Rewarding objects appear larger but not brighter

Samy Rima
Université de Toulouse, Centre de Recherche Cerveau et Cognition, Toulouse, France
Centre National de la Recherche Scientifique, Toulouse Cedex, France

Mylène Poujade
Université Pierre et Marie Curie, Paris, France
Institut de la Vision, Paris, France

Marcello Maniglia
Université de Toulouse, Centre de Recherche Cerveau et Cognition, Toulouse, France
Centre National de la Recherche Scientifique, Toulouse Cedex, France
Department of Psychology, University of California, Riverside, Riverside, CA, USA

Jean-Baptiste Durand
Université de Toulouse, Centre de Recherche Cerveau et Cognition, Toulouse, France
Centre National de la Recherche Scientifique, Toulouse Cedex, France

Whether reward can accentuate the perception of visual objects, that is, makes them appear larger than they really are, is a long-standing and controversial question. Here, we revisit this issue with a novel two-alternative forced-choice paradigm combining asymmetric reward schedule and task reversal. In a first experiment, participants ($n = 27$) choose the larger of two unequally rewarded objects in some sessions and the smaller one in other sessions. Response biases toward the most rewarding object differ significantly between the reversed tasks, revealing an influence of reward on perceived sizes. In a second experiment, participants ($n = 27$) indicate either the brighter or darker object. In contrast with the first experiment, response biases are similar between those reversed tasks, indicating that the perceived luminance is immune to reward manipulation. Together, these results reveal that if two objects are associated with different amounts of reward, participants will perceive the more rewarded object to be slightly larger, but not brighter, than the less rewarded one.

Introduction

In 1947, Jerome Bruner and Cecile Goodman published "Value and need as organizing factors in perception," in which they reported that 10-year-old children tend to largely overestimate the size of coins but not that of similarly sized wooden disks. The effect was stronger for coins of higher monetary value and further pronounced among the poorest children, leading the authors to claim that value and need trigger the perceptual accentuation of desirable objects. This seminal work ignited the "New Look" movement, a collective effort among psychologists for collecting evidences that perception is penetrated by affective, motivational, and cognitive factors, rather than immune to them (Bruner, 1957). The movement progressively vanished in the 70s, with the rise of criticisms pointing both weaknesses in the experimental findings and biases in their interpretation. However, the last two decades have witnessed a strong resurgence of the debate around the ideas advocated by the "New Look" movement (Balcetis & Lassiter, 2010; Firestone &

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Scholl, 2016). Among the studies most directly related to the seminal work of Bruner and Goodman, one study claims that objects useful for reaching a goal look bigger (Veltkamp, Aarts, & Custers, 2008). Others, in the same vein, report that muffins appear larger to food-primed dieters (van Koningsbruggen, Stroebe, & Aarts, 2011) and women's breast to sex-primed men (Den Daas, Häfner, & de Wit, 2013). Rewarding objects might also look closer (Balcetis & Dunning, 2010) and more salient in ambiguous figures (Balcetis & Dunning, 2006). Altogether, those few example studies seem to confirm a task independent perceptual accentuation hypothesis.

However, those conclusions have been questioned on the ground that these studies report an influence of reward on the participants' behavioral responses rather than on perception per se (Firestone & Scholl, 2016). Current theories of perceptual decision making consider that behavioral responses result from a two-stage process (Green & Swets, 1966; Krantz, 1969; Bogacz, Brown, Moehlis, Holmes, & Cohen, 2006; Ratcliff & McKoon, 2008), with the collection of perceptual evidences (sensory processing) followed by an estimation process. Consequently, the fact that participants tend to overestimate the size of a rewarding object reflects an accentuation that arises either at the perceptual level (i.e., the object is seen larger than what it actually is) or at the decisional level (i.e., the object is estimated as being larger than how it is actually seen).

As noted by Firestone and Scholl (2016), this second alternative is more likely in the context of simple perceptual decision-making tasks such as those used in most of the above-mentioned studies. In the tasks used by these previous studies, participants produce responses supposedly reflecting what they perceive. Nevertheless, they are neither penalized for perceptually inaccurate responses nor rewarded for accurate ones. Consequently, participants can develop decisional biases that decouple perceptual evidences and behavioral responses without consequence for the task outcome.

In the present study, we revisit the perceptual accentuation hypothesis in two experiments asking whether rewarding objects are actually perceived larger (Experiment 1) and brighter (Experiment 2) than less rewarding ones. Both experiments rely on a new approach designed to overcome the above-mentioned limitations. On the one hand, it encourages the production of perceptually accurate responses, and on the other hand, it dissociates the respective contribution of the perceptual and decisional levels. This approach uses a two-alternative forced-choice (2AFC) paradigm, which is a performance-based procedure known to discourage decisional biases and to promote accuracy (MacMillan & Creelman, 1991). Crucially, each participant performed reversed versions of the 2AFC task. In Experiment 1, participants indicate the larger between two discs in some sessions and the smaller one in others. In Experiment 2, they indicate the brighter disc in some sessions and the darker one in others. In all those tasks, we manipulated reward by allocating distinct amounts of monetary gain for the two alternatives: Gains for correct responses towards one of the discs were higher than those for correct responses towards the other. Perceptual accentuation posits that regardless of the task, the more rewarded alternative should be perceived larger and potentially brighter. With our task reversal, this implies that the more rewarded alternative should be favored in the larger/brighter tasks and disadvantaged in the smaller/darker tasks.

