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THE INFLUENCE OF VISUALIZATION ON INTUITIVE AND ANALYTICAL INFORMATION PROCESSING*

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ABSTRACT

To test the assumption in cognitive-experiential self-theory (CEST) that visualized experience is similar to real experience in people's intuitive-experiential system but not in their analytical-rational system, participants responded to a verbal description of the ratio-bias (RB) game of chance with and without vivid visualization of the situation. In real situations, people have consistently been willing to pay small sums of money for the privilege of drawing from a bowl that offered 10 winning items out of 100 in preference to one that offered 1 winning item out of 10. Some reported that although they "knew better," they "felt" they had a better chance of drawing a winning item when there were more of them. Interestingly, this irrational response does not occur when people are simply asked what they believe they would do in a real situation. In support of prediction, vivid visualization of a verbal description of the game of chance reproduced the phenomenon that otherwise occurs only in real situations. Several subsidiary predictions based on CEST were also supported, including the biasing effect of intuitive-experiential thinking on subsequent attempts to think rationally. This effect, which has been demonstrated in several other situations, has important implications for understanding human irrationality.

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INTRODUCTION

According to cognitive-experiential self-theory (CEST), imagined experience is similar to real experience in a person's experiential (intuitive) mode of information processing. We tested this hypothesis in the present study with the ratio-bias (RB) experimental paradigm, which is ideally suited for the purpose because it produces different results when presented in the form of a verbally simulated situation and a real situation. We hypothesized that vividly visualizing the verbally presented situation would produce results similar to the results repeatedly obtained in real situations but not found in verbal presentations without visualization.

In the remainder of this introduction, we discuss the effects of imagining events in different kinds of situations. We next summarize the more relevant aspects of CEST that provide the broader theoretical context that was the source of our predictions. This is followed by a description of the RB phenomenon and an explanation of why it occurs that is based on the operating principles of the experiential system, as proposed by CEST. Finally, we describe our strategy for testing our predictions.

Practical Implications of Imagery and Imagination

One of the most important practical implications of the ability to imagine events is its usefulness in planning [1]. By imagining alternative actions and outcomes, people can make decisions in a more flexible, innovative, and safe manner than if they had to rely exclusively on real-world experience. In an interesting series of experiments, Taylor and her associates demonstrated that mentally practicing effective ways to study, including the allocation of study time, resulted in an increase in real study time as well as an improvement in examination grades [1]. They also demonstrated that practicing coping with imaginary daily events improved emotional and behavioral coping with real life events. In contrast, imagining favorable outcomes in the absence of imagining the processes responsible for the outcomes, a procedure widely advocated in the popular self-help media, at best made no difference and at worst resulted in poorer performance.

What evidence is there for the effectiveness of imagery in its various applications, and why is it effective when it is? It is beyond the scope of this article to review the literature on the effectiveness of imagery. For present purposes, it will have to suffice to simply note that the effectiveness of some uses of imagery—such as its use in memory facilitation (e.g., [2, 3], in physical skill training, in some cognitive-behavioral therapies such as systematic desensitization [4], and in the control of body functions with the aid of biofeedback are well documented. Other uses of imagery, such as in training people to develop effective studying and coping habits (e.g., [1]), have received initial support but require further verification, and yet other uses, such as in the treatment of serious diseases, remain to be

adequately tested. At this point, it may be concluded that the usefulness of imagery has been well substantiated in some important areas and is a promising area for research in others.

It is important to determine why imagery is effective when it is. The reason for its effectiveness in certain situations, according to CEST, is that imagery communicates with the experiential system in its own medium, namely imagistic representation (or its functional equivalent). As a result, imagined experiences can elicit reactions similar to real experiences in the experiential system. In addition, because of the intimate relation of emotions to experiential processing [6-8], imagery may be useful in the treatment of physical illness. Because imagery through its communication with the experiential system can influence emotions, it can influence endocrine and immune functioning, thereby providing a pathway by which imagery can influence physical illness.

Before proceeding further, it will be helpful to provide a brief review of the more relevant aspects of CEST, the theory that provided the framework for the study to be reported.

Cognitive-Experiential Self-Theory

According to CEST, people process information by two independent, interactive systems, experiential and rational. These provide two fundamental ways of adapting to the world, one based on automatically learning from experience and the other on logical inference. The experiential system is a learning system that is essentially the same system with which non-human higher order animals have increasingly effectively adapted to their environments over millions of years of evolution. It operates in a manner that is automatic, preconscious, rapid, primarily imagistic, concrete, associative, and holistic, and it is intimately associated with affect. Because it is a learning system, the implicit schemas in it consist mainly of generalizations from past experience. The experiential system encodes information primarily in the form of images (or their functional equivalent), with the lowest level of organization consisting of relations between single stimuli and responses as in classical conditioning, and the higher levels consisting of more complex representations including scripts and narratives. As representation in the form of images is but one of many features of experiential processing, events can be processed primarily experientially even if some of the features of the experiential system are not present. For example verbal presentations can be processed primarily experientially if they evoke images and emotions.

