, whereas in the rating task they spent the same amount of time to generate the response but adjusted the position of the pointer on the scale less often.

Based on this seminal work and the recent application of physiological measures to the study of thinking and decision-making, we aimed to extend the understanding of the compatibility effect by measuring people's information processing by way of an eye-tracking methodology (Just & Carpenter, 1980). Several complementary methodologies to study information processing from a physiological perspective have recently proven useful to investigate how people make decisions, including event related potentials (ERPs; e.g., Polezzi et al., 2008), and fMRI (e.g., Knutson, Rick, Wimmer, Prelec, & Loewenstein, 2007; Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003). Physiological measures have also been applied to investigate intuitive and deliberative thinking systems. For instance, using skin conductance responses (SCRs), it was shown that intuitive processes can be faster than deliberative (i.e., conscious) processes in decisions based on experience (Bechara, Damasio, Tranel & Damasio, 1997). Furthermore, Horstmann, Ahlgrimm & Glöckner (2009) used eye-tracking methodology to analyze people's information processing when instructed to decide deliberatively or intuitively. Although their findings illustrated that instructing decision modes may not result in qualitatively different information processing, deciding deliberatively was related to a higher number of fixations, a more complete information search, and more repeated information inspections.

In the current paper we assess physiological and attentional eye-tracking measures that allow for a natural acquisition of information (e.g., natural eye-movements, fixations, and pupil dilations; Glöckner & Herbold, 2011; Horstmann et al., 2009; Velichovsky, 1999) while extending Schkade and Johnson's (1989) results on the information processing underlying the compatibility effect. Specifically, our goal is to show that (1) compatibility effects are also present when using simple gambles in both gain frame and loss frame, and (2) we intended to draw a connection between the compatibility effect and dual process theories (see Epstein, 1994; Chen & Chaiken, 1999; Evans, 2008). We hypothesized that the different processes activated by task compatible characteristics of an alternative could exert their effect by leading decision makers to rely on either more deliberative or more automatic thinking strategies. In particular, setting a price seems to entail more fine-tuned adjustments once an initial evaluation is established. This dynamic of adjustments could hint at a deliberative type of processing activated by the search for the most advantageous balance between costs (the price paid) and benefits (the amount of the possible gain). By deliberative processing we mean a strategy characterized by a conscious and detailed evaluation of the pros and cons of a specific gamble.[1] In contrast, a holistic strategy is based on a more general, less detailed and less conscious evaluation of the gamble. Therefore, we test the hypothesis that the pricing task requires more deliberative information processing

[1]Note that conscious evaluations might include both analytical and emotional information processing.

with a conscious process of comparison between different pieces of information. This reasoning is consistent with the fact that ratings of attractiveness are also used as a measure of affective reactions (Bateman, Dent, Peters, Slovic & Starmer, 2007) and should be more influenced by an intuitive thinking strategy. Specifying a price, on the other hand, should be mainly based on the conscious effort of setting the correct price. Thus, we expect that people exert more cognitive effort and deliberation when they are asked to set a price rather than to rate a gamble's attractiveness. As a measure of cognitive effort we will use the overall eye fixation count, that is how many times subjects look at information about a gamble's outcomes or their associated probabilities.

Hypothesis 1a: Subjects should exert more cognitive effort (in terms of eye fixation count) when providing a price than when providing ratings of attractiveness, since the pricing task should activate a more deliberative thinking strategy than the rating task.

Hypothesis 1b: Subjects should give the payoff information more weight than the respective probabilities when providing a price than when providing ratings of attractiveness. In other words, subjects should fixate prices more often than the respective probabilities when providing a price than when providing ratings of attractiveness.

We also expect to find a set of additional results based on the type of alternatives (simple gambles) that we employ in our study. For instance, subjects should exert more cognitive effort when the amount to be lost increases in comparison to an increase in the amount to be won. This is consistent with research on the effects of gain vs. loss framing on cognitive processes, which has demonstrated that people exhibit more thorough evaluations and more effortful cognitive analysis when faced with potential losses (Ditto et al., 1998; Dunegan, 1993; Fischer, Jonas, Frey, & Kastenmüller, 2007; Lopes, 1987). Additionally, research on loss aversion shows that losses loom larger than gains (prospect theory; Kahneman & Tversky, 1979) and typically carry more weight in decisions. Subjects should be more careful in judging a loss than a gain, whose relevance is psychologically less intense. This hypothesis is also consistent with previous literature describing a negativity bias (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Rozin & Royzman, 2001). Baumeister et al. concluded that it is adaptive for individuals to mobilize their attention and resources toward negative information. We believe that losses induce people to anticipate stronger affective reactions than gains, therefore causing them to pay more attention and to evaluate them more carefully. This is in line with previous work demonstrating that emotions can drive attentional processes (see Öhman, Flykt & Esteves, 2001; Anderson, 2005; Vuilleumier, 2005).

Hypothesis 2: Subjects should exert more cognitive effort (in terms of eye fixation count) as the outcome becomes increasingly negative.

In addition to different cognitive processes for gains and losses, we also examine alternatives with uncertain outcomes and alternatives with sure outcomes. Previous research demonstrated that sure outcomes have a special status in people's mind. Kahneman & Tversky (1979) described what they called the certainty effect, whereby individuals overweigh sure outcomes compared with uncertain ones. Starting from this evidence, we hypothesized that people should process alternatives with sure outcomes and alternatives with uncertain outcomes differently. In particular, subjects should exhibit more deliberative processing characteristics (e.g., fixate on more information) when presented with an uncertain outcome rather than a sure one, since uncertainty should make it more difficult to attach a specific value to the gamble. Alternatives whose outcomes are impossible to attain should be processed more easily and with less effort than alternatives whose outcomes are very unlikely but not impossible. Again, subjects should exhibit more deliberative processing characteristics when they evaluate an alternative whose outcomes are almost impossible because uncertainty makes its value harder to judge. Therefore, the current study will provide additional evidence about the processes behind the certainty effect (Kahneman & Tversky, 1979) and extend these findings to the lower end of the probability scale.

