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Evidence of Motivational Influences in Early Visual Perception: Hunger Modulates Conscious Access

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The New Look approach to perception (Bruner, 1957) posits that perception is a constructive process based on several top-down factors, such as individuals' expectations, needs, and desires. Many classical experiments from the New Look era have provided striking illustrations of the effect of motivation on perception. For example, they have revealed that poor children have a bias to overrate coin size (Bruner & Goodman, 1947) and that hungry people have a bias to overrate the brightness of pictures of food (Gilchrist & Nesberg, 1952). This line of research has not gone without criticisms (e.g., Erdelyi, 1974; McCurdy, 1956), but recent experiments have largely confirmed its validity (Aarts, Dijksterhuis, & De Vries, 2001; Balcetis & Dunning, 2006, 2010).

Despite the evidence of an effect of motivation on perception, it is still unknown at which point in the perceptual process motivational influences occur. Visual perception is generally regarded as a serial process that starts with a purely perceptual stage (i.e., early vision), in which features are extracted in visual processing areas of the brain. Early vision is followed by a postperceptual, decision stage, in which the perceptual output is categorized. Top-down influences were traditionally thought to bias only the decision stage, and early vision was described as cognitively impenetrable (e.g., Pylyshyn, 1999; Riesenhuber & Poggio, 2000). However, consistent with the idea that higher-level representations can shape the perceptual stage by a tuning process that influences which features are selected for processing (Schyns, Goldstone, & Thibaut, 1998), recent studies have revealed the existence of top-down influences on perceptual processing (e.g., influences of attention—Carrasco, Ling, & Read, 2004—and conceptual category—Lupyan, Thompson-Schill, & Swingley, 2010). Here, we report a study in which we aimed to test whether motivation can also penetrate and guide early visual processing.

All previous research on the effect of motivation on perception has employed clearly visible stimuli: In most of these studies, researchers simply observed how ambiguous stimuli were interpreted. In contrast, in this experiment, we monitored conscious access to masked visual stimuli. This enabled us to focus on the early perceptual encoding stage that occurs unconsciously. Inspired by the method used by Gaillard et al. (2006), we presented words close to the threshold of conscious perception. We expected that participants who had fasted (and were therefore motivated by food) would be more likely than satiated participants to perceive masked food-related words.

Method

Forty-two students (*M* = 20 years, *SD* = 1.2; 17 females and 25 males with a normal body mass index) participated in exchange for course credit. Participants arrived individually in the lab at noon, after 3 to 4 hr without eating, and were randomly assigned to one of two conditions. All participants were informed about a delay in testing and were asked to return later. Although some were instructed to come back 10 min later, others were instructed to come back after 1 hr and were told that they could take their lunch at the cafeteria in the interim. An assessment conducted after the experiment confirmed the efficacy of the manipulation. Participants given the opportunity to eat lunch did so, and motivation to eat (assessed on a 10-point Likert scale, with higher scores representing more hunger) was higher among participants in the fasting condition (*M* = 7.52, *SD* = 1.51) than among those who had the opportunity to eat before the experiment (*M* = 2.76, *SD* = 2.21), $p < .001$.

When they returned to the lab, participants were asked to identify words that were briefly displayed on a computer screen. First, each participant completed a pretest in which we determined the font size at which the visibility of the target word would be as close as possible to the participant's awareness threshold. This font size was then used for the 80 test trials that followed. The targets in these test trials included 20 food-related nouns (e.g., *bread*, *cake*) mixed among 60 neutral nouns (e.g., *boat*, *glove*). (The stimuli were in French but are reported in English here.) On each trial, a 67-ms premask (i.e.,

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"########") preceded the target word. The word then appeared for 33 ms and was followed by a 33-ms blank screen and a 67-ms postmask (i.e., "&&&&&&"). We obtained a subjective measure of awareness by asking participants to rate the visibility of each word on a 10-cm visual analogue scale (Sergent & Dehaene, 2004). We obtained an objective measure of awareness by using a two-alternative forced-choice task in which participants were shown the target word and a foil (e.g., *cake-sake*) and asked to select the word that had just been presented. We derived a perceptual sensitivity index (d') from this measure; d' is intended to reflect only perceptual processing by eliminating decision bias. A greater d' indicates greater perceptual processing of the stimuli.