To illustrate how this "task-reversal" 2AFC (TR-2AFC) paradigm disentangles the respective contributions of perception and decision in reward-induced response biases, we consider the case of two discs simultaneously presented to the left and right of a central fixation cross. The discs differ only in that the right one (R*) is associated with a higher promise of reward. In such a case, perceptual evidences are assumed to form a centered Gaussian distribution whose width reflects the noise associated with the perceptual discrimination process. If participants perform the task without considering the reward asymmetry (no bias hypothesis; upper row in Figure 1), the decision criterion will also be centered, resulting in equal probabilities of selecting R* or L and no response bias ($\Delta p = pR^* - pL = 0$), irrespective of the task ("larger/brighter?" vs. "smaller/darker?"). If the reward manipulation does not affect perception but induces a reward-optimization strategy (decision bias hypothesis; second row), the decision criterion would be shifted (Bogacz et al., 2006), thus increasing the probability of selecting R* and producing similar response biases in the reversed tasks. By contrast, the perceptual accentuation hypothesis posits that R* is actually perceived larger/brighter than L, implying a shift of the perceptual evidences (perceptual bias hypothesis; third row). Consequently, the probability of choosing R* increases in the bigger/brighter tasks, but it decreases in the smaller/darker tasks, producing opposite response biases between the reversed tasks. Finally, both decision and perceptual biases could coexist (both biases hypothesis; fourth row). They would exert additive actions in the bigger/brighter tasks but antagonist actions in the smaller/darker tasks, thus causing more important response biases toward R* in the larger/brighter tasks than in the smaller/darker tasks. Note that for clarity, decision and perceptual biases are assumed to be of equal strength in Figure 1. However, this is not necessary for distinguishing the different alternatives. Pure decision or perceptual biases predict response biases of equal magnitude in the

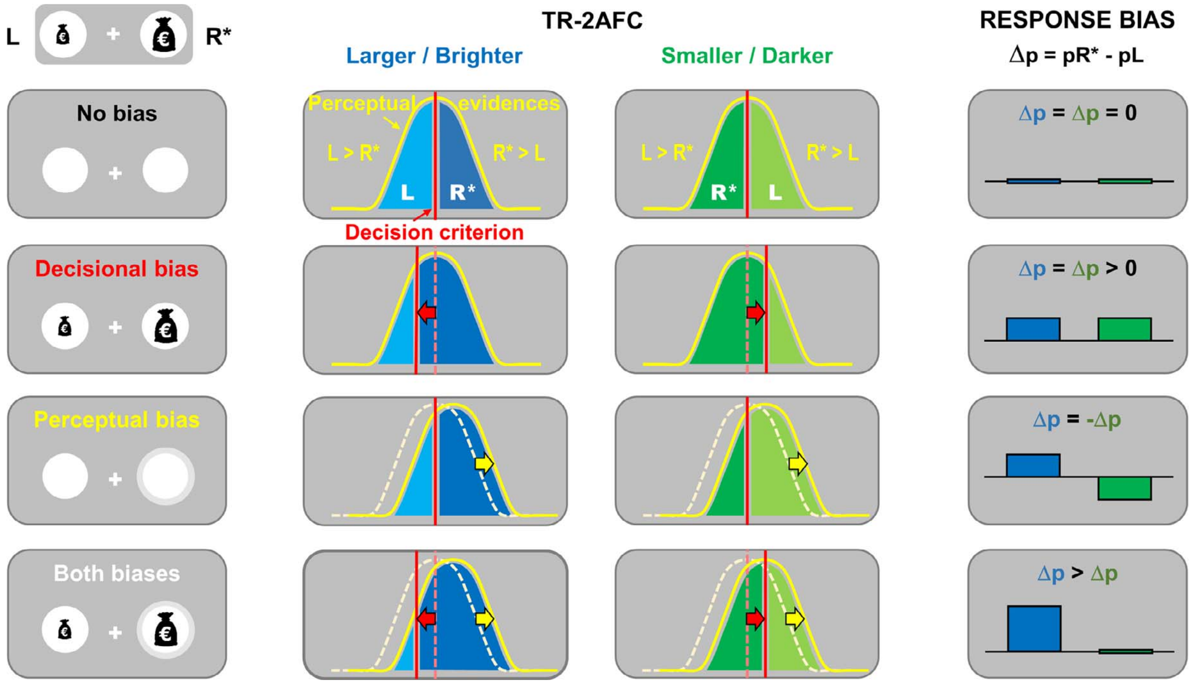

Figure 1. The task-reversal two-alternative forced choice (TR-2AFC) procedure. For both the size and luminance discrimination tasks, the response toward the left (L) or right (R) alternative results from a decision criterion (in red) applied to the collected perceptual evidences (in yellow). When the alternatives cannot be perceptually told apart, a higher promise of reward attached to one of them (R*) can produce distinct scenarios, presented in the left column. We illustrate the underlying actions on the decision criterion and/or the perceptual evidences for the reversed tasks in the two central columns. The right column shows the outcomes for the different hypotheses, in terms of response biases (the probability of selecting the more rewarded alternative versus the less rewarded one).