In contrast to the experiential system, the rational system operates in a manner that is relatively effortful, primarily conscious, primarily verbal, analytical, and affect-free, and it derives its schemas from logical inference. Unlike the experiential system, the rational system is well suited for comprehending abstract relations and long-term consequences. As language is a comparatively recent evolutionary development, it follows that the rational system has a very brief

evolutionary history, and its long-term adaptive value remains to be demonstrated (see Table 1 for a more thorough comparison of the operating principles of the two systems).

Although each of the systems can influence the other, they do so in different ways. As a more rapid, preconscious system, the experiential system is able to bias the rational system outside of a person's awareness. This is not meant to imply that people cannot become aware of the operation of their experiential system, but only to indicate that most of the time people are likely to be unaware of its operation. In the absence of awareness, the influence of the experiential tends to be rationalized, so people usually believe their thinking is rational and uninfluenced by other sources. Recognition of the pervasive influence of the experiential system on the rational system is particularly important because it can explain almost everything that the Freudian unconscious can and much that it cannot, and it can do so in a scientifically more defensible manner consistent with evolutionary theory [6].

As a slower, conscious system, the rational system can inhibit the expression of experientially determined thoughts and behavioral tendencies. An example is someone deciding not to act on the thought that she would like to tell off her boss. The rational system also influences the experiential system unintentionally by being the source of associations in the experiential system. Consider, in this respect, a student who fails to solve a mathematics word problem because the content produces associations that are distressing or distracting. (For further discussion of the interaction of the two systems as well as supporting evidence, see Epstein and Pacini [8].)

According to CEST, behavior is normally a joint product of the two systems, with their relative contribution varying on a bipolar dimension from complete dominance by one system to complete dominance by the other. It is rare, however, for behavior to fall completely at either end of the continuum. Much more often behavior represents a compromise between the two systems.

The Ratio-Bias Phenomenon

The ratio-bias (RB) experimental paradigm refers to a game of chance that has been presented in two versions of particular relevance to the present research. One version consists of a real-life situation with monetary payoffs. The other consists of a simulated situation in the form of a verbal description without payoffs. In the real-life version, participants are presented with two trays of jellybeans, a smaller tray that contains 10 jellybeans, 1 of which is red and 9 of which are white, and a larger tray that contains 100 jellybeans, 10 of which are red and 90 of which are white. Participants are informed that on every trial in which they draw a red jellybean they will receive $2.00. The examiner, after scrambling the beans and screening them from view, asks the participants from which tray they wish to draw. Most behave in accordance with the RB phenomenon (the irrational preference for the large tray) by choosing to draw from the large tray. They also willingly

Table 1. Comparison of the Experiential and Rational Systems

Experiential system	Rational system
1. Holistic	1. Analytic
2. Automatic, effortless	2. Intentional, effortful
3. Affective: Pleasure-pain oriented (what feels good)	3. Logical: Reason oriented (what is rational)
4. Associationistic connections	4. Logical connections
5. Behavior mediated by "vibes" from past events	5. Behavior mediated by conscious appraisal of events
6. Encodes reality in concrete images, metaphors, and narratives	6. Encodes reality in abstract symbols, words, and numbers
7. More rapid processing: oriented toward immediate action	7. Slower processing: oriented toward delayed action
8. Slower and more resistant to change: Changes with repetitive or intense experience	8. Changes more rapidly and easily: changes with strength of argument and new evidence
9. More crudely differentiated: Broad generalization gradient; stereo-typical thinking	9. More highly differentiated
10. More crudely integrated: Dissociative, emotional complexes; content-specific processing	10. More highly integrated: Content-general principles
11. Experienced passively and preconsciously: we are seized by our emotions	11. Experienced actively and volitionally: we are in control of our thoughts
12. Self-evidently valid: "Experiencing is believing"	12. Requires justification via logic and evidence

Note: Adapted with permission from [9].

pay dimes for the privilege of doing so, rather than having the choice decided by the toss of a coin. As they pay, some remark that they know it is foolish to pay to choose between equal probabilities, but they feel they have a better chance of obtaining a red jellybean when there are more of them [10].

In the simulated version, participants are given a verbal description of the situation and asked to indicate how they would behave in a real situation. Most say they would have no preference and would not pay a cent to choose between two equal probabilities. However, when they are asked how they believe others would behave, most state that others would prefer to draw from the large tray and would pay to do so [10]. This suggests that they are aware of a tendency to prefer the large tray but assume that although others would behave according to this tendency, they, as more logical people, would not.

