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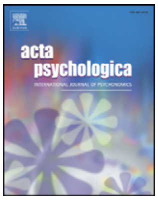

Congruency effects on the basis of instructed response-effect contingencies[☆]

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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

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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 instructed R-E contingencies rather than on instructed S–R mappings. Because it is possible that participants in Experiments 1 and 2 reinterpreted the R-E contingencies as S–R mappings, a third experiment was conducted in which the inducer task was modified such that reinterpretation could not occur. In all three experiments, an instruction-based congruency effect was observed in the diagnostic task.

1. Experiment 1

In Experiment 1 the goal of the inducer task was to remove a particular stimulus from a grid filled with two types of stimuli, such that both types of stimuli was presented an equal number of times. To this end, participants were instructed with R-E contingencies, relating a response to an effect stimulus.

1.1. Method

1.1.1. Participants

Twenty-three students at Ghent University participated for a payment of 5 Euro. All participants had normal or corrected-to-normal vision and all were naive to the purpose of the experiment.

1.1.2. Materials

Experiment 1 consisted of different runs each containing two tasks (see Fig. 1): the inducer task and the diagnostic task. In each run, both tasks used the same responses ('A'- and the 'P'-key on an AZERTY keyboard) and (effect) stimuli. For every run, a pair of effect stimuli was randomly selected from a list consisting of 56 symbols. The symbols used in Experiments 1 and 2 are: "A, B, C, D, E, F, G, H, I, J, K, M, N, O, P, Q, S, T, U, V, W, X, Y, Z, 1, 2, 3, 4, 5, 6, 7, 8, 9, &, L and §". Each effect stimulus was only assigned once either to a left ('A'-key) or right response ('P'-key) in a random fashion. This way two novel instructed R-E contingencies were created for each run, for instance, "the left key removes P" and "the right key removes Q". The 18 pairs of R-E contingencies were assigned to the three blocks of the experiment, with each block containing six runs of trials R-E contingency instructions were presented in Arial font, size 16 on the screen center, one above the other. Whether an instructed R-E contingency appeared above or below the screen center was determined randomly on each run.

The probe of the inducer task resembled a grid. This 'grid' contained the two effect stimuli instructed at the beginning of that run. One effect stimulus was presented four times on the grid. The other effect stimulus was presented three times (see Fig. 1 for an example). All effect stimuli were presented in Arial font, size 24 resulting in a grid approximately 5 cm wide and 3 cm high in the middle of the screen. Whether the most frequent effect stimulus was contingent upon the left or the right key was counterbalanced across runs.

In the diagnostic task participants judged whether a stimulus was printed upright or in *italic* by pressing the left or right key. The response mapping of this task was counterbalanced across participants. Stimuli in the diagnostic task were presented in Arial font, size 24. In each run, participants performed either 4, 8, or 16 trials of the diagnostic task. The number of diagnostic trials varied randomly across runs such that the onset of the probe of the inducer task was less predictable. This manipulation was intended to encourage participants to be constantly prepared to execute the inducer task (see Liefooghe et al., 2012). Each block consisted of two runs of each run-length. Half of the trials in the diagnostic task required a response that was in line with the R-E contingencies of the inducer task (i.e., congruent trials). On the other half, the response required by the diagnostic task mismatched with the R-E contingency (i.e., incongruent trials). Each run contained an equal number of congruent and incongruent diagnostic trials. The order of both trial types was random. Taken together, participants were presented with three blocks containing 6 runs of trials (2 runs of length 4, 2 runs of length 8, 2 runs of length 16). The first block was considered practice and not included into the analyses. Our design thus consisted of 112 diagnostic trials (56 congruent and 56 incongruent).

