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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

Fig. 1. Kitchen objects and tools were presented against a matching background with that of the surroundings (left and middle). Participants were placed in an actual kitchen of a restaurant and in a workshop during the two tasks (right).

instructions are typically given during stop-tasks in order to stimulate participants to respond as fast as possible while still being able to exert control, resulting in robust measures of response conflict.

The visual search task consisted of 7 objects randomly presented centered around fixation. In the first block typical kitchen objects were used as target stimuli while typical tools made up the distractors and vice versa in the second block (order counter-balanced). Participants were instructed to respond as quickly as possible by pressing the m key when a target stimulus (any kitchen object or any tool) was present (50% of the trials) and by pressing the z key when only distractors were presented.

EEG was recorded and sampled at 512 Hz using an Easycap system (Easycap, Munich). After acquisition, EEG data were detrended and re-referenced to average and filtered using a high pass filter of 0.5 Hz, a low-pass filter of 30 Hz and a notch filter of 50 Hz. Eye movement correction was applied on the basis of Independent Component Analysis. Artifact correction was applied on all separate channels by removing segments outside the range of ±75 μV or with a voltage step exceeding 50 μV per sampling point. Baseline correction was applied by aligning time series to the average amplitude of the interval from −300 ms to the onset of the stimulus. Finally all trials were averaged per condition. All preprocessing steps were done using Brian Vision Analyzer (BrainProducts).

To study the effect of context on response conflict and response inhibition we compared Event Related Potentials (ERPs) on stop trials when the target object was congruent vs. incongruent with the environment (i.e., we collapsed across location and object type, so each data set now contained the same amount of trials obtained in the kitchen and workshop and the same amount of trials containing kitchen object and tool stimuli). Because we used a limited amount of electrodes we exclusively focused on the centrally positioned Cz electrode for our N2/P3 ERP component analyses. The Cz electrode is typically incorporated in examination of modulations of N2/P3 ERP components (Enriquez-Geppert et al., 2010; Wokke, van Gaal, Scholte, Ridderinkhof, & Lamme, 2011). No EEG data was recorded during the visual search task, although the participants were not aware of this fact.

3. Results

To test the effect of context on responsiveness, we performed two 2 (place: kitchen and workshop) × 2 (object: tools and kitchen objects) repeated measures ANOVA's on median RT and accuracy (percentage correct stops). For RT we did not observe a main effect of place ($F(1,18) = .149$, $p = .704$, $\eta_p^2 = .008$) or object ($F(1,18) = .084$, $p = .775$, $\eta_p^2 = .005$), however we did find a significant cross-over interaction effect between place and object ($F(1,18) = 5.643$, $p = .029$, $\eta_p^2 = .24$). These findings demonstrate that participants responded differently depending on which object was presented on which location (Fig. 2a). Two-tailed post hoc t tests demonstrated ($t(18) = 2.38$, $p = .029$, $d = .55$) that participants responded faster to objects when the environment was congruent with that object (e.g., participants responded faster to tools in the workshop than when being in the kitchen, Fig. 2b). No effects were found for accuracy (all $F < 0.41$, $p > .53$, $\eta_p^2 < .023$).

To investigate whether the observed RT effect was the result of a contextual influence on visual attention, or the result of an increased perception–action coupling induced by the environment, we examined RT's from the visual search task and typical response-conflict ERPs from the stop-task (Enriquez-Geppert et al., 2010). To determine the role of context on visual

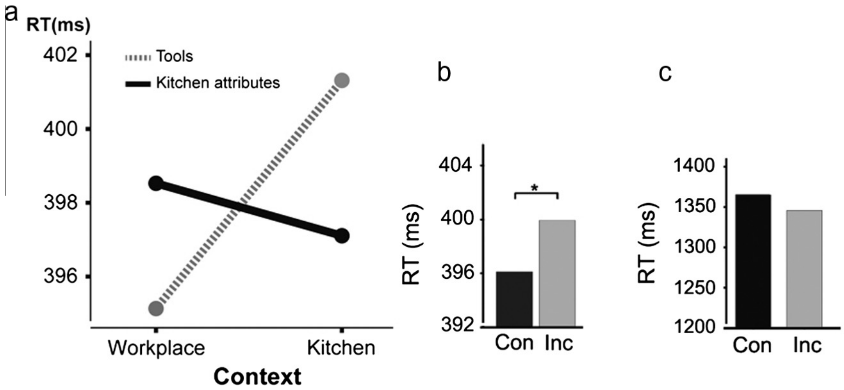

Fig. 2. (a) We observed an interaction effect between place and object, indicating that responses differed depending on where what object was presented. (b) Participants responded faster to stimuli that are assumed to be typically used in the environment where the data was recorded (context congruent). (c) Reaction times on the visual search task did not significantly differed depending on context congruency.

attention we compared median RT's when the target stimulus in the visual search task was context congruent with RT's when the target stimulus was context incongruent (Fig. 2c). We observed no effect of context on RT's in the visual search task ($t(18) = .433$, $p = .67$, $d = .099$).