The RB phenomenon has been demonstrated to be highly robust, as indicated by its replication in nine out of nine experiments (reported in [10-15]). That it is not simply an interesting but inconsequential laboratory exercise is indicated in several ways. Included is its significant relation with gambling behavior [11], with heuristic responses to vignettes [11], with measures of depression [15], and with measures of individual differences in intuitive and analytical thinking styles [13]. Most important, however, is its theoretical significance, for it provides a uniquely effective procedure for examining a conflict between the two processing modes and its resolution under various conditions.

How is the difference in the results between the real situation and the simulated situation to be explained? An explanation suggested by CEST is that the experiential system is sufficiently strongly engaged in real but not in simulated situations to override the desire of people to view or present themselves as rational.

The Present Experiment

The present experiment is part of a series of investigations on the validity of the principles of experiential processing proposed by CEST (see Table 1). By now, nearly all of the principles in Table 1 have received experimental support, and when this has not been practical or possible have been strongly conceptually supported (see review in [8]). The principle of imagistic representation is among the few for which experimental investigation is possible that have not been previously examined. The present study investigates this principle with the RB experimental paradigm. Apart from its significance for the validity of CEST, the issue of whether visualized experience produces results similar to real experience has obviously important applied as well as theoretical implications.

In the present experiment, we presented the simulated version of the RB experimental paradigm with and without visualization. The condition without visualization will be referred to as the standard condition. Participants responded from three perspectives: how they believed they would behave in a real situation, how they believed most people would behave, and how they believed a completely

logical person would behave. Having participants respond from a self- and others-perspective is the same procedure previously used in research with the simulated version of the RB paradigm [10]. Having them respond from a logical perspective is new. In previous research with the RB paradigm, we assumed that everyone was aware of the rational response because it seemed self-evident to us. This assumption was supported by several participants who spontaneously remarked that they knew it was foolish to behave contrary to the probability information but nevertheless, they felt their chances of getting a red jellybean were greater when there were more of them. Of course, observing that some individuals respond this way does not necessarily mean that everyone responds that way. In the present experiment, we directly tested the assumption that people know the rational response by having all participants respond from the perspective of a logical person.

The use of the different perspectives also follows from the assumption that people are intuitively aware of two modes of information processing and that they can choose, within limits, to respond from either mode. Both assumptions have received some support in previous research (e.g., [6, 8, 16]).

Once the experiential mode is strongly engaged, as it is assumed to be during vivid visualization, the question may be raised as to whether it influences subsequent attempts to respond rationally. According to the interactive view of CEST, the more the experiential system is engaged, the more likely it is to influence subsequent attempts to think rationally. Past research from a variety of sources has supported this assumption [16-19]. Demonstrating its occurrence in response to the RB paradigm would further extend the generality of this important phenomenon. It is important because the influence of experiential on rational thinking has significant implications for irrational decision-making.

To test for the influence of experiential on subsequent rational thinking, we varied the sequence of the standard and visualization presentations. One group received the visualization condition followed by the standard condition and the other group received the reverse order. We expected responses to the standard condition when it followed the visualization condition to exhibit a particularly strong RB effect, indicative of enhanced experiential processing. To reduce the likelihood that an implicit demand characteristic to please the examiner would produce spurious support for our hypothesis, we told participants that we wanted them to try to discount the influence of the preceding visualization experience.

Based on the assumptions that small numbers are more concrete than large numbers and that concreteness can be determined by whether an item can be visualized [2, 3], we expected people to be better able to visualize a tray containing a smaller than a larger number of jellybeans. The importance of establishing that smaller numbers are easier to visualize than larger numbers is that it plays a critical role in our explanation of why we have been able to demonstrate the RB effect with

low, but not with high, probability ratios [14]. The explanation is as follows. In a low probability condition (e.g., 10 percent) represented by a ratio of relatively small numbers (e.g., 1 in 10), both the numerosity of the target items and the "small-numbers effect" (i.e., the greater comprehensibility in the experiential system of smaller than of larger numbers and therefore of ratios expressed in smaller than in larger numbers) operate in the same direction, with both favoring selection of the large tray. Expressed otherwise, the large tray is more attractive than the small tray because it contains more red jellybeans, and the small tray is less attractive than the large tray because it more compellingly conveys a likelihood of an unfavorable outcome, which therefore also operates in favor the large tray. By the same reasoning, in high probability conditions (e.g., 90 percent), the two effects operate in opposite directions, thereby tending to cancel each other out. That is, the numerosity of the target items favors the large tray and the small-numbers effect favors the small tray (as it more compellingly suggests a favorable outcome). As a result, there is either no RB effect or a weak positive or negative effect [14].