reversed tasks, but with either the same or opposite signs respectively. Whatever their relative magnitude, the presence of both decisional and perceptual biases is marked by a higher response bias in the larger/brighter tasks than in the smaller/darker ones.

By using the TR-2AFC paradigm, we will show that reward-induced response biases indicate the presence of both perceptual and decision biases when discriminating the size of objects (Experiment 1), whereas only the decision bias operates when discriminating their luminance (Experiment 2). These results reveal that more rewarded objects are perceived slightly larger than less rewarded ones, in agreement with the perceptual accentuation hypothesis. They also show that perceptual accentuation is much weaker than that described in previous studies and that it does not extend into the luminance domain.

Material and methods

Participants

Fifty-four participants aged between 20 and 30 years old participated in the present study. Twenty-seven participants (nine males, 18 females) were involved in the first experiment on size discrimination and other twenty-seven (15 males, 12 females) participated in the second experiment on luminance discrimination. All participants were volunteers and declared having normal or corrected-to-normal vision. They were naïve about the purpose of the experiment, and we only informed them about the task to perform and that the total amount of earned money would depend on their performances in the task. The monetary gains ranged from 13 euros/session for performances at chance level to 26 euros/session for optimal performance. All participants signed an informed consent form containing all those details. The experiment met the ethical standards of the Helsinki Declaration and was approved by our local ethic committee (CLERIT).

Apparatus

Participants sat in a chair, legs uncrossed, hands on a table, within a dark experimental box. They positioned their heads within a head-support device clamped on top of the table and equipped with both chin and forehead supports. The uprights were further covered with sheets of dense foam in order minimize head movements during the experiment. Participants faced a

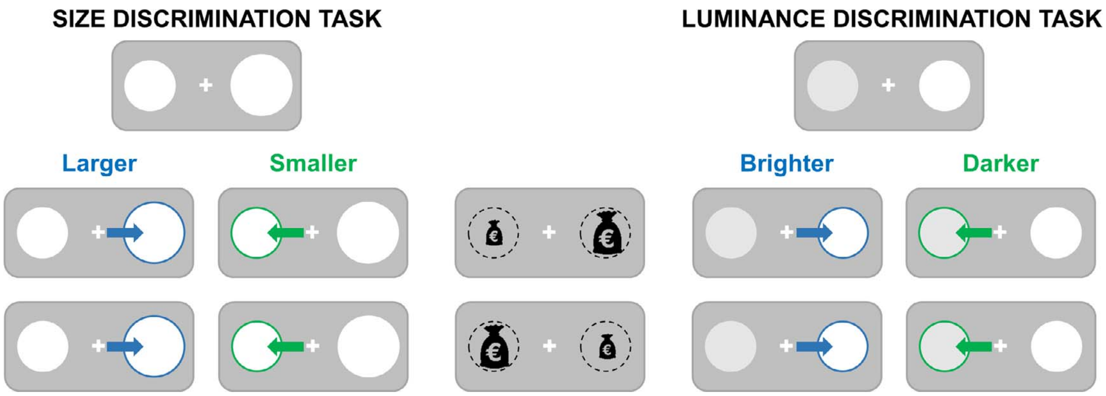

Figure 2. Experimental design. For both the size discrimination task (left) and the luminance discrimination task (right), participants performed four distinct sessions. In two successive sessions, they had to indicate the larger/brighter disc (in blue); and in the two other sessions, they had to indicate the smaller/darker one (in green). For each of these reversed tasks, the more rewarding disc was the right one in one session (upper row) and in the left one in the other session (lower row).

screen subtending 44° × 26° of visual angle at a viewing distance of 63 cm, with a resolution of 1,920 × 1,080 pixels and a refresh rate of 60 Hz. The experiment was controlled by the EventIDE software (OkazoLab), running on an Intel Core i5 based computer. A video-based binocular eye tracker (Eye Link 1000 plus) placed 35 cm in front of the participants was used to record binocular eye movements at 1 kHz per eye during the experiment.

Experiment 1: Size discrimination

Each of the 27 participants involved in the first experiment performed four distinct sessions across different days, as illustrated in Figure 2 (left panels). In two successive sessions, participants indicated in each trial the larger of two simultaneously presented discs. In the two remaining sessions, they had to indicate the smaller of the discs. We alternated the order of those reversed tasks between participants. For both tasks, we attached the higher monetary reward to the left alternative in one session and to the right alternative in the other session, to dissociate reward-induced response biases from potential leftward or rightward response biases. High and low amount of reward corresponded to 5 and 1 cents of euro for each correct trial, respectively. The white discs (180 cd/m^2) appeared on a gray background (30 cd/m^2) and were positioned 6° to the left and to the right of the central fixation cross. Across trials, their diameter differed by 2%, 4%, 8%, or 16% (mean diameter of 6°), with equal probability for the larger and smaller discs to be located rightward and leftward (50%).