Hypothesis 3a: More information should be attended to, in terms of overall eye fixation count, when subjects evaluate alternatives with uncertain outcomes (e.g., 98% chance to either gain or lose) rather than alternatives with sure outcomes (100%), because uncertainty should contribute to making an alternative's overall value more difficult to judge.

Hypothesis 3b: Similarly, the evaluation of alternatives offering an impossible outcome (0%) should induce subjects to attend to less information (in terms of overall fixation count) than the evaluation of alternatives offering outcomes that are almost impossible (e.g., a 2% chance of either gain or lose).

Finally, besides the effects of the different tasks on cognitive effort and attentional mechanisms, we also expect to find evidence for the compatibility effect in the behavioral data (i.e., in the evaluation of gambles). As demonstrated by prior research (e.g., Tversky et al., 1988), valuations should be more influenced by changes in outcome value (i.e., amounts to be won or lost) when these valuations are in form of a price. Conversely, valuations should be more influenced by changes in outcome percentage (i.e., the chances of winning or losing) when these valuations are in form of an attractiveness rating. Additionally, the cognitive processes activated by different tasks (i.e., pricing versus rating) and by the different types of outcomes (sure versus uncertain) should also affect how alternatives are evaluated. If people attend more to payoffs in the WTP-task, then they should be less sensitive to the difference between sure and uncertain outcomes, since less attention is deployed to the processing of probabilities. However, such diminished sensitivity to the difference between sure and uncertain outcomes should not arise in the rating task since, in this case, people do not attend more to payoffs than probabilities. Therefore, we expect to find a difference between sure and uncertain outcomes when subjects are asked to rate their attractiveness, whereas no difference should arise when subjects are asked to set a price.

We derive this hypothesis directly from the compatibility effect. Since the response mode has an effect on which piece of information is weighed more highly, people's appreciation of the difference between alternatives with sure and uncertain outcomes should depend on the method used to elicit preferences. For instance, even when the chances to win or lose are very close (e.g., 100% vs. 98% or 0% vs. 2%), the difference between certainty and uncertainty can still make a substantial difference in the way people perceive the alternatives. Because of the compatibility effect, such difference should be more relevant when subjects provide ratings of attractiveness rather than when they specify a price.

We hypothesized that people should provide higher attractiveness ratings for a 100% gain compared to a 98% gain and for a 2% gain compared with a 0% gain. Similarly, subjects should provide higher attractiveness ratings for a 98% loss compared with a 100% loss and for a 0% loss compared with a 2% loss. However, subjects should set similar prices for 100% and 98% alternatives and also for 0% and 2% ones.[2]

Hypothesis 4a: According to the compatibility effect, we expect that valuations of gambles are more influenced by the gambles' outcomes when these valuations consist of prices (vs. attractiveness ratings).

Hypothesis 4b: Since rating and pricing should induce people to attend to the outcomes differently, alternatives with sure and uncertain outcomes will be evaluated differently when people are asked to rate attractiveness, but not when they are asked to set a price.

In summary, the main goal of this study is to apply the eye-tracking methodology to the investigation of the compatibility effect as well as to extend the analysis of this effect by linking it to dual-process theories of decision making (see Epstein, 1994; Chen & Chaiken, 1999; Evans, 2008; Hypotheses 1a and 1b). Further, we hypothesize that subjects should exert more cognitive effort with increasing losses (Hypothesis 2). People should also attend to more information when evaluating alternatives with uncertain outcomes (98%) rather than alternatives with sure outcomes (100%; Hypothesis 3a). Similarly, they should attend to less information when evaluating alternatives with impossible outcomes (0%) rather than alternatives with almost impossible outcomes (2%; Hypothesis 3b). Finally, Hypothesis 4a and 4b state that valuations should be influenced by the gambles' attributes compatible with the response scale and that subjects should provide different evaluations for alternatives with sure versus uncertain outcomes when they provide a rating of attractiveness.

2 Method

2.1 Subjects and design

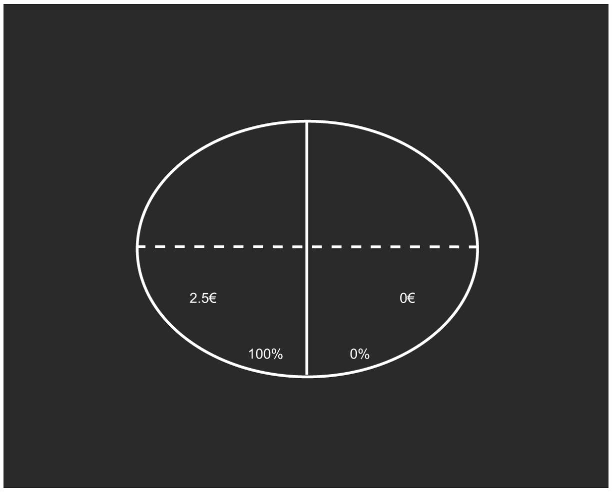
A total of 37 undergraduates (Mean age = 22.9, SD = 3.3; 59% female) from the University of Bonn, Germany, took part in the study. Subjects had normal or corrected-to-normal vision, completed the study (approximately 45 minutes) individually, and were compensated with €10 (approximately $14) for their time. The independent variables of interest included the amount to be won (lost), its associated probability, and the response mode (attractiveness rating vs. willingness to pay). They were all manipulated within-subjects, with between-subjects variables only being used for counterbalancing of the presentation order and order of the response tasks (see below). The main dependent variables consisted of the two evaluation tasks: ratings of attractiveness and willingness to pay (WTP). WTP-tasks were played only hypothetically since none of the gambles was played for real. Additionally, we recorded subjects' eye-movements during the task.