Summary of Predictions

1. In responses from a self-perspective, a RB effect will be found in the visualized condition but not in the standard condition. This prediction is based on the assumption that vividly visualized experience is similar to real experience. It follows that a visualized presentation of a simulated situation should reproduce results found in real situations and different from results obtained in simulated situations without visualization.
2. In responses from an others-perspective, a RB effect will be found in both the visualization condition and the standard condition. This prediction follows from the assumptions that the vividly visualized simulated situation will replicate previous results with real situations and that the standard situation will replicate previous results with standard situations.
3. In responses from a logical-perspective, a RB effect will not be found in either the visualized or standard conditions. This prediction follows from the assumption that most people are aware of the rational way of responding (although they often choose not to respond that way in real or vividly visualized situations).
4. Responding to the RB paradigm primarily in an experiential mode (i.e., self- and others-perspective) will influence subsequent responses in a rational mode (i.e., logical perspective). This prediction is based on the assumption in CEST that the experiential system influences the rational system.
5. People can better visualize smaller than larger numbers and therefore ratios expressed in smaller than in larger numbers. This follows from the assumption that smaller numbers are more concrete than larger numbers.

METHOD

Participants

Undergraduate volunteers (21 men, 90 women) participated in exchange for credit toward their psychology classes. They were told that the study concerned the role of imagination in a game of chance. To be included in the data analysis, participants had to meet two criteria. First, they had to report unfamiliarity with the RB phenomenon. None reported that they had previously encountered or heard about it. Second, participants had to report that they had been able to visualize the jellybeans in the experiment at least "fairly well." Reports of ability to visualize the situation were as follows: 40 percent very well; 43 percent fairly well; 13 percent moderately; 3 percent slightly; 1 percent not at all.

Data from those who reported that they could visualize less than "fairly well" ($N = 19$) were analyzed separately. The good jellybean visualizers ($N = 92$) also reported being significantly better visualizers "in general" ($M = 2.30$) than the poor jellybean visualizers ($M = 1.74$), $t\,(109) = 4.08$, $p < .000$.

Participants were divided into two sequence groups according to whether they received the standard condition followed by the visualization condition (SV, $n = 39$) or the reverse (VS, $n = 53$).

Instructions for the Standard and the Visualization Conditions

Following are the instructions for the standard condition:

> Assume that you are presented with two trays of red and white jellybeans. A small tray contains 10 jellybeans, nine of which are white and one of which is red (10% are red). A large tray contains 100 jellybeans, 90 of which are white and 10 of which are red (10% are red). The jellybeans are spread in a single layer in their trays. You must draw (without peeking of course) one jellybean from the tray of your choice. Before each trial, the beans are scrambled so it is of no use to try to remember where they were located. On each trial in which you draw a red jellybean, you win $2.00.
>
> What is interesting about this situation is that we have found in previous research that although both trays offer identical odds of winning, some people show a distinct preference for one tray over the other. Your job is to estimate how *most* people choose. We are also interested in your own preference and in your impression of how a completely logical person would react in a real situation.

The second paragraph of the instructions (see above) was carefully worded to avoid biasing responses. By including the statement about "some people" showing a preference, we hoped to make the participants feel that it was acceptable to report that most people do or do not have such a preference.

Recorded Instructions for Visualization

In the visualization condition, the identical description of the experimental situation was presented, after which recorded instructions for relaxation and visualization were given (see below). First, participants listened to a relaxation exercise modeled after the Jacobson muscle-relaxation procedure [20], after which they listened to the following visualization instructions:

> Keep the state of relaxation as you try to visualize the two trays of jellybeans as clearly as you can. Clearly visualize the small tray with 1 red bean and 9 white beans. See the jellybeans as clearly as you can. See them so clearly that you would have no trouble in painting a picture of them. Now switch to the larger tray. Visualize the larger tray of jellybeans with 10 red jellybeans and 90 white jellybeans. Visualize the beans as clearly as you can. Get a clear visual impression, just as if you were actually seeing them. What I would like you to do next is to switch back and forth between the two trays of beans until you have a very clear sense of which way it is easier to get a red bean. When you have that sense, please respond to question 1 on the answer sheet in front of you. Use as a guide to how most people would respond the way it seemed easier in your imagination to get a red bean.

We included the last instruction because previous research suggested that most people estimate how others respond based on their own response tendencies. We deemed it preferable for all participants to respond to the same explicit instructions rather than to their own different self-instructions.

After the visualization condition, participants reported whether they had previous knowledge of the experiment. They then answered the following questions:

- How well were you able to imagine the jellybeans? __not at all; __slightly; __moderately; __fairly well; __very well.
- Which were you able to visualize more clearly? __the beans in the large tray; __the beans in the small tray; __neither (both about equally).
- In general, how good are you at visualizing things? __not at all, I am not a visual person; __below average; __above average; __very good, I am a highly visual person.

Experimental Design and Procedure

The data were analyzed in a mixed design with one between-subjects variable (sequence) and one within-subjects variable (visualization vs. standard condition). Participants were tested in groups of 15 to 20 participants. They received the RB task in one of two sequences: standard condition before visualization condition (Sequence SV) or the reverse order (Sequence VS). In each condition, participants indicated their tray preference (small, large, or no difference) from each of three perspectives: how most people would choose (others-perspective); how they

themselves would choose (self-perspective); and how a completely logical person would choose (logical-perspective).

