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Conflict in the kitchen: Contextual modulation of responsiveness to affordances

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ABSTRACT

Recently, human behavior has been considered the product of continuous interactions between perception, cognition and action in which "affordances" (action possibilities the environment has to offer) play an important role. Converging evidence suggests that multiple action possibilities simultaneously compete for further processing, while external and internal factors (e.g., incoming sensory information, predictions) bias this competition. In the present study we used a stop-task to investigate whether context is able to modulate the strength of the responsiveness to affordances. We therefore placed participants in an actual kitchen and workshop during electroencephalographic recordings. A faster response to context congruent objects demonstrated that the direct surrounding is able to affect responsiveness to affordances. In addition, when responses needed to be withheld, context congruent objects evoked greater response conflict as indicated by an enhanced N2 Event Related Potential (ERP) component.

1. Introduction

For decades human behavior has been considered the product of a complex information processing system in which perception, cognition and action are computed in a serial way. In contrast, recent findings support a model that emphasizes the existence of continuous and more direct interactions between perception, cognition and action in which "affordances", i.e., action possibilities the environment has to offer, play an important role (Cisek, 2007; Cisek & Kalaska, 2010; Donner, Siegel, Fries, & Engel, 2009; Engel, Maye, Kurthen, & König, 2013; Gibson, 1979; Gold & Shadlen, 2007; Rietveld, 2008a; Withagen, de Poel, Araújo, & Pepping, 2012).

The last decade research into affordances has gained firm ground in the (cognitive) neurosciences and psychology (Cisek & Kalaska, 2010; Van Elk, van Schie, & Bekkering, 2014). The concept of affordances has been put forward by Gibson (1979), and has been integrated in recent models of interactive behavior (Cisek, 2007; Rounis & Humphreys, 2015). In these frameworks, multiple action possibilities simultaneously compete for further processing, while predictions, behavioral goals, rewards and ongoing streams of incoming sensory information modulate the strength of such activated action possibilities (Borghi, Flumini, Natraj, & Wheaton, 2012; Cisek & Pastor-Bernier, 2014; Frijda, 2010; Natraj et al., 2013; Ridderinkhof,

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2014). The way these models adopted affordances deviates from Gibson's externalist view by incorporating a neural representation of affordances (Borghi & Riggio, 2015; Cisek & Kalaska, 2010; Ellis & Tucker, 2000; Witt & Riley, 2014). This divergent use of the term affordances may not be optimal, and a better specification might prove to be more suitable (Ellis & Tucker, 2000), but lies beyond the scope of this paper. In this paper, we will follow the way recent models about interactive behavior in cognitive neuroscience have applied the term affordances, thereby focusing on the neural interactions between perception, cognition and action (Buc Calderon, Verguts, & Gevers, 2015; Cisek, 2007).

As described above, several factors influence the outcome of the competition between activated action possibilities. As such, the factors that bias the outcome of action selection can have far-reaching practical consequences. For instance the way we act upon a stimulus might differ depending on the preconception of the immediate environment in which a stimulus is being presented, which can have grave consequences (e.g., the way law enforcers react to stimuli might differ depending on the a priori appraisement of the environment in which the stimuli is present). However, studies addressing models of interactive behavior (e.g., the affordance-competition model [Cisek, 2007]) are typically confined to the realms of the lab. In this study, we used a stop-task to investigate whether the environment is able to modulate responsiveness to affordances. Crucially, we adopted an ecological experimental approach by placing participants in an *actual* kitchen or workshop during data recording. This approach deviates from previous studies exploring the relationship between context and affordances (Borghi et al., 2012) through presented pictures.

The stop-task, in which a go stimulus is typically followed by a stop signal on ~30% of the trials, is well suited to observe dynamics related to response competition, as outlined by the horse-race model (Logan & Cowan, 1984). In this framework, processes related to the "go response" race against processes related to the "stop response", and whichever arrives first "wins" the race (that response will be executed). A robust marker for response conflict, related to the simultaneous activated "go" and "stop response" (Nieuwenhuis, Yeung, Van Den Wildenberg, & Ridderinkhof, 2003), can be picked up by using electroencephalographic (EEG) recordings during stop-task performance. Specifically, a negative deflection of the EEG signal occurring after 200 ms (the N2) has been strongly linked to response conflict in the stop-task (Enriquez-Geppert, Konrad, Pantev, & Huster, 2010).

Previous work demonstrated that the mere observation of pictures of manipulable objects is able to elicit their affordances by activating the motor system (Grafton, Fadiga, Arbib, & Rizzolatti, 1997; Raos, Umiltá, Murata, Fogassi, & Gallese, 2006). In the present study, we presented kitchen objects and tools as "go stimuli" to observe how congruence with the environment (i.e., kitchen or workshop) influenced responsiveness to the affordances of these presented objects. Specifically, by using the stop-task and EEG recordings we are able to determine whether the congruence of the environment modulates the strength of activation of the "go stimulus" as indicated by measures of response conflict (N2) and reaction times.

To investigate whether the effect of context influenced visual attention we examined reaction times on a visual search task (Bar, 2004). In this task, we presented a target object among several distractors. The target and distractors consisted of pictures of kitchen objects or workshop tools (i.e., when a kitchen object was the target the distractors were made up of tools and vice versa), again presented in the actual environment of a workshop or a kitchen.

2. Material and methods

2.1. Participants

Twenty-three participants (18 female, 5 male, mean age = 24.8 years, range = 19–40) gave their written informed consent to participate in the experiment. All had normal or corrected-to-normal vision and were naive to the purpose of the experiment. Four participants only performed one session; all data from these participants were discarded (two participants were not able to participate in the second session, while two other participants were not able to perform above 60% correct on stop trials in the first session).

2.2. Procedures and analyses

In two sessions, we recorded EEG signals (24 channels) while 19 right-handed participants performed a stop-task (10 blocks, 800 trials per session) followed by a visual search task (2 blocks, 160 trials per session). In the stop-task, stimuli consisted for 50% of tools and for 50% of kitchen objects, with the grip pointing rightwards (see Fig. 1). Stimuli were presented against a background that matched the actual background of the recording site. Crucially, each session was situated in a different actual location: either in the kitchen of a restaurant or in a workshop (order counter-balanced across participants), see Fig. 1. We presented the same stimuli at both locations (only the background varied). As a consequence, at each location half of the stimuli consisted of objects that are typically being used (congruent) in that environment. On each location, experimental settings were kept as similar as possible.

Each trial started with a 1500 ms fixation period after which a kitchen object or a tool was being presented. Participants were instructed to respond as fast as possible by pressing the space bar with their right hand when an object was presented but to withhold their response in case a red X obscured the presented object after 150 ms (stimulus onset asynchrony 150 ms). The X appeared in 30% of all trials (pseudo-randomly). Prior to each block, subjects were instructed to adjust their speed such that they would perform at an accuracy level of ~75% on stop trials (feedback given after each block). These