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How to tell a wife from a hat: Affective feedback in perceptual categorization

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ABSTRACT

How do people understand that their perception is correct? In line with the recurring idea of perception as prediction, the affective feedback account of hypotheses testing suggests that correct perceptual predictions are reinforced with positive affect. In four experiments, we tested whether correct categorization of a degraded image will lead to more positive liking ratings. The obtained findings supported the proposed approach: subjects liked the images they were able to perceive correctly more than others. Importantly, these findings were independent of the initial affective valence of stimuli. A further investigation demonstrated that this effect exists only when answers are at least moderately confident. The obtained findings add to the growing amount of literature on the role of affect in basic cognitive processing.

1. Introduction

Usually, people do not question the veridicality of their perception. However, there are situations when observers may doubt their senses. In milder cases, people can be uncertain that what is seen is seen correctly — as, for example, when someone is unsure that the face in the crowd is indeed the face of a friend. In worse cases, people may constantly check the validity of their memories or perceptions. Such distortions have been described as part of "pathological worry" in studies of general anxiety disorder or of "pathological doubt" in the case of obsessive–compulsive disorder (Starcevic & Berle, 2006; Tolin et al., 2001). In contrast, sometimes people do not question the veridicality of their perceptions even when they are clearly incorrect. An example is the famous case of the man who mistook his wife for a hat (Sacks, 2011). Yet, how do we know, that we have perceived something correctly? To answer this question, it is necessary to look into the mechanisms of perception.

Perception is not a passive process. Von Helmholtz (1866) suggested that perception is guided by unconscious inferences, Bruner (1957) and Gregory (1997) used the notion of perceptual hypotheses, and currently this idea recurs in predictive coding models (Friston, 2010; Hohwy, 2012, 2013). A recent proposal is that at each level of processing affective feedback reinforces the development of a realistic model of the world (Allakhverdov & Gershkovich, 2010; Chetverikov, 2014; Chetverikov, Jóhannesson, & Kristjánsson, 2014). This approach, coined as the affective feedback account of hypotheses testing, suggests that at each level of processing our cognitive system tries to predict what our environment is. If these predictions are correct, then we are reinforced with positive affect. If they are not, then we experience negative affect that facilitates the changes of hypotheses. Hence the experience of veridical perception is different from the experience of perceptual errors in its affective valence, allowing people to distinguish between the two.

Despite the intuitive appeal of the affective feedback idea, it lacks empirical testing. Although many findings are in favor of the proposed approach, they are mostly indirect. For example, the effects of processing fluency on preferences (Bornstein & D'Agostino, 1994; Reber, Schwarz, & Winkielman, 2004) indicate that items processed with more ease are rated as more pleasant than the rest. However, processing fluency is a natural consequence of our expectations. To give an example, in Experiment 1 of Reber, Winkielman, and Schwarz (1998) processing fluency was manipulated by presenting a matching or

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non-matching prime before the picture. Observers' predictions were confirmed by the following stimuli in the case of matching prime or contradicted by non-matching one. This led both to a decrease in reaction times and to positive affect. Other cases of fluency manipulations, such as increased contrast or distortions of symmetry can be treated as manipulations of prediction accuracy, because decreased uncertainty helps to provide correct predictions (see also Van de Cruys & Wagemans, 2011). Yet, this and similar evidence are mostly circumstantial for the proposed approach.

Also in favor of the proposed approach, Chetverikov (2014) and Chetverikov et al. (2014) demonstrated that even in the absence of external feedback, errors in recognition and visual search with brief displays result in a decreased preference ratings. Their reasoning was that errors could be interpreted as inconsistent prediction. Consequently, they should be followed by negative affective feedback. However, it is unclear, whether a simple act of perception can be treated similarly to more complex tasks, such as the ones used in these studies.

More direct evidence comes from the study by Muth and Carbon (2013). The authors investigated the "aha" experience associated with the perception of a hardly-detectable Mooney faces on ambiguous background. The observers repeatedly judged the attractiveness of images, some of which contained the Mooney faces while others did not. When observers finally found the face, the ratings were more positive than before. According to the affective feedback account, when observers were able to make correct perceptual hypotheses, they received positive affective feedback. Whether this effect will generalize to stimuli other than faces is unknown, however.

To sum up, there is evidence in favor of the general idea of affective feedback in hypotheses testing. The effects of making a correct perceptual prediction on preferences have, however, only been measured in one study (Muth & Carbon, 2013). The aim of the present study was to provide further evidence that accurate hypotheses about the content of perceived images evoke positive affect.