Each session started with the calibration of the eye tracker. At the beginning of each trial, the participants had to maintain fixation on a central fixation cross for a period jittering randomly between 1,500 and 3,000 ms. Successful fixation was followed by the simultaneous appearance of the two alternatives (i.e., the two discs) that remained on the screen. Participants had 2,300 ms to move their gaze toward the chosen disc (i.e., the larger or smaller one, depending on the task). Beyond this time limit, the trial was aborted, and a text indicating to the participants that they were too late was shown for 500 ms. We signaled correct trials with an image depicting a 5-cents coin or a 1-cent coin, depending on the reward associated with the chosen disc. We accompanied the image with the sound of a cash machine, either brief or long depending on the small or high monetary gain. Incorrect trials were marked by the image of a stop sign and the sound of a buzzer, indicating the absence of gain. A new trial was initiated 200 ms after that feedback. Each session consisted of six blocks of 72 trials (nine repetitions of each condition per block). Participants were free to rest between each block.

Experiment 2: Luminance discrimination

As for the first experiment, each of the 27 participants involved in the second experiment performed four distinct sessions with task reversal ("brighter" vs. "darker" disc) and reward asymmetry reversal, as shown in Figure 2 (right panels). The discs had a fixed diameter of 6° of visual angle. Their luminance varied pseudorandomly across trials, by 2%, 8%, 16%, or 32% (mean luminance of 155 cd/m^2), with equal probability for the brighter and darker discs to be located rightward and leftward (50%). As for the first experiment, each session consisted of six blocks of 72 trials (nine repetitions of each experimental condition per block). Participants were free to rest between each block.

Data analysis

For each participant and each session, we discarded the first of the six blocks, considered as a training block. We constructed psychometric curves from the five remaining blocks by computing the proportion of rightward saccades for each experimental condition (i.e., for each difference in size or luminance between the discs). Those psychometric curves were then parametrized by fitting them with a cumulative Gaussian function (Wichmann & Hill, 2001) of the form:

$$Y = g + (1 - g - l) \times 0.5 \times \left(1 + erf\left(\frac{(X - \mu)}{\sqrt{(2 \cdot s^2)}}\right)\right)$$

where Y is the proportion of rightward saccades, X is the difference in size or luminance expressed as a percentage, g and l denote deviations of the curves' floor and ceiling from 0 and 1 respectively, while μ and s represent the mean and standard deviation of the error function (*erf*). Those last two parameters are closely related to the point of subjective equality (PSE; i.e., the condition for which the two alternatives are selected with equal probability), and to the just noticeable difference (JND; i.e., the minimal difference that can be detected between the alternatives), respectively. The goodness of fit was evaluated from adjusted r^2 values, indicating how much of the psychometric curves' variance can be explained by the cumulative Gaussian function. Across all curves measured in the present study, the minimum r^2 value was 96.7%, indicating that this model accurately describes our whole data set.

For each task and each participant, we computed profiles of response biases as the differences in the percentages of saccades toward the more and less rewarded locations. We also computed profiles of normalized saccadic reaction times toward the more and less rewarded locations.

Statistical significance of the effects of reward location and task reversal in the behavioral responses (proportions of rightward saccades, response biases, and saccadic reaction times) was assessed with two-way repeated measure analyses of variance (two-way RM ANOVA).

Results

Experiment 1: Size discrimination

For each of the 4 sessions (2 reward configurations × 2 reversed tasks; see Figure 2), we computed the mean psychometric curves across the 27 participants by reporting the mean percentage of rightward saccades as a function of the size difference between the right and left discs, as shown in Figure 3A. Unsurprisingly, as the size of the right disc increases relative to that of the left disc, the percentage of rightward saccades increases for the "larger" task (in blue) while it decreases for the "smaller" task (in green).