Results

A 2 (word type: neutral vs. food related) × 2 (condition: fasting vs. satiated) repeated measures analysis of variance was first conducted on the subjective measure of awareness. The interaction was significant, $F(1, 40) = 9.44$, $p < .01$, $\eta^2 = .191$. Although food deprivation did not affect the reported visibility of neutral words, $t(40) = 0.48$, n.s., fasting participants rated the visibility of food-related words higher ($M = 5.48$, $SD = 1.42$) than satiated participants did ($M = 4.52$, $SD = 1.51$), $t(40) = 2.06$, $p < .05$. The same analysis was then performed on the perceptual sensitivity index (d'). The interaction of word type and condition was again significant, $F(1, 40) = 4.84$, $p < .05$, $\eta^2 = .108$. Although there was no effect of hunger on the perceptual processing of neutral words, $t(40) = 0.39$, n.s., fasting participants had a greater awareness of food-related words ($M = 0.63$, $SD = 0.14$) than satiated participants did ($M = 0.51$, $SD = 0.20$), $t(40) = 2.27$, $p < .05$. Figure 1 illustrates the results for both measures.

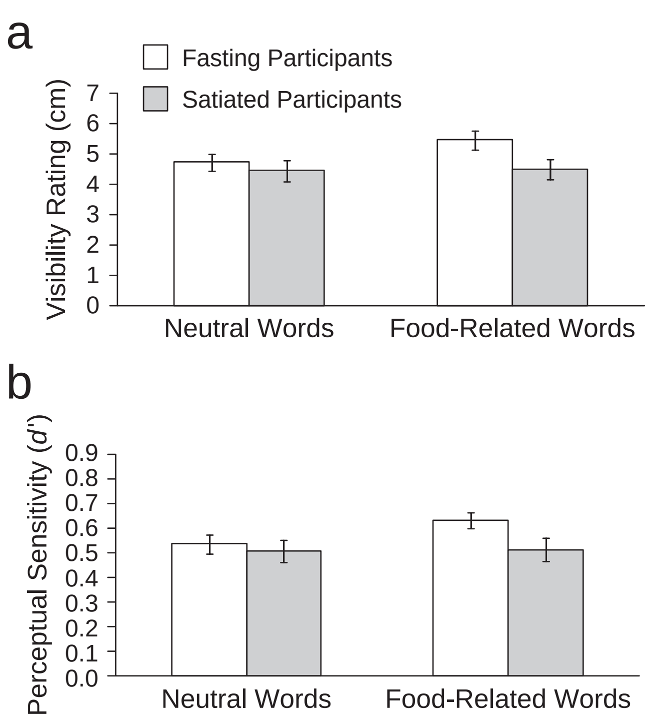

Fig. 1. Mean scores on the (a) subjective (visibility rating) and (b) objective (perceptual sensitivity index, d') measures of awareness for the target words as a function of word type (neutral vs. food related) and experimental condition (fasting vs. satiated). Error bars represent standard errors of the mean.

Discussion

The research reported here extends the generally accepted concept that people tend to see what they want to see (e.g., Balcetis & Dunning, 2006). Whereas the results of previous studies could be explained by an implicit bias occurring at a postperceptual stage, our findings indicate that motivation directly improves perceptual encoding of desired stimuli. This demonstration of a modulation of conscious access reveals that motivational influences can penetrate early perceptual processing. Specifically, our results imply that the stimuli were quickly processed unconsciously on a semantic level, and that the stimuli most relevant to participants' goals were most likely to be selected to reach consciousness.

Bar's (2007) model provides an explanation as to how top-down factors can influence early vision. According to this model, rudimentary information from visual input is rapidly extracted through nonconscious processing and is then contrasted with representations activated in memory. If the extracted information and a representation match, conscious perception is facilitated. Neuroimaging studies support this idea that the brain anticipates the relevance of stimuli; results indicate that information extracted in visual areas is quickly sent to the orbitofrontal cortex, where it can be compared with the activated representations (e.g., Kveraga, Boshyan, & Bar, 2007). Orbitofrontal cortex also plays a crucial role in motivation, especially in the food reward system (Kringelbach, 2005). This fact reinforces the idea that following need deprivation, the activation of representations associated with need satisfaction (Strack & Deutsch, 2004) can play a presensitizing role in early perception.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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