2.2 Materials and procedure

The experiment contained 16 gambles that were constructed out of four different probabilities (i.e., 0%; 2%; 98%; 100%) to win or lose one of four different amounts of money (€2.50; €5.00; €7.50; €10.00). Each probability was crossed with each payoff amount to result in 16 winning gambles and 16 losing gambles. Subjects evaluated the 32 gambles twice: once on an attractiveness scale (anchored by -5 = "very unattractive" and 5 = "very attractive") and once by specifying a price that they were willing to pay to play a winning gamble or a price that they were willing to pay in order to not have to play a losing gamble (on a scale of €0 to €10 in 10-cent increments), resulting in 64 total trials. For each gamble there were four attributes visible on the computer screen

[2] We are aware that subtle changes in the wording may have a significant impact on people's preferences, therefore influencing the results. For instance, we presented the alternatives with uncertain outcomes as 98% chance to gain (lose) €X and 2% chance to gain (lose) nothing. Different results might be found when the same alternative is worded as 98% chance to gain (lose) €X and 2% chance to lose (gain) nothing (see also Bateman et al., 2007).

Figure 1: Screenshot of gambles presentation during the experiment.



at each presentation: the probability to win (lose), the winning (losing) amount, the complimentary probability to win (lose) nothing and a zero to denote the amount attached to the complimentary probability. For example, a gamble with a 2% probability to win €5.00 was accompanied by the complimentary 98% probability to win €0.

The length and location of the scale on the screen was identical in both response modes: 500 pixels in length and placed at the bottom of the screen. The presentation order of the gambles was fully randomized and the order of the response mode (attractiveness rating vs. willingness-to-pay) was block-randomized within-subjects. The gamble attributes regarding the winning (losing) probability and amount were presented in one of four quadrants of a circle and equidistant to the center of the computer screen. The gamble attributes of the complementary probability were presented in the opposite horizontal quadrant (always leaving 2 quadrants empty each trial). This was done in order to avoid anticipatory attentional focus prior to the onset of the gamble attributes (see Figure 1, for an example of how the gambles were presented).

Subjects' eye-movements were recorded with the Eyegaze binocular system (LC Technologies), with a binocular sampling rate of 120 Hz and fixation accuracy of about 0.45°. The two infrared-sensitive corneal cameras were positioned underneath a 17-inch color computer screen monitor (Samsung Synchmaster 740B, refresh rate 60 Hz, reaction time 5 ms) with a resolution of 1280 x 1024 pixels and approximately 60 cm away from the subject. Individual fixations were recorded for fixations with a length of at least 50ms and fixation radius of 20 pixels. To determine information acquisition, for each trial we determined four (out of eight possible) fixed (160 pixels long and 50 pixels high) non-overlapping areas of interest (AOIs) around the gamble attributes (i.e., two probabilities and two outcomes), which were recorded as an AOI-fixation when subjects fixated on that attribute.

At the start of the experiment, subjects were informed about the eye-tracking procedure and that they were about to be presented with several gambles. They were also informed that in some blocks the required evaluation was a rating of each gamble's attractiveness, whereas in other blocks they had to state how much they would be willing to pay to play a winning gamble (or to avoid having to play a losing gamble). On each trial of the experiment subjects first saw a white fixation cross at the center of the black screen for 150ms, then an indicator of the type of response they were asked to make (attractiveness rating or WTP) for 2000ms, then another fixation cross for 150ms followed by the display of the gamble attributes. Subjects could take as much time as they wanted to look at the gambles' attributes, once they were ready to answer they had to press the spacebar in order to continue and evaluate the gamble. In between the display of the gamble and the evaluation screen a blank screen of 500ms was interleaved. For a schematic representation of the procedure see Figure 2.[3]

3 Results

3.1 Preliminary data analyses

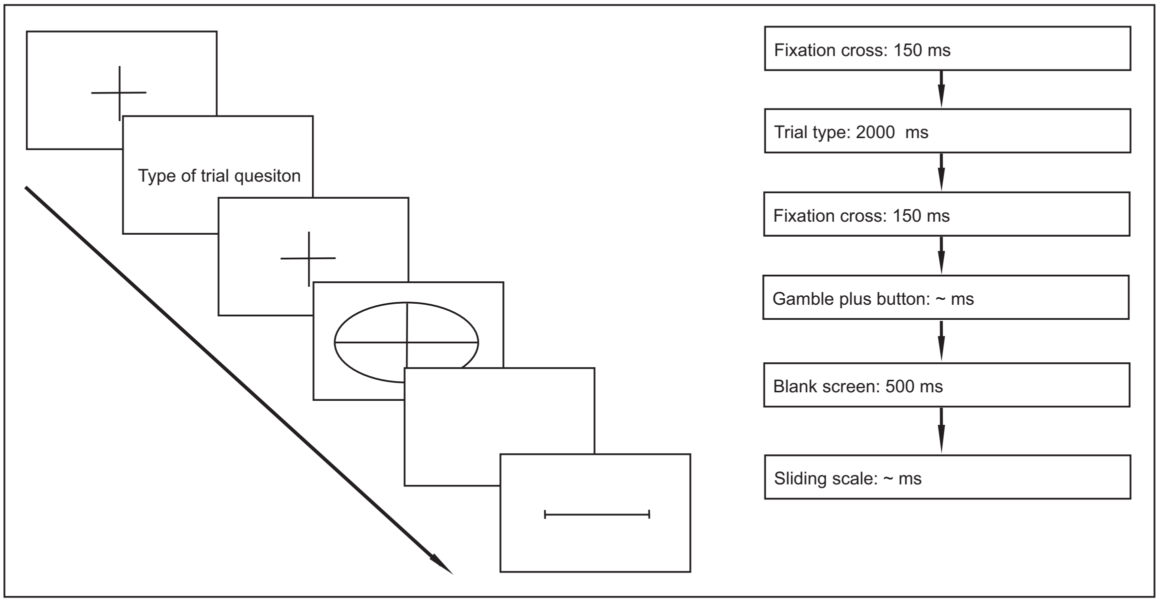
A manipulation check on the influence of the counterbalancing factors response mode and order of gambles revealed no difference in valuations due to the order of the response mode ($p > .31$) or presentation order of gambles ($p > .53$).[4] Subjects' changes in mean pupil dilation for every trial were calculated by subtracting the base rate pupil dilation (measured during the presentation of fixation crosses and blank screens in-between trials) from the average pupil dilation over all fixations during any single trial. The mean fixation duration for each trial was calculated by averaging across all fixations within each trial during which the gamble was presented on the screen. Table 1 details the summary statistics for the eye-tracking analysis by response mode.[5]