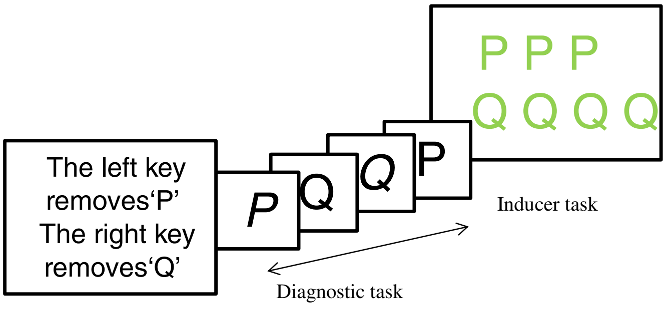

Fig. 1. Overview procedure of Experiment 1.

1.1.3. Procedure

Participants were tested individually by means of personal computers with a 17-inch color monitor running Tscope (Stevens, Lammertyn, Verbruggen, & Vandierendonk, 2006). Instructions were presented on the screen and paraphrased by the experimenter if necessary. The main instructions were followed by a practice block. During this block, participants were monitored and additional instructions were given if necessary. The practice block was followed by two test blocks. After every block there was a brief pause.

A run started with the presentation of the R-E contingencies for the inducer task (e.g., the left key removes 'P'; the right key removes 'Q'). These contingencies remained on screen until the participant pressed the spacebar or a maximum time of 20 s elapsed. The first trial of the diagnostic task started 750 ms after the removal of the R-E contingencies. The stimulus remained on screen until a response was provided or a response deadline (2000 ms) was exceeded. Incorrect responses were followed by a red screen for 200 ms, before the 750 ms inter-trial interval started. The probe of the inducer task was presented 750 ms after the last trial of the diagnostic task. The goal of the inducer task was to change the display in such a way that both effect-stimuli appeared an equal number of times. Hence, participants had to remove one of the effect-stimuli that was presented four times in the grid. For instance, if the letter P appeared four times in the grid and R-E contingency instructions stated that a P could be removed by pressing the left key, participants had to press the left key. The response deadline was 2000 ms. When participants pressed one of the two keys, the corresponding effect stimulus was removed from the grid. If participants removed the wrong effect stimulus an error message, the word 'FOUT' (wrong in Dutch) was displayed for 200 ms. A new run started after 750 ms. The experiment took about 20 min.

1.2. Results

The data of two participants were excluded from further analyses due to excessive error rates. The first excluded participant had an error rate of 50% in the inducer task. The second excluded participant had an error rate of 46% in the diagnostic task.

For the RT analysis, only correct trials of the diagnostic task were included (data loss: 6.5% of all trials). Trials with RTs longer than 2.5 SDs from a participant's mean cell RT were excluded (data loss: 2.6% of the total amount of correct trials). Mean RTs and the proportion of errors were each subjected to a repeated-measure ANOVA with instruction-based congruency (congruent, incongruent) as within-subjects factor.

There was a significant instruction-based congruency effect for the RTs, $F(1,20) = 5.03$, $MSE = 385$, $\eta_p^2 = .20$, $p < .05$, with faster responses on congruent diagnostic trials ($M = 532$ ms; $SD = 66$ ms) than on incongruent diagnostic trials ($M = 546$ ms; $SD = 65$ ms). This effect was also significant for the proportion of errors,

$F(1,20) = 6.77$, $MSE = 0.0012208$, $\eta_p^2 = .25$, $p < .05$, with less errors made on congruent diagnostic trials ($M = .05$; $SD = .04$) than on incongruent diagnostic trials ($M = .08$; $SD = .04$). In the inducer task, the average RT was 1033 ms ($SD = 307$ ms) and the average error rate was .08 ($SD = .27$).