Importantly, inspection of the psychometric curves shows that in the "larger" task, the percentage of rightward saccades is higher when the high monetary reward is to the right (filled circles) compared to when it is to the left (open squares). However, this is not the case for the "smaller" task, with a high degree of overlap between the psychometric curves for the two reward conditions. Two-way RM ANOVA with size difference and reward configuration as main factors confirm a significant effect of reward in saccadic responses for the "larger" task, $F(1, 26) = 24.46$, $p < 10^{-4}$, but not for the "smaller" task, $F(1, 26) = 1.15$, $p = 0.29$. As shown in Figure 3B, this leads to a shift of the PSEs between the two configurations of reward in the "larger" task but not in the "smaller" task (left panel). The JNDs are largely unaffected in both tasks (right panel). We provide PSE and JND values in the left columns of Table 1. By subtracting the percentage of rightward saccades between the two reward configurations for each task and each participant, we computed the mean profiles of reward-induced response biases shown in Figure 3C. The profile is bell-shaped for the "larger" task (upper panel) but flat for the "smaller" task (middle panel), so that the difference of response biases between the tasks (lower panel) reflects a strong task-dependence of the response biases. These observations are confirmed statistically by a two-way RM ANOVA showing that response biases are a function of both the size difference, $F(7, 182) = 4.25$, $p < 10^{-3}$, and the task, $F(1, 26) = 12.02$, $p < 10^{-2}$, with a significant interaction between those factors, $F(7, 182) = 4.41$, $p < 10^{-3}$. Finally, it is interesting to note that the task-dependency is also observable in the saccadic reaction times (Figure 3D). The more rewarding location evokes statistically faster reaction times than the less rewarding one in the "larger" task: left panel; two-way RM ANOVA, $F(1, 26) = 11.82$, $p < 10^{-2}$; but not in the "smaller" task: right panel; $F(1, 26) = 0.29$, $p = 0.60$.

Our data indicates a marked effect of task reversal in the reward-induced response biases which are significant in the "larger" task and virtually absent in the "smaller" task. This is proof that response biases are the resultant of both perceptual and decisional biases (see the both biases hypothesis, lower row of Figure 1). Consequently, objects that are more rewarding are actually perceived slightly larger than less rewarding ones, in agreement with the perceptual accentuation hypothesis.