[3] Due to a programming mistake, data for attractiveness ratings in the 98% and 100% gambles with negative outcomes was lost for 29 subjects. Therefore, analyses reported in the text that pertain to losses are based on the data from eight subjects.

[4] Unless otherwise noted, we standardized both subjects' ratings on the attractiveness scale and their willingness to pay.

[5] Additional preliminary analyses on the general information acquisition patterns per trial also found that subjects fixated more on the amount to be won or lost (M = 3.58; SE = 0.24) and the associated probabilities (M = 3.49; SE = 0.19) than on the zero outcome (M = 2.62; SE = 0.17) and its associated probabilities (M = 3.15; SE = 0.17).

Figure 2: Experimental procedure.



3.2 Compatibility effect, processing strategies and cognitive effort

We expected that subjects engage in a more deliberative processing strategy in the WTP-task compared to the rating task, where ratings should be characterized by a more holistic type of processing (Hypothesis 1a). Additionally, the compatibility effect predicts that the outcomes of the gambles are given more weight in the WTP-task than in the attractiveness rating-task (Hypothesis 1b). To test these hypotheses, we conducted a repeated-measures regression with the type of gamble attribute (outcomes vs. probabilities), response mode (WTP vs. attractiveness rating), and the corresponding interaction as predictors of subjects' fixations on the amounts to be won (or lost) and associated probabilities.[6] Results revealed a significant effect of response mode, b = .47, $t(37) = 3.43$, $p = .002$, a non-significant effect of gamble attribute, b = .04, $t(37) = 0.58$, $p > .57$, and a marginally significant interaction, b = .08, $t(37) = 1.96$, $p = .058$. As expected, per trial more fixations on the amount to be won (lost) and associated probabilities were recorded in the WTP-task ($M = 3.95$; $SE = 0.29$) compared to the attractiveness rating task ($M = 3.01$; $SE = 0.18$), supporting Hypothesis 1a. This suggests that attractiveness ratings rely on a more holistic judgment without extensive information acquisition, and possibly recruit intuitive processes relative to more deliberative processes that underlie a precise WTP-response. Additionally, the marginally significant interaction lends some support to Hypothesis 1b, such that more fixations were recorded on the amount to be won (lost) ($M = 4.07$; $SE = 0.34$) than on the associated probabilities ($M = 3.84$; $SE = 0.26$) in the WTP-trials, whereas the amount of fixations in the attractiveness rating-task was fairly equal for outcomes ($M = 2.97$; $SE = 0.20$) and probabilities ($M = 3.05$; $SE = 0.18$).

In addition to fixations on the amount to be won (lost) and its associated probability, we were further interested in the following eye-tracking measures of information processing: number of total AOI fixations (including fixations on the zero-outcome and its associated probability), the average fixation length, and mean pupil dilations. The total AOI fixations measure overall information uptake by the subjects. The mean duration length of a fixation indicates the type of processing done by the subjects, with longer fixations denoting deeper processing and shorter fixations reflecting a scanning of information (Horstmann, et al., 2009; Velichovsky, 1999). Finally, pupil dilation is related to cognitive effort required by a task (with bigger pupil size usually being correlated with higher cognitive effort) and is also associated with emotional arousal (see Beatty, 1982). To predict these eye-tracking measures, we regressed each on the type of task (WTP vs. attractiveness ratings), the amount to be won (lost), its corresponding probability, and the respective interactions. These analyses should provide additional support for Hypothesis 1a and 1b as well as test Hypothesis 2, which states that cognitive effort should increase as the outcome amount decreases.

[6]We controlled for clusters in repeated observations (Rogers, 1993) in this and all other repeated-measures regressions. Predictors and criterion variables were standardized prior to analyses.

Table 1: Eye-tracking summary statistics by response mode: Means and (standard errors).

	WTP		Attractiveness	
Pupil size (radius in mm)	2.100	(.050)	2.090	(.060)
Pupil dilation (Δ)	−.040	(.005)	−.059	(.005)
Mean fixation duration (in sec)	.203	(.005)	.194	(.004)
Mean evaluation time (in sec)	4.320	(.270)	3.280	(.160)
Number of AOI fixations per decision	14.060	(.950)	11.320	(.620)
Number of total fixations per decision	21.030	(1.190)	16.870	(.780)
Proportion of fixations on amounts to be won (lost)	.299	(.010)	.270	(.008)
Proportion of fixations on probabilities of amounts to be won (lost)	.277	(.007)	.266	(.006)
Number of attribute-based transitions (attribute-wise)	2.010	(.130)	1.620	(.100)
Number of alternative-based transitions (alternative-wise)	4.830	(.370)	4.030	(.250)

Note. Eye-tracking statistics are calculated during presentation of gambles (excluding the response phase); attribute-based transitions are transitions between the two outcomes (and the two probabilities), alternative-based transitions consist of transitions between outcomes and their respective probabilities within one side of the gamble; standard errors are robust and adjusted for 37 clusters of observation.