To examine the role of context on response conflict we compared the N2 on stop trials when the target object was congruent vs. incongruent with the environment (collapsing across location and object type). As Fig. 3 demonstrates we found an increased N2 ($t(18) = 2.31$, $p = .033$, $d = .53$) when participants had to withhold their response when the target object was congruent with the context in comparison to an incongruent context. This effect was specific for the N2 and did not generalize to other stop-task EEG components (P3: $t(18) = .94$, $p = .36$, $d = .37$).

4. Discussion

In the present study, we observed faster responses in a stop-task when objects corresponded with the preconceived functionality of the environment, while such context congruent objects evoked greater response conflict when responses needed to be withheld (reflected in an enhanced N2 ERP component). Our results indicate that an environment with specific (action) associations is able to influence responsiveness to affordances.

Although the identity of the presented objects was not relevant for task performance, we still observed effects related to responsiveness to affordances, suggesting that affordances are activated relatively automatic (but see, Tipper, Paul, & Hayes, 2006). On the other hand, our results demonstrate that there is also room for considerable adjustment of or flexibility in the activation of affordances: A stronger activation of the "go stimulus", when the stimulus matched the functionality of the

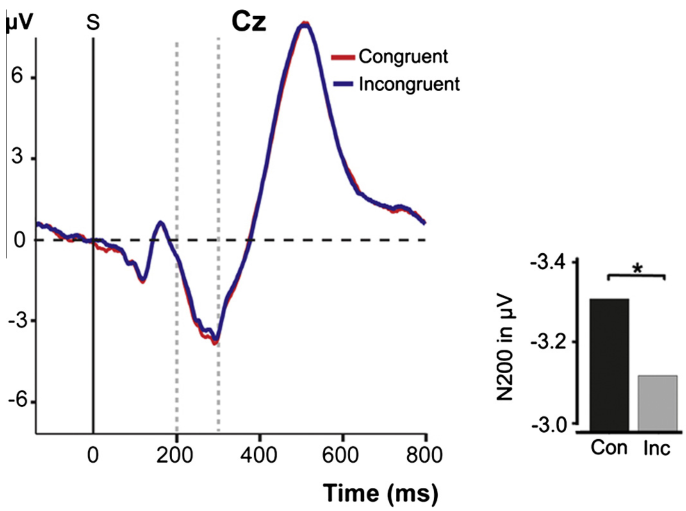

Fig. 3. An enhanced N2 ERP component (200–300 ms) was observed when participants had to withhold their response on trials where contextual congruent objects were presented compared to trials on which less context typical objects were presented.

environment, indicates that context is able to influence (i.e., boost or suppress) responsiveness to affordances (Borghi & Riggio, 2015).

In order to find out whether context acts as an early or late filter on activation of affordances (Borghi & Riggio, 2015; Van Elk et al., 2014), a different task set-up than presented here is necessary. It would be interesting to use a variety of different time intervals between the go and stop stimulus (as commonly used in stop-tasks), in order to parametrically determine the timing of contextual effects on response conflict measures. Nonetheless, the manipulation of environment did not produce any effect on RTs during the visual search task, indicating that the observed effect of context is not purely caused by alterations in visual attention. Instead, the findings of faster responses and an enhanced N2 on context congruent trials suggest that the environment influences the strength of the perception–action coupling. Due to logistics we were limited in the number of participants we could test. However, we do not expect it to be likely that an increase in the number of participants would have resulted in faster RTs on context congruent trials compared to context incongruent trials (see Fig. 2c).

The scope of the observed effects should be investigated further by varying context, tasks and characteristics of the agent (Rietveld, 2008b). For instance it would be interesting to see how the level of expertise of the participants interacts with the effect of context (Farrow & Abernethy, 2003). Further, this research provides an interesting way for examining how responsiveness to affordances interacts with different environments in clinical disorders such as addiction (Cousijn, Goudriaan, & Wiers, 2011). Despite the fact that interactions between the environment and human behavior have attracted a lot of attention recently, most studies are still performed in (well controlled) lab settings. Possibly, the advent of highly applicable virtual reality set-ups and increasingly portable experimentation systems will make it more feasible to study human behavior in a more ecological valid manner.

Conflict of interest

The authors report no conflict of interest associated with this manuscript.

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References

Bar, M. (2004). Visual objects in context. *Nature Reviews Neuroscience, 5*(8), 617–629.

Borghi, A. M., Flumini, A., Natraj, N., & Wheaton, L. A. (2012). One hand, two objects: Emergence of affordance in contexts. *Brain and Cognition, 80*(1), 64–73.

Borghi, A. M., & Riggio, L. (2015). Stable and variable affordances are both automatic and flexible. *Frontiers in Human Neuroscience, 9*.

Buc Calderon, C., Verguts, T., & Gevers, W. (2015). Losing the boundary: Cognition biases action well after action selection. *Journal of Experimental Psychology: General, 144*.

Cisek, P. (2007). Cortical mechanisms of action selection: The affordance competition hypothesis. *Philosophical Transactions of the Royal Society B: Biological Sciences, 362*(1485), 1585–1599.