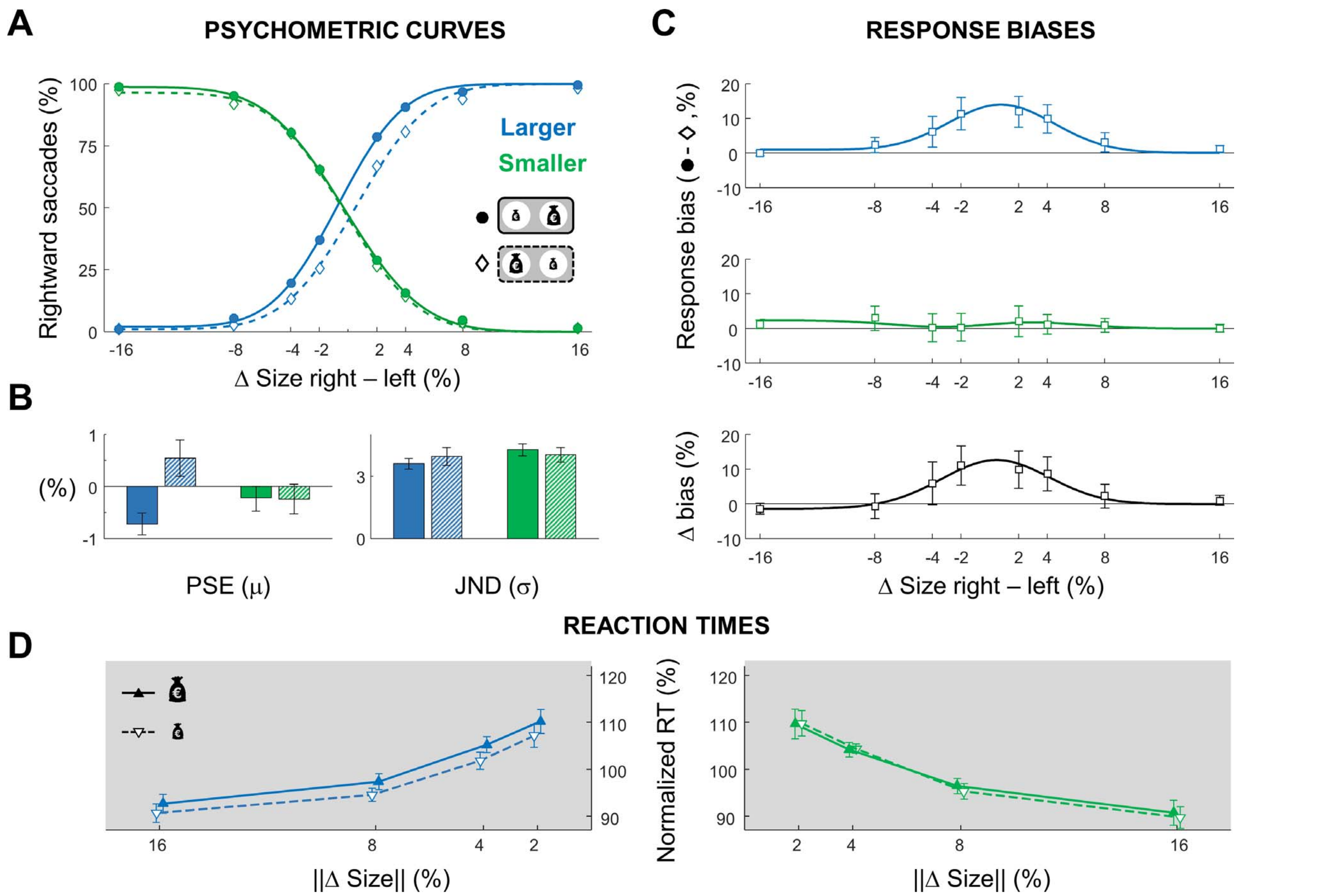

Figure 3. Results of the size discrimination tasks. (A) Mean psychometric curves for the "larger" (in blue) and "smaller" (in green) tasks and for the higher reward located to the right (filled circles) and to the left (open diamonds). We plot the mean percentage of rightward saccades as a function of the size difference (Δ size) between the right and left discs. (B) Related fitting curve parameters and their 90% CI. Left panel shows the means (μ) of the cumulative Gaussian functions, related the PSE. Right panel shows their widths (σ), related to the JND. Values are provided in Table 1, left columns. (C) Mean profiles of response biases as a function of the size difference for the "larger" (upper panel) and "smaller" (middle panel) tasks, with their difference (lower panel). Error bars indicate the 90% CI of the mean response biases. (D) Mean normalized saccadic reaction times as a function of the absolute size difference for the more rewarding (open triangles) and less rewarding (filled triangles) discs. Reaction times for the "larger" and "smaller" tasks are shown in the left and right panels, respectively. Error bars indicate the 90% CI of the mean reaction times.

Task	Reward	PSE	JND
Size: Experiment 1			
Larger	Right	−0.72 ± 0.21	3.70 ± 0.27
	Left	0.55 ± 0.36	3.95 ± 0.42
Smaller	Right	−0.25 ± 0.24	4.26 ± 0.29
	Left	−0.24 ± 0.29	4.02 ± 0.35
Luminance: Experiment 2			
Brighter	Right	−1.21 ± 0.16	7.46 ± 0.28
	Left	2.08 ± 0.26	6.81 ± 0.37
Darker	Right	2.00 ± 0.26	6.90 ± 0.38
	Left	−1.39 ± 0.27	7.32 ± 0.38

Table 1. Points of subjective equality (PSE) and just noticeable differences (JND) for the psychometric curves of the size (left columns) and luminance (right columns) discrimination tasks. *Note*: Values are provided with their 90% CI.

Experiment 2: Luminance discrimination

As in the first experiment, we computed mean psychometric curves across the 27 participants by reporting the mean percentage of rightward saccades as a function of the luminance difference between the right and left discs (Figure 4A). Once again, the percentage of rightward saccades increases for the "brighter" task (in blue) and decreases for the "darker" task when the right disc becomes increasing brighter than the left disc. However, a notable difference with the first experiment is already evident, since the higher percentage of rightward saccades for the high monetary reward to the right (filled circles) compared to the left (open squares) is present for both reversed tasks. Two-way RM ANOVAs with lumi-