3.2.1 Total number of AOI fixations, fixation length, and pupil dilation

Results of the regression analyses are presented in Table 2. As expected, the total number of AOI fixations increased in the WTP-task compared to the attractiveness rating-task. In line with Hypothesis 1a, more careful information acquisition took place when subjects were asked to set a price for a gamble compared to rating its attractiveness. Additionally, the number of total AOI fixations decreased as the outcome increased, which is supportive of Hypothesis 2.[7] Finally, the marginally significant interaction (p = .059) between task and outcome amount provides further evidence for Hypothesis 1b, as the relationship between the amount to be won (lost) and total AOI fixations was stronger in the WTP-task, b = −1.04, $t(37) = -3.58$, $p = .001$, than in the attractiveness rating task, b = −.65, $t(37) = -2.44$, $p = .02$. Additionally, results revealed that total AOI fixations increased as percentages decreased. Furthermore, the interaction between outcome amount and percentages revealed that fixations increased with decreasing amount only for low probabilities (i.e., 0 and 2%).

Similar to the results for the number of fixations, we also found a main effect for type of task and percentage for the average fixation duration. The average duration of a fixation was significantly longer in the WTP-task, indicating deeper and more deliberative processing compared to the attractiveness rating task (Hypothesis 1a). Also, fixation length increased as percentages decreased and as the winning (losing) outcomes decreased, albeit not significantly so (as would be predicted by Hypothesis 2). Moreover, the interaction between type of task and outcome was not significant (as would be predicted by Hypothesis 1b).

Finally, results for pupil dilations showed a main effect for task type such that pupil dilation was bigger in the WTP-task compared to the rating task, supporting the notion that subjects exerted more cognitive effort during pricing tasks (Hypothesis 1a). Also, pupil dilation increased as percentages decreased. However, neither the main effect for outcome amount nor the interaction between outcome and task reached statistical significance.

3.3 Difference between alternatives with sure (or impossible) and uncertain outcomes

Next we examined whether fixations on the AOIs were dependent on whether the gambles had sure (100%) or impossible outcomes (0%) rather than near sure (98%) or almost impossible outcomes (2%). In addition, we included the type of task (WTP vs. ratings) and the interaction between task and type of probability (certain vs. probable) to predict fixation counts on the AOIs of interest (i.e., winning/losing outcome and its associated probability). Results indicate that there were more AOI-fixations to the winning (losing) probability when the

[7] Further analyses revealed that the effect of outcomes on fixation count are best described by a linear trend (b = −1.01, $t = -4.71$, $p<.001$) such that fixations decreased as the outcome amount increased from −10 to 10. Using a dichotomous gain vs. loss predictor instead of continuous outcomes showed similar results such that fixation counts were higher for losses than gains, b = −0.53, t = −2.94, p<.001.

Table 2: Total AOI fixation count, mean fixation duration, and mean pupil dilation.

	AOI fixation count		Mean fixation duration		Mean pupil dilation	
Type of Task (0 = attractiveness; 1 = WTP)	1.52**	(3.40)	.005**	(3.07)	.010**	(3.49)
Outcome amount	−.63***	(−3.52)	−.002	(−1.48)	.0004	(.20)
Percentage	−1.25***	(−5.47)	−.003+	(−1.96)	−.003	(−2.39)
Task x Outcome	−.42+	(−1.95)	−.001	(−.73)	−.002	(−1.39)
Task x Percentage	−.24	(−1.10)	.001	(.98)	.001	(.41)
Outcome x Percentage	.64***	(3.46)	.002	(1.59)	.001	(.62)
Task x Outcome x Percentage	.17	(1.07)	.001	(.62)	−.001	(−.77)
Constant	12.54***	(18.65)	.198***	(43.11)	−.050***	(−13.02)
Observations	2130		2130		2129	

Note. Outcome amount includes all gain and loss outcomes; *t* statistics in parentheses are based on robust standard errors and adjusted for 37 clusters of observation; predictors were standardized; + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3: AOI fixations dependent on task and uncertain (98%) vs. sure (100%) probabilities.

	Fixations on winning/losing %		Fixations on winning/losing $	
Type of task (0 = attractiveness; 1 = WTP)	.465**	(3.03)	.660***	(3.52)
Probability (1 = 100%; 0 = 98%)	−.316**	(2.83)	−.195+	(−1.95)
Task x probability (1 = 100%; 0 = 98%)	−.110	(−1.24)	−.102	(−1.18)
Constant	3.420***	(15.54)	3.419***	(14.79)
Observations	948		948	

Note. *t* statistics in parentheses are based on robust standard errors and adjusted for 37 clusters of observation; predictors are standardized; + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

gamble featured a 98% rather than a 100% outcome. In other words, subjects paid more attention to the probability of an almost sure outcome (i.e., 98%) than on the probability of a sure outcome (i.e., 100%; see Table 3). This effect was almost significant ($p = .059$) for fixations for the winning (losing) outcome. These findings are in line with Hypothesis 3a, which states that subjects should attend to more information about probabilities when evaluating alternatives with almost sure outcomes than alternatives with sure outcomes. Also, as already demonstrated fixations for both probabilities and outcome information increased in the WTP-task. Furthermore, although neither of the interactions reached statistical significance, subjects paid significantly more attention to almost sure probabilities (i.e., 98%) than sure probabilities (i.e., 100%) only in the WTP-trials, b = −0.43, $t(37) = -3.52$, $p = .001$, whereas this was not the case in attractiveness trials, b = −0.20, $t(37) = -1.27$, $p = .211$. Similarly, subjects paid significantly more attention to outcomes of almost sure vs. sure probabilities in the WTP-trials, b = −0.30, $t(37) = -2.46$, $p = .019$, but not in the attractiveness trials, b = −0.09, $t(37) = -0.66$, $p = .513$.