The experimenter read the instructions aloud and asked the participants to read along on their own forms. Instructions varied by visualization condition and sequence. When the standard condition was first, participants first completed the RB task without further instructions. In the visualization condition that followed, the experimenter read the following additional instructions:

> Please try to vividly imagine the jellybeans. We are interested in whether imagining the jellybeans makes a difference. You may find that it makes a difference or that it makes no difference. The instructions for imagining the jellybean game are recorded. Please listen carefully to the instructions, and do your best to imagine the situation as instructed.
>
> While I read the first two paragraphs out loud, I would like you to read along to yourself. Next, I will play a tape that will instruct you on visualization. The important thing is to get into a state where you visualize the jellybeans as clearly as possible. Please listen very carefully, and do your best to follow the instructions. When the tape is over, please answer the questions on the form.

The participants were then presented with the recorded instructions for relaxation and visualization.

The instructions for the standard condition when it was presented second were as follows:

> In the next part of the experiment, please read about the jellybeans without trying to vividly visualize them this time. We are interested in whether visualizing the jellybeans makes a difference, so we need a comparison of conditions with and without visualization. One group receives a standard condition, without visualization, followed by the visualization condition. Another group, the one to which you have been assigned, receives the visualization condition first and the standard condition next. It is important, for the next part of the experiment, that you try your best to discount the influence of the visualization condition. Put the visualization condition behind you and approach the task fresh, as if you had not had previous instructions to vividly imagine the jellybeans. Do not feel you have to change your responses from the previous condition. It is up to you to indicate whether visualization does or does not influence your responses.

As indicated in the introduction, we did not expect participants to succeed in discounting the impressions they had gained in the visualization condition. We nevertheless asked them to try to discount the effects of the visualization to show that even when instructed to do so they are unable to discount the experience. We also wished to counter a possible implicit demand for producing a positive sequence effect, i.e., for participants to try to please the examiner by showing that the visualization experience influenced their subsequent responses in the standard condition, which they might believe the examiner wanted. In any event, given the

discounting instructions, any finding of a biasing effect of visualization on subsequent responses in the standard condition could be regarded as conservative compared to results that would be obtained with an absence of discounting instructions. After participants completed the standard and visualization conditions, they returned the completed forms in an envelope. They were then thanked and debriefed.

RESULTS

The RB Effect as a Function of Visualization, Perspective, and Sequence

Table 2 summarizes the percentage of tray choices and no-preference responses in the visualization and standard conditions from each perspective. Although most participants expressed a tray preference when responding from the others- and the self-perspectives, a considerable majority (72 to 74 percent) indicated no preference when responding from the logical-perspective. To test for the RB effect (preference for the large tray) in each condition, large- and small-tray choices were compared by chi-square analysis to an expectancy of an equal division.

It will be recalled that predictions about the influence of visualization and of response-perspectives on the RB effect were as follows: In responses from a self-perspective, a RB effect will be exhibited in the visualization condition but not in the standard condition. In responses from an others-perspective, a RB effect

Table 2. Tray Selection by Visualization Condition and Perspective

	Tray selection			
	Small	Large	No preference	χ^2
Standard condition				
Others-perspective	19%	76%	5%	32.29***
Self-perspective	30%	42%	27%	1.81
Logical-perspective	12%	16%	72%	.62
Visualization condition				
Others-perspective	15%	80%	4%	40.91***
Self-perspective	16%	60%	24%	22.86***
Logical-perspective	10%	16%	74%	1.5

Note: $N = 92$. Chi-square tests (1 *df*) compared the frequency of large and small tray choices to the expectancy of an equal division.

***$p < .001$.

will be exhibited in both conditions. In responses from a logical perspective, a RB effect will not be exhibited in either condition.

Self-Perspective Responses

In support of the prediction about responses from a self-perspective, the RB effect in self-perspective responses was significant in the visualization condition but not in the standard condition. Among those who indicated a tray preference in the visualization condition, a significantly greater number preferred to draw from the large tray (79 percent) than from the small tray (21 percent), χ^2 (1, $N = 70$) = 22.86, $p < .001$. In the standard condition, there was no significant difference in preference in a similar comparison, with 58 percent choosing the large tray and 42 percent the small tray. Comparison of the responses in the visualization and standard conditions revealed that the large tray was selected significantly more often in the visualization condition than in the standard condition, χ^2 (1, $N = 24$) = 6.00, $p < .05$. Eighteen people selected the large tray in the visualization but not in the standard condition, and 6 showed the opposite pattern.

Among the poor visualizers, there were no significant RB effects in self-perspective responses in either condition. Exactly 50 percent selected the large tray in both standard and visualization conditions.