1.3. Discussion

We obtained a significant instruction-based congruency effect in the diagnostic task: response performance, both in terms of speed and accuracy, was better on congruent diagnostic trials compared to incongruent diagnostic trials. These findings indicate that instruction-based congruency can be obtained on the basis of R-E contingencies, as it is the case for S–R mappings. Nevertheless, a potential concern of Experiment 1 is that participants actually experienced the R-E contingencies during the diagnostic task. Congruent diagnostic trials unfolded in line with the sequence of events specified by the R-E contingencies of the inducer task: the presented stimulus disappeared in response to a key press which – according the R-E contingencies of the inducer task –would remove that stimulus in the inducer task. In contrast, for incongruent diagnostic trials, the stimulus that disappeared when pressing a key, was – according to the R-E contingencies of the inducer task – not the effect stimulus that should disappear when pressing that key. Consider, as an example, that participants are provided with the following R-E contingencies of the inducer task: “The left key removes P; the right key removes Q” and the instructions of the diagnostic task indicate that stimuli printed upright (e.g., P) should be responded to with a left-key press and stimuli printed in italic (e.g., *P*) should be responded to with a right-key press. On a congruent diagnostic trial, the stimulus ‘P’ could be presented upright and participants respond left following the instructions of the diagnostic task, which causes that stimulus to disappear, ending that diagnostic trial. This sequence of events coincides with the sequence of events specified by the R-E contingencies, namely, “The left key removes P.” On an incongruent diagnostic trial, the stimulus ‘*P*’ is presented, but now in italic. Following the instructions of the diagnostic task, a right key-press is required and the stimulus ‘*P*’, which will make that stimulus disappear, again indicating the end of the trial. The sequence of events experienced on these incongruent trials thus is at odds with the sequence of events specified by the R-E contingency, “The left key removes P.” The difference in performance between congruent and incongruent trials in the diagnostic task may thus not only be related to a match/mismatch between the response required in the diagnostic task and the R-E contingencies of the inducer task, but also to a difference in the sequence of events experienced in the diagnostic task and the sequence of events specified by the R-E contingencies of the inducer task. In order to rule out this alternative interpretation, a second experiment was conducted.

2. Experiment 2

Experiment 2 was identical to Experiment 1 for the exception that the goal of the inducer task was now to add an effect stimulus to obtain a balanced grid. The instructed R-E contingencies of the inducer task now specified that a particular key-press would make a particular effect stimulus appear on the screen (e.g., the left key produces ‘P’; the right key produces ‘Q’), rather than make it disappear. Accordingly, the sequence of events experienced in the diagnostic task did not coincide with the sequence of events specified by the R-E contingencies, and these both for the congruent and incongruent diagnostic trials. However, as in Experiment 1, the correct responses on congruent diagnostic trials corresponded with the R-E contingencies of the inducer task, while this was not the case for the correct responses on incongruent diagnostic trials. The question was whether the instruction-based congruency effects observed in Experiment 1 could be replicated under such conditions.

2.1. Method

Twenty-one students at Ghent University participated for payment of 5 Euro. All participants had normal or corrected-to-normal vision and all were naive to the purpose of the experiment. Materials and procedure were identical to Experiment 1 with one exception. Instead of removing an effect stimulus in the inducer task, participants were now instructed to add an effect stimulus to balance the grid (see Fig. 2). Instructed R-E contingencies (e.g., the left key produces ‘Q’; the right key produces a ‘P’) and error feedback were adapted accordingly. If participants made the correct response, the corresponding effect stimulus now appeared on the empty grid space.

2.2. Results

The data of one participant with an error rate of 42% in the inducer task were excluded from further analyses. For the RT analysis, the same exclusion criteria as in Experiment 1 were used (data loss errors: 6.2% of all trials; data loss RTs longer than 2.5 SDs from a participant's mean cell RT: 2.5% of the total amount of correct trials).

There was a significant instruction-based congruency effect for the RTs, $F(1,19) = 14.21$, $MSE = 2070$, $\eta_p^2 = .43$, $p < .01$, with faster responses on congruent diagnostic trials ($M = 634$ ms; $SD = 131$ ms) than on incongruent diagnostic trials ($M = 667$ ms; $SD = 134$ ms). There was no difference between congruent ($M = .06$; $SD = .05$) and incongruent diagnostic trials ($M = .07$; $SD = .06$) trials in the proportion of errors, $F < 1$. In the inducer task, the average RT was 1050 ms ($SD = 290$ ms) and there was an average error rate of .11 ($SD = .34$).