Cisek, P., & Kalaska, J. F. (2010). Neural mechanisms for interacting with a world full of action choices. *Annual Review of Neuroscience, 33*, 269–298.

Cisek, P., & Pastor-Bernier, A. (2014). On the challenges and mechanisms of embodied decisions. *Philosophical Transactions of the Royal Society B: Biological Sciences, 369*(1655), 20130479.

Cousijn, J., Goudriaan, A. E., & Wiers, R. W. (2011). Reaching out towards cannabis: Approach-bias in heavy cannabis users predicts changes in cannabis use. *Addiction, 106*(9), 1667–1674.

Donner, T. H., Siegel, M., Fries, P., & Engel, A. K. (2009). Buildup of choice-predictive activity in human motor cortex during perceptual decision making. *Current Biology, 19*(18), 1581–1585.

Ellis, R., & Tucker, M. (2000). Micro-affordance: The potentiation of components of action by seen objects. *British Journal of Psychology, 91*(4), 451–471.

Engel, A. K., Maye, A., Kurthen, M., & König, P. (2013). Where's the action? The pragmatic turn in cognitive science. *Trends in Cognitive Sciences, 17*(5), 202–209.

Enriquez-Geppert, S., Konrad, C., Pantev, C., & Huster, R. J. (2010). Conflict and inhibition differentially affect the N200/P300 complex in a combined go/nogo and stop-signal task. *Neuroimage, 51*(2), 877–887.

Farrow, D., & Abernethy, B. (2003). Do expertise and the degree of perception–action coupling affect natural anticipatory performance? *Perception – London, 32*(9), 1127–1140.

Frijda, N. H. (2010). Impulsive action and motivation. *Biological Psychology, 84*(3), 570–579.

Gibson, J. J. (1979). *The theory of affordances in the ecological approach to visual perceptual.*

Gold, J. I., & Shadlen, M. N. (2007). The neural basis of decision making. *Annual Review of Neuroscience, 30*, 535–574.

Grafton, S. T., Fadiga, L., Arbib, M. A., & Rizzolatti, G. (1997). Premotor cortex activation during observation and naming of familiar tools. *Neuroimage, 6*(4), 231–236.

Logan, G. D., & Cowan, W. B. (1984). On the ability to inhibit thought and action: A theory of an act of control. *Psychological Review, 91*(3), 295.

Natraj, N., Poole, V., Mizelle, J. C., Flumini, A., Borghi, A. M., & Wheaton, L. A. (2013). Context and hand posture modulate the neural dynamics of tool–object perception. *Neuropsychologia, 51*(3), 506–519.

Nieuwenhuis, S., Yeung, N., Van Den Wildenberg, W., & Ridderinkhof, K. R. (2003). Electrophysiological correlates of anterior cingulate function in a go/no-go task: Effects of response conflict and trial type frequency. *Cognitive, Affective, & Behavioral Neuroscience, 3*(1), 17–26.

Raos, V., Umiltá, M. A., Murata, A., Fogassi, L., & Gallese, V. (2006). Functional properties of grasping-related neurons in the ventral premotor area F5 of the macaque monkey. *Journal of Neurophysiology, 95*(2), 709–729.

Ridderinkhof, K. R. (2014). Neurocognitive mechanisms of perception–action coordination: A review and theoretical integration. *Neuroscience & Biobehavioral Reviews, 46*, 3–29.

Rietveld, E. (2008a). Situated normativity: The normative aspect of embodied cognition in unreflective action. *Mind, 117*(468), 973–1001.

Rietveld, E. (2008b). Special section: The skillful body as a concernful system of possible actions phenomena and neurodynamics. *Theory & Psychology, 18*(3), 341–363.
Rounis, E., & Humphreys, G. (2015). Limb apraxia and the "affordance competition hypothesis". *Frontiers in Human Neuroscience, 9*.
Tipper, S. P., Paul, M. A., & Hayes, A. E. (2006). Vision-for-action: The effects of object property discrimination and action state on affordance compatibility effects. *Psychonomic bulletin & review, 13*(3), 493–498.
Van Elk, M., van Schie, H., & Bekkering, H. (2014). Action semantics: A unifying conceptual framework for the selective use of multimodal and modality-specific object knowledge. *Physics of Life Reviews, 11*(2), 220–250.
Withagen, R., de Poel, H. J., Araújo, D., & Pepping, G. J. (2012). Affordances can invite behavior: Reconsidering the relationship between affordances and agency. *New Ideas in Psychology, 30*(2), 250–258.
Witt, J. K., & Riley, M. A. (2014). Discovering your inner Gibson: Reconciling action-specific and ecological approaches to perception–action. *Psychonomic Bulletin & Review, 21*(6), 1353–1370.
Wokke, M. E., van Gaal, S., Scholte, H. S., Ridderinkhof, K. R., & Lamme, V. A. (2011). The flexible nature of unconscious cognition. *PLoS ONE, 6*(9).