Similarly, we found that more attention is given to the winning (losing) outcomes as well as their respective probabilities when the chance to win (lose) was possible (i.e., 2%) rather than impossible (i.e., 0%; see Table 4). These findings are in line with Hypothesis 3b, which states that subjects should attend to less information about probabilities when evaluating alternatives with impossible outcomes than alternatives with almost impossible outcomes. In addition, more fixations on the respective AOIs were present in WTP-trials vs. attractiveness trials. Finally, both for fixations on winning (losing) outcomes as well as their respective probabilities a significant interaction between task and probability type demonstrated that subjects attended more to the information of probable (vs. impossible) gambles in the WTP-trials (b = −0.52, $t(37) = -4.30$, $p < .001$, and b = −0.49, $t(37) = -4.06$, $p < .001$ for probabilities and outcomes, respectively) than in attractiveness trials (b = −0.08, $t(37)$

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Table 4: AOI fixations dependent on task and uncertain (2%) vs. impossible (0%) probabilities.

	Fixations on winning/losing %		Fixations on winning/losing $	
Type of task (0 = attractiveness; 1 = WTP)	.345*	(2.69)	.479**	(2.99)
Probability (1 = 0%; 0 = 2%)	−.303**	(−3.59)	−.276**	(−2.80)
Task x probability (1 = 0%; 0 = 2%)	−.221**	(−3.27)	−.220**	(−3.30)
Constant	3.456***	(17.65)	3.583***	(14.64)
Observations	1182		1182	

Note. *t* statistics in parentheses are based on robust standard errors and adjusted for 37 clusters of observation; + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

= −0.88, p = .385, and b = −0.06, $t(37) = -0.56$, p = .581 for probabilities and outcomes, respectively).

Overall these results demonstrate that, in line with Hypothesis 3a and 3b, a 98% probability attracts more attention than a 100% probability, possibly because it may be harder to process or represent mentally. Likewise, a 2% chance seems to attract more attention than 0%. Additionally, the interactions with the type of task further suggest that this effect is stronger when subjects set a price for the gambles compared to rating the gambles' attractiveness.

3.4 Compatibility effect in the evaluation of gambles

According to the compatibility effect, valuations should be influenced more by outcomes when they represent prices rather than attractiveness ratings. Therefore, we regressed gamble outcomes, type of task (WTP vs. attractiveness ratings), and the interaction on subjects' evaluations separately for winning and losing outcomes. For winning outcomes, results indicated that valuations were higher as gamble outcomes increased, b = .45, $t(37)$ = 13.87, p <.001, that valuations were higher for attractiveness ratings than prices, b = −.46, $t(37) = -7.51$, p <.001, and also a significant interaction between gamble outcomes and task, b = .24, $t(37)$ = 5.2, p <.001. As expected, the influence of gamble outcomes had a stronger effect on valuations in the WTP-task, b =.69, $t(37)$ = 11.35, p <.001, than in the attractiveness rating task, b = .20, $t(37)$ = 3.89, p <.001. For losing outcomes, results were similar such that valuations were significantly predicted by gamble amount, b = −.39, $t(37) = -9.42$, p <.001, by task, b = −.19, $t(37) = -3.00$, p <.01, and the interaction, b = −.42, $t(37) = -8.87$, p <.001. Importantly, gamble amount was predictive of valuations only in the WTP-task, b = −.81, $t(37) = -10.43$, p <.001, and not in the attractiveness rating task, b = .03, $t(37)$ = 0.66, p=.514. Additionally, we also tested whether valuations were more influenced by the gambles' percentage to win when the task was to provide attractiveness ratings rather than WTP-prices (as would be predicted by the compatibility effect). A regression with gamble percent, type of task, and the interaction on subjects' evaluations for winning gambles revealed a main effect for gamble percent, b =.69, $t(37)$ = 14.36, p <.001, and task, b = −.24, $t(37) = -5.21$, p <.001, in addition to a significant interaction, b = −.10, $t(37) = -3.06$, p <.01. As expected, the relationship between gamble percent and evaluations was stronger in the rating task, b = .79, $t(37)$ = 13.75, p <.001, than in the WTP-task, b = .59, $t(37)$ = 10.02, p <.001. For losing gambles, valuations were also significantly predicted by percentages, b = .08, $t(37)$ = 2.19, p <.05, by task, b = .31, $t(37)$ = 6.49, p <.001, and the interaction, b = .44, $t(37)$ = 9.05, p <.001. Not surprisingly, while increasing percentages decreased attractiveness ratings, b = −.36, $t(37) = -5.25$, p <.001, it increased WTP (for not having to play the gamble), b = .52, $t(37)$ = 10.06, p <.001. The above results are in direct support of the compatibility effect and Hypothesis 4a.

Hypothesis 4b states that there should be a difference in the evaluation of alternatives offering sure gains (or sure losses) versus uncertain gains (or uncertain losses) when subjects are asked to rate them rather than to set a price. Both z-scores and rescaled means for gains and losses at the different probability levels are presented in Table 5.

To test whether alternatives with sure and uncertain outcomes will be evaluated differently depending on the response mode (Hypothesis 4b), we conducted regression analyses with the type of task (WTP vs. attractiveness ratings), type of probability (sure outcome vs. uncertain outcome), type of outcome (wins vs. losses) and the respective interactions as predictors of evaluations. Results are detailed in Table 6. According to Hypothesis 4b, we expected that valuations for sure (and impossible) vs. un-

Table 5: Evaluation of alternatives in the two experimental tasks (both raw and rescaled means).