2.3. Discussion

Experiment 2 controlled for a confound between instruction-based congruency and the (mis)match of the sequence of events experienced in the diagnostic task and the sequence of events specified by the R-E contingencies of the inducer task. To this end, the R-E contingencies indicated that key-presses would result into the appearance of an effect stimulus, rather than to the removal of an effect stimulus. Nevertheless, the results of Experiment 2 were partly in line with the results of Experiment 1: responses on congruent diagnostic trials were faster than on incongruent diagnostic trials, indicating an instruction-based congruency effect on the basis of R-E contingencies. In contrast to Experiment 1, the error rates did not indicate the presence of an instruction-based congruency effect. It should be noted, however, that previous research using a similar procedure did also not consistently observe instruction-based congruency effects in the error rates (see Everaert et al., 2014; Liefooghe et al., 2013, 2012). The reason for this is most probably that error rates in the diagnostic task are generally very low and lacking in variance.

Taken together, the results of Experiments 1 and 2 seem to offer a convincing demonstration that instruction-based congruency effects can be obtained on the basis of R-E contingencies. Nevertheless, a crucial difference between the current study and previous research on action

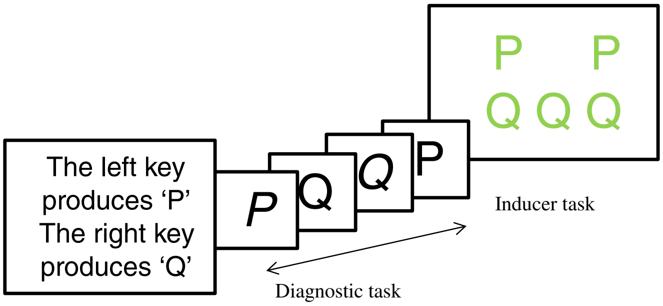

Fig. 2. Overview procedure of Experiment 2.

effects, is that in the current study the participants were required to actively implement the instructed R-E contingencies. Whereas this contingency was irrelevant in the diagnostic task, it was relevant for performing the inducer task. This contrasts with most research on action effects in which the acquired R-E contingency is never relevant (e.g., Elsner & Hommel, 2001; Hoffmann, Sebald, & Stöcker, 2001; Ziessler, 1998). Because the instructed R-E contingencies were relevant in the inducer task it is possible that participants adopted specific strategies with respect to the way in which the R-E contingencies of the inducer task were interpreted. Until now, we assumed that participants interpreted the R-E contingencies of the inducer task as intended, with the stimulus being considered as an effect of a particular response. Alternatively, it could be that participants interpreted the R-E contingencies as S–R contingencies. In view of the goal to balance the number of stimuli in the probe grid of the inducer task, participants first had to infer the identity of the stimulus that had to be removed (Experiment 1) or added (Experiment 2). For instance, when presented with a grid containing four times 'Z' and three times 'Q' in Experiment 2, participants had to infer that the stimulus 'Q' had to be added. In other words, the identity of the stimuli in the grid was of importance in order to decide which key to press. As a result, participants may have reinterpreted R-E contingencies, such as, "the left key produces P; the right key produces Q", as S–R mappings, such as "For P, press left key, For Q, press right key." In other words, participants may have considered the stimuli not as effects of a particular response, but as stimuli to which a particular response had to be made. In short, it is possible that the instruction-based congruency effects observed in Experiments 1 and 2 is based on a re-interpretation of R-E contingencies as S–R mappings. It should be noted, however, that we discouraged such a strategy because in order to perform the inducer task correctly these S–R mappings were not sufficient. Only when additional internally generated rules were kept active in memory, such as 'react to the stimulus that is presented the least' (Experiment 2), these S–R mappings were correct. Since it is likely that both reconsidering the instructed R-E contingencies and maintaining additional task rules is effortful, we doubt that participants were motivated to pursue such a complex strategy. Alternatively, participants could have formulated more complex S–R mapping rules for the inducer task. In Experiment 2, for example, such S–R mappings could have been "if two P's are presented, press left; if two Q's are presented, press right" or "If there are less P's than Q's presented, press left; if there are less Q's than P's presented, press right". In both cases, however, these formulated S–R mappings did not match the events in the diagnostic task in which only one effect stimulus was presented. As a consequence, no response compatibility effect should have been observed. Nevertheless, although we doubt that participants pursued a 'reinterpretation strategy' in Experiments 1 and 2, we cannot exclude that such strategy may have contributed to the results obtained in these experiments. We therefore conducted a third experiment for which the reinterpretation of R-E contingencies into S–R contingencies was even less likely.

