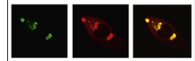


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Research Report

Repetition priming results in sensitivity attenuation

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ABSTRACT

Repetition priming refers to the change in the ability to perform a task on a stimulus as a consequence of a former encounter with that very same item. Usually, repetition results in faster and more accurate performance. In the present study, we used a contrast discrimination protocol to assess perceptual sensitivity and response bias of Gabor gratings that are either repeated (same orientation) or alternated (different orientation). We observed that contrast discrimination performance is worse, not better, for repeated than for alternated stimuli. In a second experiment, we varied the probability of stimulus repetition, thus testing whether the repetition effect is due to bottom-up or top-down factors. We found that it is top-down expectation that determines the effect. We discuss the implication of these findings for repetition priming and related phenomena as sensory attenuation.

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1. Introduction

Repetition priming refers to the change in the ability to perform a task on a stimulus as a consequence of a former encounter with that very same item (for a review see Schacter and Slotnick, 2004). It is usually assessed using tasks in which participants have to identify repeated and non-repeated stimuli, most of the time words or objects, or to make some sort of decision based on features of the item. Repetition priming has been shown to take place on different levels, from perceptual-conceptual (Friese et al., 2012; Sayres and Grill-Spector, 2006) to motor levels (Dobbins et al., 2004; Hsu and Waszak, 2012; Moutsopoulou and Waszak, 2012). On all these levels, repetition results in faster and more accurate performance.

As concerns the underlying brain mechanisms, neuroimaging studies have demonstrated repetition priming to go along with decreased brain activity following item repetition (for reviews see Grill-Spector et al., 2006; Henson and Rugg, 2003). This decrease in activity across stimulus repetition has been referred to as repetition suppression. It has been demonstrated with single-cell recordings in monkeys (Miller and Desimone, 1994), as well as in humans using fMRI (Grill-Spector and Malach, 2001) and EEG/MEG (Henson et al., 2004). Several models have been proposed in the literature to account for neural repetition suppression (see for example Grill-Spector et al., 2006). Initially, the underlying mechanisms were thought to be related to bottom-up factors. The sharpening model assumes that repetition suppression is due to a repeated stimulus being represented more sparsely, because the firing rate of neurons

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responding to irrelevant features decreases across repetitions (Desimone, 1996; Kok et al., 2012a; Wiggs and Martin, 1998). According to the facilitation model, repetition suppression is due to stimuli being processed more quickly when presented more than once (i.e., neurons firing for a shorter period of time) (Henson and Rugg, 2003; James and Gauthier, 2006). The fatigue model, finally, suggests that repetition suppression results from neurons being less responsive when a stimulus is repeated due to firing rate adaptation and synaptic depression (Grill-Spector and Malach, 2001; Kaliukhovich and Vogels, 2011). More recently, however, repetition suppression has been found to be reduced when stimulus repetition is unexpected, suggesting that it reflects a reduction in top-down perceptual “prediction error” due to a repeated stimulus being more expected than an unrepeated stimulus (Summerfield et al., 2008).