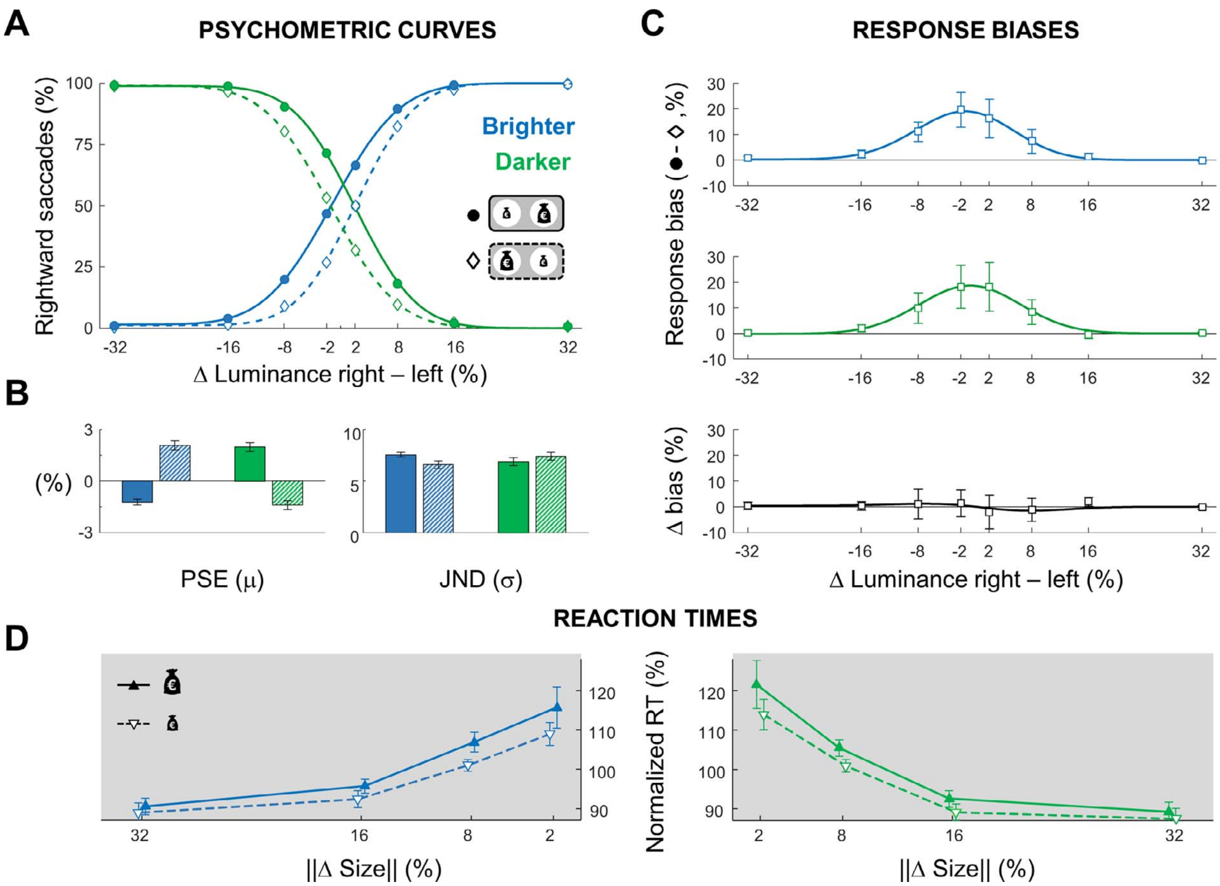

Figure 4. Results of the luminance discrimination tasks. (A) Mean psychometric curves for the "brighter" (in blue) and "darker" (in green) tasks and for the higher reward located to the right (filled circles) and to the left (open diamonds). (B) Related fitting curve parameters and their 90% CI. Values are provided in Table 1, right columns. (C) Mean profiles of response biases as a function of the luminance difference for the "brighter" (upper panel) and "darker" (middle panel) tasks, with their difference (lower panel). Error bars indicate the 90% CI of the mean response biases. (D) Mean normalized saccadic reaction times as a function of the absolute luminance difference for the more rewarding (open triangles) and less rewarding (filled triangles) discs. Reaction times for the "brighter" and "darker" tasks are shown in the left and right panels, respectively. Error bars indicate the 90% CI of the mean reaction times.

nance difference and reward configuration as main factors indicate a significant effect of reward for both the "brighter," $F(1, 26) = 22.00$, $p < 10^{-4}$, and "darker," $F(1, 26) = 15.36$, $p < 10^{-3}$) tasks. Figure 4B reinforces this view by showing that the PSE shifts between the two reward configurations are very similar for the "brighter" and "darker" tasks, while the JNDs remain roughly constant (right columns of Table 1). The mean profiles of reward-induced response biases (Figure 4C) are similarly bell-shaped for the "brighter" (upper panel) and "darker" task (middle panel), leading to a flat profile of response bias differences between the tasks (lower panel). These observations are confirmed by a two-way RM ANOVA showing a highly significant influence of luminance differences. $F(7, 182) = 14.18$, $p < 10^{-13}$, but with no direct, $F(1, 26) = 0.06$, $p = 0.80$, or interactive, $F(7, 182) = 0.37$, $p = 0.92$ influence of the task. Again, the saccadic reaction times (Figure 4D) confirm the conclusions drawn from the psychometric curves and response biases, since the more rewarding location evokes faster reaction times for both the "brighter": left panel; two-way RM ANOVA, $F(1, 26) = 9.23$, $p < 10^{-2}$; and "darker": right panel; $F(1, 26) = 8.68$, $p < 10^{-2}$) tasks.

Thus, the results of this second experiment indicate that reward induces behavioural biases in luminance discrimination tasks, but those biases are immune to task reversal. Such results are those expected if reward only affects the decision criterion (see the decision bias hypothesis, second row of Figure 1). Consequently, perceptual accentuation does not seem to extend into the luminance domain: We do not perceive objects that are more rewarding brighter than less rewarding ones.

Discussion

The objective of the present study was to re-evaluate the perceptual accentuation hypothesis (Bruner, 1957), according to which valuable objects might be seen larger than they really are. To that end, we developed a new task-reversal two-alternative forced-choice (TR-2AFC) paradigm. This paradigm allows us to measure the participants' percepts accurately by penalizing inaccurate response, and disentangle the respective contribution of the perceptual and decisional levels in reward-induced response biases. With TR-2AFC, response biases toward the most rewarding alternative are expected to be similar between reversed tasks if they solely reflect a reward optimization strategy (decision bias), to be opposite if they solely reflect a perceptual accentuation (perceptual bias), or to reflect the additive action of these two mechanisms (both biases).

In a first experiment, we found that response biases differed significantly between the "larger" and "smaller" tasks, indicating the presence of both decision and perceptual biases. The existence of a perceptual bias is important as it supports the idea of a perceptual accentuation mechanism: Participants perceive objects that are more rewarding slightly larger than less rewarding ones. In a second experiment with another pool of participants, we tested whether this perceptual accentuation extends into the luminance domain. Results showed that response biases toward the most rewarding alternative were similar between the "brighter" and "darker" tasks, arguing for the presence of a reward-induced decision bias, but without perceptual bias. Consequently, the perceptual accentuation hypothesis does not apply in the luminance domain: Participants do not perceive objects that are more rewarding brighter than less rewarding ones.