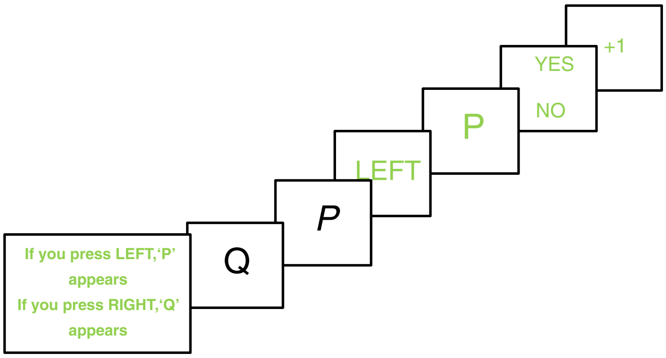

Fig. 3. Overview procedure of Experiment 3.

3. Experiment 3

In Experiment 3 (Fig. 3), a reinterpretation of R-E contingencies as S–R mappings was discouraged by changing the demands of the inducer task in such a way that participants would consistently consider the effect stimuli in every R-E contingency as an effect of a particular response and not as a target to which that response had to be made. In order to do so, novel R-E contingencies of the inducer task were instructed at the beginning of each run, such as "if you press left, 'P' appears; if you press right, 'Q' appears". As in the previous experiments, these instructions were followed by a number of trials of the diagnostic task. Finally, the probe of the inducer task started. In this task, the word LEFT or the word RIGHT was presented and participants had to press the left or the right key accordingly. The response to these words resulted in the appearance of an effect stimulus. On half of the runs, the contingency between the produced response and the presented effect stimulus matched with the instructed R-E contingencies (e.g., a left key-press followed by a P) and on the other half of the runs it did not (e.g., a left key-press followed by a Q). Participants had to evaluate as quickly as possible whether the contingencies matched by using a separate set of responses. In short, the responses of the R-E contingencies were made in response to the words LEFT and RIGHT, which thus functioned as target stimuli in this task. In contrast, the effect stimuli never had to be responded to by using the responses described in the R-E contingencies. Reinterpreting the R-E contingencies as S–R mappings thus was unnecessary for Experiment 3.

It should be noted that the inducer task in this experiment requires participants to recall the instructed R-E contingencies. When using instructed S–R mappings, Liefooghe et al. (2012) did not observe instruction-based congruency effects when participants had to recall instructed S–R mappings without having to apply them to a particular stimulus (i.e., when participants had to recognize verbally or visually presented S–R mappings or had to repeat the instructions aloud when a probe was presented). These null effects may suggest that the manipulation used in Experiment 3 is not effective to produce an instruction-based congruency effect. However, a follow-up study by Liefooghe et al. (2013), which demonstrated that a stringent preparation demand is a key prerequisite to observe instruction-based congruency effects. Of most importance to our study were the results of Experiment 2 of Liefooghe et al. (2013) in which an instruction based congruency effect could only be observed with a short response deadline (1500 ms) and not when there was a long response deadline (5000 ms). Based on these findings we reasoned that the recall conditions used in the study of Liefooghe et al. (2012) may have been too lenient in the sense that participants might not have been encouraged enough to represent the instructed S–R mappings in such a way that instruction-based congruency effects could be observed in the diagnostic task. Accordingly, stringent task demands were imposed on the inducer task of Experiment 3. More specifically, similar to Liefooghe et al. (2013; Experiment 2) participants were encouraged to respond very fast by imposing a strict time window. Moreover, participants were motivated to respond accurately by earning and losing points depending on their response performance.

