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Review

Expectation mismatch: Differences between self-generated and cue-induced expectations☆

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ABSTRACT

Expectation of upcoming stimuli and tasks can lead to improved performance, if the anticipated situation occurs, while expectation mismatch can lead to less efficient processing. Researchers have used methodological approaches that rely on either self-generated expectations (predictions) or cue-induced expectations to investigate expectation mismatch effects. Differentiating these two types of expectations for different contents of expectation such as stimuli, responses, task sets and conflict level, we review evidence suggesting that self-generated expectations lead to larger facilitating effects and conflict effects on the behavioral and neural level – as compared to cue-based expectations. On a methodological level, we suggest that self-generated as compared to cue-induced expectations allow for a higher amount of experimental control in many experimental designs on expectation effects. On a theoretical level, we argue for qualitative differences in how cues vs. self-generated expectations influence performance. While self-generated expectations might generally involve representing the expected event in the focus of attention in working memory, cues might only lead to such representations under supportive circumstances (i.e., cue of high validity and attended).

Contents

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1. The distinction between self-generated and cue-induced expectations

In the current review we argue for a differentiated analysis of the role of expectations in the context of task preparation and cognitive conflict. We will suggest that self-generated expectations can be quantitatively and qualitatively different from cue-induced expectations. In addition we will point out similarities between sequential modulations known as conflict adaptation effects and similar modulations for expectations. However, some general considerations are in place, before we can focus on the comparison between self-generated and cue-induced expectations. Participants are forming expectations concerning upcoming stimuli (e.g., Bruner and Postman, 1949; Marcus et al., 2006), responses (e.g., Notebaert et al., 2009), task sets (e.g., Duthoo et al., 2012), conflict level (e.g., Alpay et al., 2009; Duthoo et al., 2013), and action effects (e.g., Kühn et al., 2010). The latter authors, for instance, found a BOLD response in fMRI signal in the fusiform face area vs. the parahippocampal place area when participants were expecting the presentation of a face vs. house. They were expecting the stimulus as it had been repeatedly paired with the key press action currently performed. Expectations led to similar activations as presented stimuli. As expectation involves pre-activation of stimulus representations, stimuli can be processed faster and actions can be selected more quickly, because the respective thresholds can be reached faster (cf. Waszak et al., 2012). In their review Waszak and colleagues furthermore demonstrated that this can come at the cost of difficulties in distinguishing expected from presented stimuli unless the experimental procedure clearly separates them.

Apart from stimulus identity, expectations can also involve the specific timing of stimuli (e.g., Coull and Nobre, 2008; Fischer et al., 2013; Grosjean et al., 2001; Klein-Flügge et al., 2011; Nobre et al., 2007; Niemi and Näätänen, 1981; Schwartze and Kotz, 2013) and specific response elements (e.g., Thomaschke et al., 2011). Expectation effects occur in many experimental designs – irrespective of whether one is focusing on them in the research question or tries to control and balance them as the focus lies elsewhere. For instance, in a choice reaction task, participants form expectations concerning upcoming stimuli and responses if provided a minimum amount of time to form an expectation (e.g., Marcus et al., 2006; Martini et al., 2013).

The notion of expectation as an independent theoretical construct has served as an example for redundant theorizing by critics of early cognitive psychology (e.g., Skinner, 1950). However, it has gained considerable support through cognitive modeling, where prediction error is at the core of many learning models (e.g., Sutton and Barto, 1981), as well as through the discovery of neural correlates (e.g., Bubic et al., 2009; Eppinger et al., 2013; Garrison et al., 2013; Hämmerer et al., 2011; Schultz et al., 1997). In neurocognitive and behavioral research, expectation is often studied via mismatch effects. Such aftereffects of expectations concerning affectively neutral stimuli (the focus of the current review) have been reported based on EEG (Courchesne et al., 1975; Fabiani and Friedman, 1995) and EEG in combination with fMRI (Opitz et al., 1999; Strobel et al., 2008). Most notably, Gläscher et al. (2010) have dissociated outcome expectation (i.e., expecting to be rewarded) from expectations concerning other task events (i.e., expecting a specific stimulus to occur). In their task it could, for instance, happen that participants were presented a stimulus different from the one expected, but nevertheless earned the expected reward. Alternatively, the stimulus was the expected one but reward was unexpectedly withheld. Gläscher et al. correlated parameters of either kind of reward and of stimulus expectation trial by trial with fMRI data to argue that a mismatch of expected and presented stimulus leads to an update of stimulus expectation in intraparietal sulcus and lateral prefrontal cortex. Unfulfilled reward expectations in turn are followed by an update in the ventral striatum. As we will focus on stimulus expectations rather than on reward expectations, we will take chess as an example in order to further elaborate this distinction. Stimulus expectations can entail specific moves by the opponent that will likely follow the current change on the board. To the contrary, reward expectations would make a chess pattern feel dangerous – even when one does not know the specific chain of moves that most likely will follow. Single-unit recordings in monkeys (Bayer and Glimcher, 2005; Schultz et al., 1997) and human fMRI (D'Ardenne et al., 2008) have been taken to suggest that unfulfilled reward expectations lead to reward prediction errors related to dopaminergic neurons in the ventral tegmental area and substantia nigra pars compacta (cf. Gläscher et al., 2010). In line with dopaminergic modulation, reward prediction error correlates with BOLD signals in the ventral striatum (Haruno and Kawato, 2006; McClure et al., 2003; O'Doherty et al., 2003). The predominance of work on reward prediction error might have led to the impression that studying reward expectation is studying expectation in general. However, beyond reward expectation, people (Gläscher et al., 2010) and animals (Blaisdell, 2008; Ostlund et al., 2008) build representations of transition spaces of stimuli (i.e., which stimulus is expected to follow which cue depending