Acta Psychologica 158 (2015) 43–50

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Congruency effects on the basis of instructed response-effect contingencies☆

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ARTICLE INFO

Article history:
Received 2 April 2014
Received in revised form 30 March 2015
Accepted 7 April 2015
Available online 29 April 2015

PsycINFO classification:
2340
2343

Keywords:
Congruency effect
Response-effect contingencies
Instructions
Instruction-based effects

ABSTRACT

Previous research indicated that stimulus–response congruency effects can be obtained in one task (the diagnostic task) on the basis of the instructed stimulus–response mappings of another task (the inducer task) and this without having executed the instructions of the inducer task once. A common interpretation of such finding is that instructed stimulus–response mappings are implemented into functional associations, which automatically trigger responses when being irrelevant and this without any practice. The present study investigated whether instruction-based congruency effects are also observed for a different type of instructions than instructed S–R mappings, namely instructed response-effect contingencies. In three experiments, instruction-based congruency effects were observed in the diagnostic task when the instructions of the inducer task specified response-effect contingencies. On the one hand, our results indicate that instruction-based congruency effects are not restricted to instructed S–R mappings. On the other hand, our results suggest that the representations that mediate these effects do not specify the nature of the relation between response and effect even though this relation was explicitly specified by the instructions.

Although instructions play a vital role in our daily life functioning, little is known about how instructions actually influence behavior. On the one hand, instructions can specify particular response strategies that participants could adopt when performing a particular task. Research in this context has demonstrated, for instance, that instructions specifying the intention to respond particularly fast on certain stimuli could result in the attenuation of automatic interference effects (e.g. Cohen, Bayer, Jaudas, & Gollwitzer, 2008; Miles & Proctor, 2008). On the other hand, instructions can also specify the stimulus–response (S–R) mappings of a task (for a review, see Meiran, Cole, & Braver, 2012). A substantial amount of research focusing on this type of instructions observed that instructed S–R mappings, which have never been executed before, can automatically bias performance when being irrelevant (e.g., Cohen-Kdoshay & Meiran, 2007, 2009; De Houwer, Beckers, Vandorpe, & Custers, 2005; Eder, 2011; Everaert, Theeuwes, Liefooghe, & De Houwer, 2014; Liefooghe, De Houwer, & Wenke, 2013; Liefooghe, Wenke, & De Houwer, 2012; Meiran & Cohen-Kdoshay, 2012; Meiran, Pereg, Kessler, Cole, & Braver, in press-a, in press-b; Theeuwes et al., 2014; Wenke, De Houwer, De Winne, & Liefooghe, in press; Wenke, Gaschler, & Nattkemper, 2007; Wenke, Gaschler, Nattkemper, & Frensch, 2009).

An example of a procedure that has been used for investigating an automatic influence of instructed S–R mappings is provided by Liefooghe et al. (2012). These authors presented participants with different runs of trials on which two tasks had to be performed which shared stimuli and responses: the inducer and the diagnostic task. At the start of each run participants received two novel arbitrary S–R mappings of the inducer task, each assigning a stimulus either to a left or a right response based on the identity of the stimulus (e.g., If 'X', press left; if 'Y', press right). Before executing the inducer task, several trials of the diagnostic task were performed, on which participants decided whether a stimulus was presented in italic or upright, again by pressing a left or right response key (e.g., upright, press left; italic, press right). After a number of trials of the diagnostic task, a probe stimulus of the inducer task was presented. Liefooghe et al. (2012) observed that performance in the diagnostic task, in terms of speed and sometimes in terms of accuracy, was better on responses that matched with the instructions of the inducer task (e.g., 'X' presented upright or 'Y' presented in italic) than on responses that did not match with the S–R mappings of the inducer task (e.g., 'Y' presented upright or 'X' presented in italic). Given that (1) the diagnostic task was performed immediately after the presentation of the instructions of the inducer task, thus prior to the application of these instructions and (2) the inducer task comprised novel S–R mappings on each run, the conclusion was drawn that the congruency effect observed in the diagnostic task was based on the instructed S–R

☆ This research was supported by grant BOF09/01M00209 of Ghent University to Jan De Houwer.

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http://dx.doi.org/10.1016/j.actpsy.2015.04.002
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mappings of the inducer task, which were never executed overtly before. Liefooghe et al. (2012), (see also Meiran et al., 2012; Wenke et al., 2007) suggested that instruction-based congruency effects indicate that instructed S–R mappings are transformed into procedural associations during task preparation, which automatically trigger response activations when being irrelevant (see, Everaert et al., 2014; Meiran et al., in press-a, in press-b).

Although instruction-based congruency effects have been observed many times in recent years, studies indicated that these effects are subject to several boundary conditions. For instance, instruction-based congruency effects disappear when working memory is taxed too heavily (Cohen-Kdoshay & Meiran, 2007, 2009; Meiran & Cohen-Kdoshay, 2012) and they are only observed when participants intend to apply the instructed S–R mappings (Liefooghe et al., 2012) and actively prepare themselves on the basis of these instructed S–R mappings (Liefooghe et al., 2013; Wenke et al., 2009). Although there is a steady increase in our insights about instruction-based congruency effects, research has focused exclusively on one specific type of instructed relationships, namely S–R mappings. Accordingly, the question arises whether similar effects can be observed on the basis of different types of instructions. The present study aims to make a first step in this direction by investigating to which extent instruction-based congruency effects can be obtained on the basis of instructions specifying the contingency between a particular response and the effect it elicits in the environment (i.e. Response-Effect or R-E contingencies).