Others-Perspective Responses

In support of the prediction for others-perspective responses, significant RB effects occurred in others-perspective responses in both the standard condition, χ^2 (1, $N = 87$) = 32.29, $p < .001$, and the visualization condition, χ^2 (1, $N = 88$) = 40.91, $p < .001$ (see Table 2). Moreover, the two conditions did not produce different degrees of the RB effect. The difference in large-tray relative to small-tray selections among the 18 participants who responded differently in the visualization and standard conditions did not approach significance, χ^2 (1, $N = 18$) = .89. The results for the poor visualizers mimicked those for the better visualizers.

Logical-Perspective

In support of the prediction for logical-perspective responses, it can be seen in Table 2 that most participants reported that a logical person would not have a preference between the two trays. Nevertheless, a substantial number of participants (28 percent in the standard condition and 26 percent in the visualization condition) reported that a logical person would have a preference. Among these, the number of participants who reported that a logical person would favor the large tray over the small tray did not differ significantly from the number who believed the opposite. That is, there was no RB-effect.

No-Preference Responses

No-preference responses represent the rational judgment for deciding between two choices that have identical outcome-likelihoods. It can be seen in Table 2 that no-preference responses varied greatly as a function of perspective. The percentage of no-preference responses across conditions was greater from a self-perspective (26 percent) than from an others-perspective (4 percent), but considerably smaller than from a logical-perspective (73 percent). Apparently, the participants considered themselves more rational than most people but less rational than a completely logical person, consistent with previous research [10].

Sequence Effects

In support of prediction, the RB effect across all perspectives was greater in the standard condition when it followed than when it preceded the visualization condition. The opposite effect did not occur: presenting the standard condition first did not significantly influence responses in the visualization condition. This pattern occurred in responses from each of the perspectives. In others-perspective responses, the proportion of large tray choices was significantly greater (among those who expressed a preference) in the standard condition when it followed (88 percent) than when it preceded (70 percent) the visualization condition, χ^2 $(1, N = 87) = 4.25, p < .05$. This indicates that the previously reported finding of a significantly greater RB effect in the visualization condition than in the standard condition across sequences when participants responded from an others-perspective would be even stronger if the comparison were restricted to the first presentation (i.e., before presentation of the other condition).

In self-perspective responses, the percentages of large-tray responses in the standard condition (among those who expressed a preference) when it followed and when it preceded the visualization condition were, respectively, 69 percent and 45 percent, χ^2 $(1, N = 67) = 4.04, p < .05$. In logical-perspective responses, the corresponding percentages were 73 percent and 36 percent, χ^2 $(1, N = 26) = 3.55$, $p = .06$. It is noteworthy that a strong tendency toward a RB effect was observed in the standard condition from a logical- and a self-perspective only when they followed the visualization condition. This is consistent with the view, according to CEST, that experiential processing, once activated, biases subsequent attempts at rational processing. The results from the others-perspective responses suggest that strong engagement in experiential processing (as mediated by visualization) can make subsequent processing, even if primarily experiential to begin with, even more experiential. For the poor visualizers, there was no tendency in any of the conditions for a RB effect to be influenced by sequence.

Surprisingly, no sequence effects were found in any of the conditions with respect to the number of participants who chose the no-preference option. Apparently, the sequence effect influenced the RB effect only in those who were

sufficiently irrational as to have a preference between two equal probabilities. The percentages of no-preference selections in the standard condition when it preceded and when it followed the visualization-condition were, respectively, 21 percent ($N = 39$) and 32 percent ($N = 53$). The corresponding percentages for the others-condition were 5 percent ($N = 39$) and 6 percent ($N = 53$), and, for the logical-condition, 72 percent ($N = 39$) and 72 percent ($N = 53$). In no case did chi-square approach significance. Nor was there a tendency in any condition for a sequence effect in the no-preference selections of the poor visualizers.

Comparison of the Magnitude of the RB Effect in Imagined and Real Situations

Having established that responses from a self-perspective produced a RB effect in a simulated situation when participants vividly imagined the situation, the question remains as to how strong the effect was compared to the effect obtained in a real situation. To answer this question, the results in the present experiment from a self-perspective with visualization when presented first (i.e., before the presentation of the standard condition) were compared with those previously obtained in a real situation. Unfortunately, in the most comparable real situation, participants had to draw from one of two trays without a no-preference option. Thus, the results are not strictly comparable. Nevertheless, they are of interest as they can be interpreted within limits. In the visualization group, 76 percent expressed a preference for one of the trays. Among these, 79 percent chose the large tray. In the real situation, 77 percent chose the large tray. Thus, the results are almost identical. However, it should be considered that the figure for the large-tray preference in the visualization condition is probably inflated compared to that for the real condition because the more rational 24 percent of the participants who expressed no preference were not included in the visualization condition. A not unreasonable conclusion is that there is probably a slightly stronger RB effect in the real situation than in the visualized situation.