3.1. Method

Twenty-six right-handed students at Ghent University participated for payment of 5 Euros. All participants had normal or corrected-to-normal vision and were naive to the purpose of the experiment. The symbols used in Experiment 3 are: "A, B, C, D, E, F, G, H,I, J, K, M, N, O, P, Q, S, T, U, V, W, X, Y, Z, 1, 2, 3, 4, 5, 6, 7, 8, 9, &, L, §, !, $, à, µ, £, R, {, }, [,], è, ç, ?, ù, :, é, ;,), (and 0". The diagnostic task was identical to the previous experiments. The inducer task was changed in several ways. First, the R-E contingency instructions now merely indicated that a particular key-press would be followed by a particular effect stimulus (e.g., if the left key is pressed, ‘P’ appears; if the right key is pressed, ‘Q’ appears). Second, the goal of the inducer task was adapted. Participants were now asked to evaluate the correctness of a R-E sequence.

The inducer task started with the presentation of the target word LINKS or RECHTS (the Dutch words for ‘left’ and ‘right’ respectively). Participants responded to the word by pressing the left or the right key, respectively. If either a response deadline of 1500 ms was exceeded or an incorrect response was made, the message ‘press left/right’ appeared above the cue until participants pressed the correct key. Immediately after participants pressed the correct key an effect stimulus appeared and stayed visible for 750 ms. Fifty ms after the onset of the effect stimulus the words JA (‘yes’ in Dutch) and NEE (‘no’ in Dutch) appeared above and below the effect stimulus, with JA always above and NEE always below. Participants were asked to evaluate whether the effect stimulus following the response was in line with the instructed R-E contingencies. In half of the runs, the effect stimulus that followed the response was in line with the instructed R-E contingencies. In the other half of the runs, two types of mistakes were included on an equal number of runs. First, the response was followed by the effect to which the other response was linked in the instructions. Second, the incorrect effect stimulus was a new stimulus that had not been previously linked to a response. These ‘new’ effect stimuli were presented to encourage participants to encode both R-E contingencies presented at the beginning of each run.

Responses for evaluating the R-E contingency, were made with the middle finger and the thumb of the right hand by using the ‘)’-key and ‘;’-key respectively, on an AZERTY keyboard. Response mappings were identical for all participants: a ‘yes’-response was made with middle finger and a ‘no’-response was made with the thumb. The response deadline was 1500 ms.

Participants were rewarded for a good performance and punished for a bad performance in the inducer task. When both the left/right response to the target word and the yes/no response were correct, participants received one point. If one of both responses was incorrect, a point was subtracted. Feedback concerning the points was presented 50 ms after the yes/no response for 750 ms. On the top of the screen the point earned or lost during that run was displayed. The total number of points was presented at the bottom of the screen. If the total number of points was positive it was presented in green, otherwise it was presented in red. Finally, because of the complexity of the inducer task an additional practice block was performed at the start of the experiment. This practice blocks consisted of 6 runs. After this practice block there was one practice block with both tasks followed by two test blocks (see the procedures of Experiments 1 and 2). The number of runs and trials during these blocks were identical to Experiment 1 and 2.

3.2. Results

The data of three participants who made more than 58% of errors in the inducer task were excluded from further analysis. For the RT analysis, the same exclusion criteria were used as in the previous experiments (data loss errors: 8.6% of all trials; data loss RTs longer than 2.5 SDs from a participant's mean cell RT: 2.7% of the total amount of correct trials).