Recently, repetition suppression has been discussed as a possible mechanism for a phenomenon called sensory attenuation (cf., Waszak et al., 2012). Sensory attenuation takes two different forms. First there is the finding that self-generated stimuli are perceived as less intense than externally generated stimuli (e.g., Blakemore et al., 1998; Sato, 2008). We are going to refer to this as intensity attenuation. In addition there is the finding that contrast discrimination is impaired for self-generated stimuli (Cardoso-Leite et al., 2010; Roussel et al., 2013). We will refer to this as sensitivity attenuation. Several studies also investigated this effect with neurophysiological correlates of anticipated action effects. It has been shown that when the stimulus is anticipated the neural response is reduced compared to externally triggered or not anticipated stimuli (e.g., Aliu et al., 2008; Baess et al., 2009; Blakemore et al., 1998; Gentsch and Schütz-Bosbach, 2011; Hughes et al., 2013; Hughes and Waszak, 2011; Roussel et al., 2014; Schafer and Marcus, 1973). Waszak et al. (2012) suggest that sensory attenuation of self-produced stimuli (i.e., anticipated action effects) is based on similar if not identical neural mechanisms as repetition suppression. They suggest that action effect anticipation results in the preactivation of the pathway coding for the expected stimulus. If action effect anticipation results in activity similar to the activity triggered by the true perception of the anticipated stimulus, then the activity triggered by a correctly anticipated action effect is actually the repetition of the anticipation-based activity. As a consequence, a correctly anticipated action effect should be subject to the same neural dynamics as a stimulus that is truly repeated, at least to a certain degree. As discussed by Waszak et al. (2012) this also suggests a possible link to the Perkey-effect (Waller et al., 2012) where sensitivity is reduced when a stimulus is imagined, and therefore arguably the internal stimulus representation is activated, at the same time as it is physically presented. Sensory attenuation could, thus, be due to bottom-up neural sharpening, facilitation, and/or fatigue, or to top-down reduction of perceptual prediction error.

Note that, however, the effects of repetition priming and action effect anticipation on performance seem to be contradictory. Repetition priming has been demonstrated to enhance performance (Morton, 1969; Tenpenny, 1995), whereas action effect anticipation results in sensitivity attenuation, i.e., a decrease in perceptual performance (Cardoso-Leite et al., 2010; Roussel et al., 2013). Nevertheless, studies on sensory attenuation

are usually psychophysical studies in which participants are required to detect a stimulus in noise or to indicate the stimulus' intensity. Repetition priming experiments, on the other hand, never used a psychophysical detection protocol. Instead, participants are usually required to issue a motor response, for example to respond as fast as they can to a target stimulus.

Taken together we conclude that, if mechanisms of action effect anticipation and repetition priming are similar, then we should observe the same perceptual effects in case of a repeated stimulus as in case of a stimulus that is anticipated by an action. That is, a repeated stimulus should be perceptually attenuated. The present study tests this notion. In Experiment 1, we adapted a contrast discrimination protocol that has been used before successfully to assess perceptual sensitivity and response bias of anticipated and unanticipated visual action effects (Roussel et al., 2013, 2014). Roussel et al. made participants learn an association between left and right key presses and the presentation of the letters A and H, respectively. They then made participants perform left and right key presses that randomly triggered presentation of either an H or an A at one of two possible contrasts. Participants were required to make a discrimination judgment between the two contrasts. They showed contrast discrimination to be worse when the prediction (H or A, as learned during the association phase of the experiment) matches the true stimulus, demonstrating sensitivity attenuation. The present study uses the same protocol. However, instead of testing contrast discrimination of stimuli that have been correctly anticipated by an action or not, we assessed contrast discrimination when a (Gabor grating) stimulus is presented twice with the same orientation (repetition trial) versus when the orientation is changed from the first to the second presentation (alternation trial). We predicted that contrast discrimination performance will be worse for repeated stimuli. A second experiment was designed to test whether this effect was due to repetition as such or due to expectation. We varied the probability of stimulus repetition, such that in one block repetition trials were more frequent (repetition block) while alternation trials were more frequent in the other block (alternation block). Such a manipulation is commonly assumed to result in participants learning to expect the more frequent stimulus (e.g. Grotheer and Kovács, 2014; Kok et al., 2012b, 2013; Summerfield and de Lange, 2014; Summerfield et al., 2008). If the attenuation is due to repetition as such then it should occur on repetition trials in both blocks, while if it is due to expectation it should occur on repetition trials in the repetition block and on alternation trials in the alternation block where these are more frequent and therefore alternation is expected.

2. Results

2.1. Experiment 1

In Experiment 1 we tested the hypothesis that stimulus repetition, which is found to induce repetition suppression at the neuronal level, is associated with decreased performance in contrast discrimination. Here discrimination performance (d') was lower in the repetition condition (d' repetition: 1.60) than in the alternation (d' alternation: 1.76) condition. A one-tailed t -test

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