Visualization of the Two Trays

Forty-six percent of the participants reported better visualization of the small than of the large tray; 21 reported the opposite; and 33 percent reported equal visualization of the two trays. In support of prediction, significantly more participants reported that they were better able to visualize the small than the large tray than the opposite, $\chi^2(1, N = 61) = 8.67, p < .01$. As the ability to visualize an item is a recognized test of whether it should be regarded as concrete [2, 3], the results are consistent with the assumption that smaller numbers are more concrete than larger numbers.

The poor visualizers were evenly divided among those who reported that they were better able to visualize the small than the large tray (33 percent), the large than the small tray (33 percent), and both trays equally (33 percent).

DISCUSSION

The findings in the present study replicated previous findings and produced new findings that supported five predictions derived from CEST. The replicated findings include the occurrence of the RB effect in a simulated, standard (without visualization) situation when participants responded from the perspective of how they expected others to behave in a real situation. Also included was the absence of a RB effect when participants responded from a self-perspective. The new findings were as follows: 1) Visualization of a simulated situation produced a RB effect similar to that obtained in real situations and different from that obtained in the identical simulated situation without visualization. 2) When participants responded from a logical perspective, there was an absence of a RB effect in both the standard and the visualization condition. This establishes, for the first time, that most participants know the rational response despite often behaving otherwise. 3) A stronger RB effect was found in the standard condition when it was preceded by the visualization condition than when it was presented first. Of particular interest, this was not only true when participants responded from a self- or others-perspective, but it also occurred when participants responded from a logical-perspective. Although most participants, regardless of order of presentation, endorsed the "no-preference" option when responding from a logical-perspective, it is noteworthy that in the standard condition when it followed the visualization condition, among those who showed a preference, it was strongly in the RB direction. As will shortly be discussed, this finding has interesting implications for the influence of the experiential on the rational system. 4) Participants were better able to visualize a tray with a smaller number of jellybeans than one with a larger number. It will be recalled that this outcome is of critical importance in the explanation we offered of why the RB phenomenon can be demonstrated with small but not with large probability-ratios.

In the remainder of the Discussion Section, we consider the implications of each of the new findings.

Implications of the Finding that Responses to Visualized and Real Situations are Similar

The finding that visualization of a simulated situation produced results very similar to findings consistently obtained in previous research with real situations and different from results obtained in the identical simulated situation without visualization is consistent with the view in CEST that the experiential system encodes events primarily imagistically. To the extent this is true, imagined

experience functions in the experiential system in a similar manner as real experience. This can explain a wide variety of applied benefits that have been demonstrated and/or claimed for visualization and imagined experience. Included are coping with everyday stressful events [1, 21], various kinds of performance [1, 22], likelihood estimates and compliance [23], and the extinction of anxiety [4, 24], among other benefits. Although visualized experience is not as effective in changing behavior as real experience, it has many important advantages, including being safer, more flexible, more available, and less costly. A particularly useful way that visualization-as-vicarious-experience can be used, according to CEST, is as a source of self-knowledge [7], a topic to which we turn next.

According to CEST, important information about the reactions of the experiential system can be obtained by imagining oneself in personally significant situations. The knowledge consists of awareness of how the implicit beliefs that are activated in the situation automatically, and usually outside of awareness, influence one's feelings, conscious thoughts, and behavior. The procedure can best be described by the use of an example.

Ralph often thought he wanted a wife and children, but somehow he managed to avoid getting married, often at the last moment. In all of these situations, he was able to cite compelling reasons as to why he should not marry the person he had been seeing. After reading a book about CEST [25], it occurred to him that he may want to get married in his rational, but not in his experiential mind. To investigate this possibility, he used a procedure described in the book for examining implicit motivations in the experiential system. He began by adopting a relaxed, meditative state. After achieving it, he vividly visualized coming home after work to his wife and children. He let the scenario unfold naturally without attempting to direct it. As it unfolded, he carefully attended to his feelings and thoughts. To his astonishment, the feelings were unpleasant. He imagined his wife fussing about the children and paying little attention to him. When he protested to her about how he was being ignored, she accused him of being immature. He tried imagining pleasant scenes about coming home to his family, but they all turned sour. He found himself thinking, "If this is what marriage is going to be like, who needs it?"

From this brief exercise, Ralph became aware that, as much as he believed at the rational level that marriage was desirable, at the experiential level it was threatening. He realized that, should he get married, he would have to contend with distressing automatic reactions in his experiential system. His choice was either to give up the thought of marriage or to work on overcoming his negative automatic reactions.

Imagery and fantasy can also be used in ways that go beyond serving as vicarious experience. For example, it is possible to communicate with the experiential system at a symbolic level through the use of fantasy, and the knowledge gained thereby can be put to therapeutic use [25, 26]. However, it is beyond the scope of this article to discuss such procedures. An excellent source of

information about a wide variety of therapeutic uses of imagery and fantasy is a book edited by Singer and Pope [27].