Our results are consistent with previous studies documenting an effect of motivational factors on the perceived size of visual objects (Bruner & Goodman, 1947; Veltkamp et al., 2008; van Koningsbruggen et al., 2011; Den Daas et al., 2013). However, it is important to note that the effect of reward we found is rather small when compared to those previous studies. Based on the values provided in Table 1, one can consider that the overall PSEs (i.e., averaged PSEs between the two reward configurations) are 0.63% for the "larger" task ([0.55 – (–0.72)]/2) and ~0% for the "smaller" task ([–0.24 – (–0.25)]/2). Considering that the perceptual and decisional biases add up in the "larger" task and cancel each other in the "smaller" task, simple algebraic calculation tells us that the disc attached to 5 cents of euro is perceived ~0.32% larger than that attached to 1 cent of a euro. This perceptual accentuation represents only a fraction of the mean JND (see Table 1), but it nevertheless produces significant response biases, as shown in Figure 3. By contrast, previously reported effects are ~12% in Den Daas et al. (2013), ~25% in Bruner and Goodman (1947), ~35% in Veltkamp et al. (2008), ~40% in van Koningsbruggen et al. (2011). Clearly, it is difficult to imagine how such large perceptual distortions could fit with the need to form representations of the outside world that would be veridical enough to guarantee accurate interactions. Based on the present results, it is likely that those previously described effects of reward are in fact mostly caused by decisional rather than perceptual biases. Further investigation will need to quantify the contribution of each.

Another difference with the above-mentioned studies is that we did not compare behavioural responses to objects of distinct intrinsic values (e.g., coins vs. wooden discs in Bruner & Goodman, 1947) or from groups of participants with supposedly distinct motivational states (e.g., food-primed versus flower-primed dieters in Veltkamp et al., 2008). Our contrast targets within-subject differences between tasks involving intrinsically neutral and identical objects (i.e., luminance-defined discs). As such, we can rule out low-level differences and familiarity effects with the visual stimuli (Firestone & Scholl, 2016), but also other between-group differences, as confounding variables.

However, because we attached the rewarding signal to a spatial location, we cannot address whether reward signals act directly on visual perception or through the mediation of spatial attention (Maunsell, 2004). Recently, Chelazzi and colleagues (2014) found that reward-location coupling produces a long-lasting increase in the probability of detecting a target at that particular location; which indicates that reward signals might durably bias the attentional system (Chelazzi, Perlato, Santandrea, & Della Libera, 2013). Since Anton-Erxleben and colleagues (2007) have shown that participants can perceive attended objects as being larger, our results in the size domain agree with the idea that they attend more to the most rewarding location. However, such explanation does not fit with the fact that objects are not perceived brighter, while spatial attention has been shown to increase the apparent contrast (Carrasco, Ling, & Read, 2004) and luminance (Tse, 2005) of attended objects.

Assuming that the perceived size of visual objects and the extent of activation they trigger in early visual cortex are linked (Murray, Boyaci, & Kersten, 2006; Schwarzkopf & Rees, 2013), an alternative explanation posits that coupling a reward to a particular location induces a cortical overrepresentation of that particular location. Such cortical remodeling could be mediated by dopaminergic projections of the ventral tegmental area (VTA) that have already been shown to promote cortical remodeling in the auditory cortex (Bao, Chan, & Merzenich, 2001), to influence activity in early visual cortex (Serences, 2008; Arsenault, Nelissen, Jarraya, &

Vanduffel, 2013) and to shape both instrumental and Pavlovian associations to visual objects (Arsenault, Rima, Stemmann, & Vanduffel, 2014).

Whatever the underlying mechanisms, our results reveal that we cannot generalize the influence of reward to all dimensions of visual perception. This result echoes recent findings that visual motion does not affect all dimensions of auditory perception (Maniglia, Ward, & Grassi, 2017). Evidencing the limits of contextual influences on perception represents an important step toward understanding the origins and functions of such phenomenon (Firestone & Scholl, 2016). The absence of perceptual accentuation in the luminance domain might be linked to the fact that in natural conditions, luminance strongly depends on external factors (time of the day, weather, etc.) so that a slight accentuation might provide little ecological advantage. The absence of reward effect on luminance would logically extend to our experimental conditions, even if luminance is finely controlled. By contrast, perceiving behaviorally important objects as slightly larger than they really are may ease their detection (Bruner, 1957) and, additionally, may help making their rewarding status more appealing (Balcetis & Dunning, 2010) without compromising accurate interactions with those objects.

Keywords: size perception, luminance perception, TR-2AFC, reward

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Corresponding author: Jean-Baptiste Durand.
Email: jbdurand@cnrs.fr.
Address: CNRS CERCO UMR, Toulouse Cedex, France.

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