In four experiments reported here we used categorization task with ambiguous images to test, whether subjects able to perceive the object in these images will like them more than those who do not. Unlike Muth and Carbon (2013), we held exposure time constant for all stimuli and controlled for the effect of processing fluency by incorporating response time into the analyses. Experiment 1 provided initial data on the effects of correct perception on preferences. Experiment 2 demonstrated that this effect could not be attributed to initial affective valence of the stimuli. Experiment 3 further demonstrated that subjects like correctly categorized stimuli more than incorrectly categorized ones only after at least moderately confident answers. Finally, Experiment 4 replicated the findings of Experiment 2 and Experiment 3.

2. Experiment 1

In Experiment 1 we tested the hypothesis that perception of an object will evoke positive affect.

2.1. Method

2.1.1. Participants

Twenty undergraduate psychology students (17 females, age $Mdn = 20$) at Saint Petersburg State University voluntarily participated. No incentive was provided for taking part.

2.1.2. Materials and procedure

A set of 28 "hidden figure" black-and-white images, similar to the famous Dalmatian picture, were used as stimuli. These images depicted humans (N = 9), animals (N = 10), and inanimate objects (N = 10). Participants were informed that they would be participating in a study of perception, and that their task was to categorize images using the three aforementioned categories. Some of the images contained both humans and objects ("man sitting on a bench"). Subjects were instructed that if they saw both objects and human or object and animal they should categorize it as human or animal, respectively. The categorization task allows testing the accuracy of perception and lacks the ambiguity of free report interpretation (see the General discussion).

There were 3 training trials and 25 test trials. The trial sequence is presented in Fig. 1. After being exposed to a stimulus for 1000 ms, participants categorized it using the keyboard arrow keys ("left" — human, "down" — animal, "right" — object). Participants were then asked to rate each stimulus for liking ("How much do you like the presented image?") using a 100-point rating scale. No feedback about the accuracy of categorization was provided.

The first three images, one for each of the categories, were presented in the same order for each participant. Participants were repeatedly exposed to these images until they categorized them correctly. The remaining images were presented only once. The order in which the remaining images were presented was randomized.

2.2. Results

2.2.1. Categorization

The average categorization accuracy was well above chance, $M = 0.78$ [0.66, 0.87],[2] $t(59) = 22.13$, $p < .001$.

2.2.2. Liking

The liking ratings were analyzed using linear mixed-effects regression, LMER, with the *lme4* package in R (Bates, Maechler, Bolker, & Walker, 2013). In contrast to a more traditional approach with data aggregation and repeated-measures ANOVA analysis, LMER allows controlling for the variance associated with random factors without data aggregation (see Baayen, Davidson, & Bates, 2008; Judd, Westfall, & Kenny, 2012).[3] By using random effects for subjects and stimuli, we controlled for the influence of different mean ratings associated with these variables. For the sake of brevity, we present only the *F* tests from the LMER results here (type III Wald *F* tests with Kenward–Roger degrees of freedom approximation).

Average liking ratings and their confidence intervals are presented in Fig. 2A. Ratings were more positive after correct answers than after errors, $M = 54.28$ [51.88, 56.68] vs. $M = 44.57$ [40.49, 48.66], $F(1, 469) = 11.86$, $p < .001$. To assess the effect of fluency of processing, we repeated the analysis, this time including response time as predictor. Response time was logarithmically transformed to reduce the influence of extreme values (Fazio, 1990). If subjects' ratings were more positive because some stimuli were processed more fluently than others were, then there should be a negative effect of response time on liking. Indeed, we found a significant negative effect of response time, $F(1, 486) = 11.89$, $p < .001$. However, the effect of answer correctness still was significant, $F(1, 468) = 7.73$, $p = .006$, indicating that differences between correct and incorrect answers cannot be fully explained by differences in processing fluency.

We then analyzed stimuli by answer category to see if the attribution of stimuli to specific categories may explain the effects obtained for categorization accuracy. Table 1 shows means and confidence intervals for liking split by answer category. A two-way LMER with answer category and answer correctness showed significant effect of answer correctness, $F(1, 455) = 9.01$, $p = .003$, and a main effect of answer category, $F(2, 389) = 9.03$, $p < .001$. The interaction effect was not significant, $F(2, 118) = 1.08$, $p = .342$. Subjects rated images categorized as humans, $t(275) = 1.79$, $p = .074$, and animals, $t(138) = 2.36$, $p = .020$, as more likeable when the categorization was correct. For stimuli

[2] Here and in what follows, we present 95% confidence intervals in square brackets after mean values.

[3] The same analyses repeated with by-subject aggregation and repeated-measures ANOVA yielded the same results in regard to the decisions about effects' statistical significance. Confidence intervals were wider in the case of ANOVA than in the case of LMER as expected due to the data aggregation.