Implications of Findings from Responses from a Logical-Perspective

In the present study, for the first time participants were asked to respond to the RB paradigm from a logical-perspective in addition to the other two perspectives. In support of prediction, an RB effect was neither found in the standard nor in the visualization condition from this perspective. Instead, most participants selected the "no-preference" option. This finding, although hardly surprising, indicates that most people are aware of the rational response despite often responding otherwise. It is of considerable interest because it indicates that even when the rational solution to a problem requires no more effort to access than an intuitive solution, people may prefer the intuitive solution in certain situations.

The fact that 27 percent of the participants failed to select the "no-preference" option when responding from a logical-perspective indicates that many people are far less sophisticated about rationality than one might suspect. However, it is consistent with the view in CEST that experiential processing often co-opts rational processing. Given experiential thoughts that are highly compelling, some people believe their experientially determined responses are rationally determined. That is, they "rationalize" their experientially determined behavior [6, 28]. It would be interesting in further research to examine the correlates of regarding experientially determined responses in the RB paradigm as rational. One would suspect that individuals who behave in this manner when responding from a logical perspective may be hysterical in temperament and more easily hypnotized than those who behave more rationally.

Implications of Experiential Processing Influencing Subsequent Rational Processing

The finding that presenting the visualization condition first influenced subsequent responses from all three perspectives provides further evidence that experiential processing biases rational processing. It is impressive, in this respect, that in responses from the self-perspective, an RB effect was obtained in the standard condition only when it followed the visualization condition. It is even more impressive that similar results were obtained when participants responded from a logical perspective. One would have thought that the logical response is so blatantly obvious that it would not be affected by simply presenting the visualization condition first. That it was affected indicates the considerable influence of experiential processing on subsequent rational processing, an issue which will be more thoroughly discussed shortly.

It is noteworthy that the RB effect that was obtained when participants responded from an others-perspective, which was the only perspective that

produced an RB effect in the standard condition when presented first, became significantly greater when it followed the visualization condition. This provides evidence that initial experiential responding in one situation promotes experiential responding in other situations in which it otherwise would not likely occur.

The finding that experiential processing biases subsequent rational processing is not confined to research with the RB paradigm. Other investigators [17, 19, 29] as well as our associates and ourselves (e.g., [16]) have obtained similar findings with other experimental paradigms. The importance of these findings is that they support the view in CEST that a major reason why humans often think irrationally despite their capacity for rational reasoning is the biasing effect of their experiential system on their rational system [6, 25, 26]. This frequently is not obvious because people are very effective rationalizers. They are able to convince themselves and others that what was actually experientially determined was rationally determined. Relatedly, they unintentionally create situations that provide evidence that supports their experiential beliefs, thereby convincing them that their reactions are rationally determined.

Implications of the Finding that People Can Better Visualize Smaller than Larger Numbers

We were interested in demonstrating that people can better visualize smaller than larger numbers because, as noted in the introduction, it would support a critical assumption in our explanation of why the RB phenomenon has been found with low, but not with high, probability ratios. The positive findings therefore give credence to our explanation.

Another implication of the finding that small numbers can be better visualized than larger numbers is that it adds support to the concretive principle of experiential processing, which is one of the basic principles of experiential processing (see Table 1). Considering that "10% is 10%," why should it matter if this probability is expressed as 1 in 10 or 10 in 100? From a rational perspective, it should, of course, not matter at all. In contrast, it should matter a great deal from an experiential perspective if the experiential system is a concretive system.

The concretive principle of CEST can elucidate a variety of observations of human thinking in everyday life as well as research findings. In real life, it is well known that concrete examples improve communication and that people often prefer to make judgments on the basis of a few concrete experiences rather than on more informative statistical information. Observe any heated group discussion, and you are likely to be impressed with the ability of a single person to sway the group by citing an engaging personal experience. In research relevant to this issue, it has been demonstrated that concrete examples are disproportionately influential in decision-making, in causal inference, in data coding, in the prediction of future events, in the recognition and recall of events, in the development and

maintenance of stereotypes, and in causing people to ignore important normative data, including base-rate information (see reviews in [30] and [31]). The explanation of these effects up to now has relied on considerations of individual stimulus and processing attributes, such as vividness, attention, rehearsal, and the elicitation of imagery. But why should these particular features be implicated, and what, if anything, do they have in common? The answer is that they are all associated with the principles of the experiential system, and, in particular, its encoding of information in the form of concrete representations. The real world is experienced in its most fundamental and engaging manner as a series of immediate, concrete experiences. Higher levels of abstraction, made possible by the use of language in the rational system, are a less compelling way of apprehending reality. It is no wonder, then, that people often react primarily experientially, despite "knowing better" in their rational system [6, 11, 18, 28]. As indicated in Table 1, experiencing is believing, whereas intellectual understanding is only knowing.

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