			Probability							
			0%		2%		98%		100%	
Gain frame	Z-scores	WTP (SE)	−.61	(.08)	−.53	(.10)	.55	(.11)	.65	(.13)
		Attractiveness (SE)	−.49	(.11)	−.07	(.09)	1.16	(.07)	1.40	(.06)
	Rescaled data	WTP	.69		.94		4.22		4.52	
		Attractiveness	−2.73		−1.29		2.99		3.82	
Loss frame	Z-scores	WTP (SE)	−.57	(.07)	−.47	(.07)	.47	(.09)	.56	(.12)
		Attractiveness (SE)	−.08	(.11)	−.45	(.10)	−.95	(.09)	−.99	(.12)
	Rescaled data	WTP	.82		1.11		3.93		4.25	
		Attractiveness	−1.32		−2.58		−4.32		−4.47	

Note. Z-scores were computed separately for WTP and attractiveness trials. Rescaled WTP scores denote actual prices in Euros, and rescaled attractiveness ratings ranged from −5 to +5.

certain outcomes depend on the type of task. The significant interactions between the type of probability and task for the comparison between 0% vs. 2% supports our hypothesis. However, this interaction was not significant for the comparison between 98% vs. 100%. The significant three-way interaction further suggests that the interaction between probability type and task depends on whether the gamble outcomes were positive or negative. For positive outcomes, subjects gave higher valuations for gambles with a 2% vs. a 0% chance of winning, but this effect was stronger for attractiveness ratings than for WTP-prices, b = .33, t (37) = 3.42, p <.01. For negative outcomes, subjects gave higher valuations for gambles with a 0% vs. 2% chance of losing, but again this effect was stronger for attractiveness ratings than for WTP-prices, b = −.46, t (37) = −5.54, p <.001. For gambles with 98% vs. 100% chances of winning (losing), the pattern of results looked similar but failed to reach significance both for winning gambles and losing gambles (ps > .17). Overall, these results demonstrate that the difference between impossible and uncertain outcomes primarily emerges in ratings of attractiveness but not when subjects focus more on payoffs making the difference between probabilities less relevant. Results for sure vs. uncertain outcomes were less clear, which might have resulted from a lack of power in these conditions.

Finally, we also examined whether valuations of gambles were predicted by fixations on information regarding the gamble's outcome (i.e., amount to be won or lost) and respective percentage, and whether this was dependent on the type of task. We ran separate regression analyses for positive and negative outcomes, in which subjects' valuations of the gambles were predicted by the proportion of fixations on outcome, respective probability, and the two-way interactions with task type. Results in Table 7 show that (apart from the main effects for task) fixations on outcomes as well as fixations on probabilities increased valuations for gambles. With the exception of fixations on probabilities for loss gambles, these effects were not task dependent. For loss gambles, more fixations on percentages increased people's willingness to pay (to not play the gamble), b = .20, t (37) = 4.06, p <.001, while it did not change attractiveness ratings, b = −.06, t (37) = −1.00, p =.325.

4 Discussion

The present paper used an eye-tracking technique to assess the effect that a specific set of variables has on the strategies used to process and evaluate these monetary prospects. In particular, we manipulated the type of task (response mode: WTP vs. attractiveness rating), the amounts to be won (lost), and the probabilities associated with the outcome of simple gambles (sure or impossible outcomes vs. uncertain, almost sure or almost impossible ones).

The objective of manipulating the response mode was to replicate and extend previous findings that have demonstrated that people attend significantly more to the outcomes of a gamble in a WTP-task compared with choice and rating tasks (Schkade & Johnson, 1989). Further, we argue that people do not just attend more to out-

Table 6: Evaluation of alternatives dependent on task, outcome, and probability.

	Valuations 2% vs. 0%		Valuations 98% vs. 100%	
Outcome type (0 = losses; 1 = gains)	.373***	(4.10)	2.113***	(16.80)
Probability type (0 = uncertain; 1 = sure)	.367***	(5.03)	−.042	(−.79)
Type of task (0 = attractiveness; 1 = WTP)	−.024	(−.23)	1.416***	(9.71)
Outcome type x probability	−.781***	(−6.00)	.284***	(3.91)
Outcome type x task	−.427***	(−3.75)	−2.026***	(−11.86)
Probability x task	−.463***	(−5.54)	.139	(1.80)
Outcome type x probability x task	.794***	(5.40)	−.280*	(−2.21)
Constant	−.449***	(−4.69)	−.951***	(−10.60)
N	1182		948	

Note. *t* statistics in parentheses are based on robust standard errors and adjusted for 37 clusters of observation; Valuations were standardized; + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 7: Evaluation of alternatives dependent on task, fixations on outcome and fixations on probability.

	Valuations 2% vs. 0%		Valuations 98% vs. 100%	
Type of task (0 = attractiveness; 1 = WTP)	−.246***	(−5.16)	.172**	(2.95)
Fixations on Outcome	.126*	(2.25)	.116*	(2.13)
Fixations on Probability	.178***	(3.96)	.099**	(3.10)
Task x Fixations on Probability	−.049	(−1.17)	.141**	(2.97)
Task x Fixations on Outcome	−.023	(−.51)	.055	(1.15)
Constant	.242***	(4.86)	−.210***	(−3.59)
N	1182		944	

Note. *t* statistics in parentheses are based on robust standard errors and adjusted for 37 clusters of observation; variables were standardized; + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

comes when asked to set a price but they exert more effort in doing this. In other words, we maintain that WTP-evaluations are made relying on deliberative thinking processes whereas attractiveness ratings are based on more holistic processes. The eye-tracking methodology allows us to reach a more precise conclusion on this issue than previous data from the Mouselab computer-based process-tracing technique (Schkade & Johnson, 1989).