There was a significant instruction-based congruency effect for the RTs, $F(1,22) = 4.70$, $MSE = 658$, $\eta_p^2 = .18$, $p < .05$, with faster responses on congruent diagnostic trials ($M = 552$ ms; $SD = 73$ ms) than on incongruent diagnostic trials ($M = 569$ ms; $SD = 69$ ms). There was also a significant instruction-based congruency effect for the proportion of errors, $F(1,22) = 5.99$, $MSE = .001110$, $\eta_p^2 = .21$, $p < .05$, with less errors made on congruent diagnostic trials ($M = .07$; $SD = .05$) than on incongruent diagnostic trials ($M = .10$; $SD = .07$) trials. In the inducer task, the average RT to the target word was 855 ms ($SD = 230$ ms) and there was an average error rate of .07 ($SD = .26$). The yes/no response had an average RT of 466 ms ($SD = 319$) and an error rate of $M = .14$ ($SD = .34$). The RTs were measured from the onset of the Yes/No screen.

3.3. Discussion

In Experiment 3, the inducer task was adapted in such a way that reinterpreting the instructed R-E contingencies as S–R mappings was completely redundant in order to perform the inducer task. Despite these changes in the task procedures, an instruction-based congruency effect was observed in the diagnostic task, corroborating the results of the previous experiments. Both in terms of response speed and accuracy, performance was superior on congruent diagnostic trials compared to incongruent diagnostic trials. This result confirms the conclusion that instruction-based congruency effects can be obtained on the basis of instructed and actively prepared R-E contingencies.

4. General discussion

The present study investigated whether instruction-based congruency effects could be obtained on the basis of instructed R-E contingencies. To this end, we adapted the procedure used by Liefooghe et al. (2013, 2012); see also (Everaert et al., 2014; Theeuwes et al., 2014) in such a way that the instructions of the inducer task now included R-E contingencies rather than S–R mappings. In three experiments, we observed an instruction-based congruency effect in the diagnostic task. It is concluded that instruction-based congruency effects are not only obtained with instructions of S–R mappings but also with instructions of R-E contingencies. The present findings thus indicate that instruction-based congruency effects can be possibly observed on the basis of different types of instructions.

The observation of instruction-based congruency effects on the basis of instructed R-E contingencies suggests that the associations formed on the basis of instructions relate stimulus and response codes, without qualifying the type of relation these codes have. Although the present study did not directly test whether instructed S–R mappings lead to similar unqualified associations, the proposals of Hommel (2009) may lead to the conclusion that this is indeed the case and that associations formed on the basis of instructed R-E contingencies and associations formed on the basis of instructed S–R mappings are similar. An important difference between the present study and previous research on R-E contingencies is that the R-E contingencies of the inducer task are explicitly instructed. In contrast, the congruency effects in previous studies are typically based on contingencies that are experienced between task-relevant responses and task-irrelevant effects and this without explicit instruction of these contingencies (e.g., Elsner & Hommel, 2001). While associations that are unqualified for experienced R-E contingencies may be the result of participants not being explicitly aware of the particular relation these contingencies include, our data suggest that these associations are still unqualified when this relation is explicitly instructed by instructions. Alternatively, it is possible that relational information is encoded in a representation that mediates both experience-based and instruction-based R-E congruency effects but that this propositional representation can operate irrespective of this information (De Houwer, 2014). In other words, it is possible that participants do encode that a response produces an effect (i.e., store a qualified association), but that the presentation of the effect can still result in the retrieval of information about the response without any impact of information about the relation between response and effect (i.e., “produces”). In either case, our results demonstrate that congruency effects based on R-E contingencies are mediated by representations that allow for a backward activation of responses by effects, even when the information about the relation between response and effect is provided explicitly.