Research on action-effect learning has provided strong evidence that congruency effects can be obtained on the basis of previously learned R-E contingencies (for a review see Shin, Proctor, & Capaldi, 2010). For instance, Hommel (1996; Experiment 2) first subjected participants to a training phase in which pressing a response key once or twice resulted in the presentation of a left-sided tone or a right-sided tone, respectively. In a subsequent test phase, participants had to respond to the identity of a visual stimulus by pressing the response key once or twice. The left–right stimulus position varied randomly and was irrelevant. Hommel (1996; Experiment 2) observed faster responses when the visual stimulus position (e.g., left) matched with the auditory tone position (e.g. left) that was associated with the response required to the identity of the visual stimulus (e.g., a single key press). Grosjean and Mordkoff (2002) demonstrated that the Simon effect (Simon & Rudell, 1967), a congruency effect between the irrelevant left–right stimulus location and the left–right response location, could be modulated by presenting left–right post-response stimuli, which could either correspond to the response location or not. The Simon effect increased when congruent post-response stimuli were presented and decreased when incongruent post-response stimuli were presented.

Research on action effects is particularly relevant for research on cognitive control as it challenges strict forward models of information processing (e.g., Massaro, 1990; Sanders, 1980; Sternberg, 1967; see Hommel, Müsseler, Aschersleben, & Prinz, 2001 for an in depth discussion) by emphasizing the importance of the consequences or expected consequences of a particular action in the environment. Action effects are at the core of influential theories on cognitive control, such as the common coding theory (Prinz, 1990) and the theory of event coding (Hommel, 2009), which elaborate on the ideomotor principle (Herbart, 1825; Lotze, 1852). The ideomotor principle states that actions are activated on the basis of a representation of the effects these actions evoke in the environment. Experiencing an effect that is contingent upon the execution of an action leads to the formation of a bidirectional association between an action and the perceived effect. Based on this R-E association, the activation of the effect automatically leads to the activation of the associated response. Hommel (2009) proposed that a stimulus and a response are integrated into a functional association independently of the order in which the stimuli and responses are experienced (i.e., a stimulus before a response as in S–R contingencies or a stimulus after a response as in R-E contingencies). Within this view, congruency effects based on R-E contingencies are similar to congruency effects based on S–R contingencies (see also, Dutzi & Hommel, 2009; Elsner & Hommel, 2001; Hommel, 2005).

Of interest for the present purpose is a study of Hommel, Alonso, and Fuentes (2003), which observed that action effects can generalize over words sharing semantic features. In an acquisition phase, the production of a particular response consistently resulted in the appearance of a particular word on the screen. In the test phase, participants responded to words that were semantically associated with the words that were presented as response effects in the acquisition phase. Performance was better when the response to the words in the test phase corresponded with the response preceding the semantically related word in the acquisition phase. This finding suggests that a congruency effect based on R-E contingencies can be obtained with stimuli that never co-occurred with a particular response in the acquisition phase, but that resemble stimuli that were part of a previously learned R-E contingency. Although the findings of Hommel et al. (2003) indicate that direct experience is not a prerequisite to observe R-E contingency effects, the question remains whether instructions about R-E contingencies are sufficient to produce congruency effects, as it is the case for instructed S–R mappings.

The present study offers a more stringent test of the question whether instruction-based congruency effects can be obtained on the basis of instructed R-E contingencies. As mentioned before, this is an important issue as it deals with the boundary conditions of the instruction-based congruency effect as a tool for understanding how instructions moderate behavior. At the same time, the observation of instruction-based congruency effects on the basis of instructed R-E contingencies can offer us additional insights on the nature of the type of representation that mediates these effects. Based on the proposal of Hommel (2009), the observation of an instruction-based congruency effect on the basis of instructed R-E contingencies may suggest that while the associations formed on the basis of instructions do include stimulus and response codes, they do not include a qualification of the particular relation between these codes (i.e., a particular effect is contingent upon a particular response), even though such relation is explicitly specified by the instructions. At the very least, the representation that mediates instruction-based congruency effects must allow for a backward activation of response representations upon the activation of effect representations. A bi-directional response-effect association seems a likely candidate for such a representation.

In order to test whether congruency effects could also be obtained on the basis of instructed R-E contingencies, we used a variant of the aforementioned procedure used by Liefooghe et al. (2013, 2012); see also Everaert et al., 2014; (Theeuwes, Liefooghe, & De Houwer, 2014). In a series of three experiments, the instructions of the inducer task specified R-E contingencies rather than S–R mappings. In Experiments 1 and 2, the inducer task consisted of a grid filled with two stimuli and participants had to remove (Experiment 1) or add (Experiment 2) a particular stimulus such that both stimuli were present an equal number of times in the grid. To this end, participants had to press a left or a right key, which led to the addition or removal of a particular stimulus. In other words, a particular response resulted in a particular effect, namely the addition or removal of a specific stimulus. We will refer to this stimulus as the *effect stimulus*. Each run of trials started with the presentation of two novel R-E contingencies, with each contingency relating a left or right response to a particular effect stimulus. After the presentation of the instructions of the inducer task, participants performed a diagnostic task as outlined above. Importantly, the effect stimuli described in the R-E contingencies of the inducer task were used as stimuli in the diagnostic task. On congruent diagnostic trials, the stimulus and the correct response were part of the same R-E contingency in the inducer task. On incongruent diagnostic trials, the stimulus required a response that was different from the one specified in the R-E contingency of the inducer task. As such, the difference between congruent and incongruent trials could be investigated as in the studies of Liefooghe et al. (2013, 2012), but it was now based on