Results confirmed that outcomes of gambles are given more weight in the WTP-task compared to the rating task. Subjects attended more to this information when they had to provide a price, whereas the attention directed to outcomes and probabilities was not significantly different when subjects were asked to judge the gambles' attractiveness. In addition, AOI-fixations, fixation duration, and average pupil dilation were greater for the WTP-task compared with the rating task. These results support our hypothesis that subjects engage in a more careful and deliberative information acquisition and thinking process when setting a price for playing (or not playing) a gamble. This is a possible reason that leads to weighting outcomes more highly in the WTP-task, since people may need to think consciously about the trade-off between what they pay and what they may get in exchange or even calculate the expected value of the gamble. These findings are consistent with an explanation of the task effect based on dual-process models (see Epstein, 1994; Chen & Chaiken, 1999; Evans, 2008), in which ratings are based on somewhat more holistic processes than setting prices. As we stated earlier, we define deliberative and holistic processing as conscious versus automatic rather than analytic versus affective. This is an important clarification since we are not suggesting that specifying a price is necessarily a task requiring a cold, analytical processing, but rather that the higher effort exerted in this condition is a consequence of the need for conscious evaluation of different pieces of information, possibly including affective reactions. Therefore, our conclusion is not in contrast with the fact that attending to more information could be a way to fine-tune the affective reactions induced by the components of a gamble.

To our knowledge this is the first time that the compatibility effect is linked with dual-process theories and with the use of different thinking processes in pricing tasks versus rating tasks. Setting a price requires an evaluation of the amount of the win (loss) but also a trade-off between costs and benefits. Differently, ratings of attractiveness seem to be more holistic and based on a more general perception of the stimuli, which relies on a more balanced attendance to the different characteristics of stimuli (in our case the amount of the gain (loss) and the associated probability).

In addition, we manipulated the amount to be won (lost) to assess whether it had any impact on the way subjects process information about the gambles. A first contribution of this manipulation was to extend the compatibility effect to alternatives entailing a clear loss. Previous findings have shown that task-response compatibility and preference reversals can be obtained not only when presenting people with pairs of mixed gambles having positive expected values, but also presenting them with pairs of mixed gambles having negative expected values (Lichtenstein & Slovic, 1973). However, previous studies have not tested the compatibility effect with simple gambles offering only a loss. As postulated by prospect theory (Kahneman and Tversky, 1979) people react differently to gains and losses and are more sensitive to results involving negative outcomes than positive ones (i.e., loss aversion). It is noteworthy that the greater weight attached to outcomes in WTP-tasks is present not only when people evaluate simple gambles and alternatives with sure outcomes offering a monetary gain but also when they evaluate simple gambles and alternatives with sure outcomes offering a monetary loss.

Further, using both alternatives offering gains and alternatives offering losses in the specific context of an eye-tracking study we were able to assess whether information processing depended on the amount to be won (or lost). Results demonstrated that the overall number of fixations was higher when the outcome amount decreased, suggesting that higher losses induce people to scan information more carefully and engage in more deliberative information processing. These findings are not only consistent with the notion of loss aversion (Kahneman & Tversky, 1979), but also with work showing that people's attention is more sensitive to negative information and events (Baumeister et al., 2001; Fischer et al., 2007; Rozin & Royzman, 2001).

Our investigation of the different levels of probability was designed to explore whether processing of certain vs. uncertain outcomes also involves qualitatively different processing modes. In doing so, we assessed both ends of the probability continuum. Our findings are consistent with previous research on the certainty and reflection effects demonstrating that sure outcomes have a special status in people's mind and are usually preferred to an alternative with uncertain outcomes in the gain frame, whereas they are often rejected in the loss frame (Kahneman & Tversky, 1979). We found that sure outcomes tend to attract less attention since there are fewer fixations when subjects evaluate these alternatives than when they evaluate uncertain ones. Similar results were found for both ends of the probability continuum. A 0% chance to gain (or lose) attracted less attention than a low, almost non-existing chance (2%) to obtain the same outcomes. In the same way, a 100% chance to gain (or lose) attracted less attention than a high, almost certain chance (98%) to obtain the same outcomes. In both cases subjects engaged in fewer fixations on those probabilities that correspond with the end points of the scale (0% and 100%), therefore hinting that these two pieces of information are indeed easier to evaluate (e.g., expected-value calculations should be easier).

Finally, after assessing the eye-tracking indexes related to cognitive effort, we looked into the effect that our independent manipulation had on the evaluation of the different alternatives. Results revealed a substantial difference between the two tasks. When people had to rate the attractiveness of alternatives they were influenced by the probabilities whereas in the pricing task, outcomes seemed to be more important. These results provide evidence of the effect that different processing strategies activated by variations in contextual factors (i.e., the task used to elicit preferences or the degree of uncertainty) may have on people's preferences.

On the basis of our results we argue that the compatibility effect is related to the different thinking strategies people use when providing a price rather than a rating. However, there is at least one alternative explanation that warrants further investigations. This explanation is based on the simple fact that WTP and ratings have different behavioral consequences, since specifying a price implies the chance of playing that amount of money for real, whereas a rating does not imply that the gamble will be played. Further research is required to understand how much this behavioral difference can influence people's preferences and interact with the use of different processing in rating and WTP.

Despite this limitation, the present work provides important evidence for the compatibility effect being linked to dual-process theories in an economic context. Consistent with this approach, we found that a pricing task is more likely than a rating task to engage people's attention and to induce them to exert more effort. We also demonstrated that contextual features of the alternatives can selectively activate different information processing strategies. For instance, we found that the uncertainty of the outcome is more likely than certainty to induce people to attend to more information.

Our results extend prior work on the role of attention in the construction of preferences (e.g., Armel, Beaumel, & Rangel, 2008; Ashby, Dickert, & Glöckner, 2012; Dickert & Slovic, 2009; Shimojo, Simion, Shimojo, & Scheier, 2003; Willemsen et al., 2011) and dual information processing in the classic finding of preference reversals in the compatibility effect (Schkade & Johnson, 1989). It is quite likely that the influence of deliberative vs. holistic processing is not restricted to preferences regarding simple gambles. However, future research should critically investigate the role of cognitive processes underlying response mode effects in different domains.

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