In view of research on experienced-based R-E contingencies, the question can also be addressed whether merely instructed R-E contingencies for which the effects are irrelevant for the inducer task, can also lead to instruction-based congruency effects. We have two reasons to believe that instruction-based congruency effects will not arise under those conditions. First, unpublished experiments in our lab indicated that participants do not seem to implement parts of the instructions that are completely irrelevant for performing the inducer task, such as an irrelevant stimulus feature. Second, Liefooghe et al. (2013) demonstrated that participants need to actively prepare for the inducer task in order to observe instruction-based congruency effects, which suggests that instructions are implemented into functional associations only when a stringent demand to do so is imposed (see also, Wenke et al., 2009). In other words, instruction-based congruency is a by-product of task preparation and will thus only extend to information (stimuli, responses, effects) that is needed to prepare and perform a task. This contrasts with experienced-based congruency effects, which have been observed independently of the demand of actively implementing information (see e.g., Yamaguchi & Proctor, 2011, for an example in the context of the task-rule congruency effect). The main distinction between instruction-based and experienced-based congruency effects thus appears to be that instruction-based congruency effects require the active involvement of working memory (see, Liefooghe et al., 2013, 2012; Meiran et al., 2012), while experience-based congruency effects could also be mediated by associations which have already been established in long-term memory (e.g., Hommel, 2005; Meiran & Kessler, 2008, but see Ansorge & Wühr, 2004). Hence, experience-based congruency effects do not require active preparation and can result also from the incidental learning of contingencies that involve task-irrelevant information.

The present study also produced some additional results that are interesting with respect to our understanding of how and when instructions bias performance. First, our results suggest that instruction-based congruency effects can be obtained across tasks that overlap to a lesser degree than was the case in the initial procedures that were used to investigate instruction-based congruency effects. For instance, in the procedure used by Liefooghe et al. (2013, 2012) the goals of the inducer and the diagnostic task were highly comparable, namely judging stimulus identity by pressing a left or right key in the inducer task and judging stimulus orientation of the same stimuli by pressing the same left or right key in the diagnostic task. As Meiran et al. (2012) has pointed out, the effects obtained with such procedures may result from a similarity between the inducer and the diagnostic task, which could trigger participants to inadvertently apply the instructed S–R mappings of the inducer task to the diagnostic task. On the basis of instance theories of automaticity (e.g., Logan, 1988), it could be hypothesized that even a single (erroneously) execution of the instructions of the inducer task during the diagnostic task is sufficient to form S–R associations that bias performance in the diagnostic task. In other words, congruency effects in the diagnostic task may not be based on associations solely formed on the basis of instructions but on associations formed on the basis of actual execution of instructions of the inducer task in the diagnostic task. In the present study, the instructions of the inducer task consisted of R-E contingencies, which were less likely to be erroneously applied to the diagnostic task, as both tasks had very distinct task goals. Yet, as we have discussed before, participants may have reinterpreted the instructed R-E contingencies as S–R mappings in Experiments 1 and 2. A reinterpretation strategy is however implausible for Experiment 3 in which an instruction-based congruency effect was still obtained when participants had only to detect (mis)matches between instructed and experienced R-E contingencies in a modified inducer task. The results of the present study and in particular the results of Experiment 3, thus suggest that instruction-based congruency effects are observed even when the chance of misapplying the instructions of the inducer task to the diagnostic task is minimal.

A second interesting observation in the present study is that the average response speed in Experiment 2 ($M = 650$, SD $= 133$) was slower than in Experiment 1 ($M = 539$, $SD = 65$). This increase in RTs could be related to the fact that in Experiment 2 the sequence of events specified by the R-E contingencies of the inducer task (adding a missing letter) was at odds with the sequence of event shown in the diagnostic task (removal of a stimulus with a button press). This difference is noteworthy, because it may indicate an additional way in which instructions can influence behavior at a time at which those instructions are irrelevant. The difference between Experiments 1 and 2 could suggest that instructions about the sequence of events in one task (the inducer task) can elicit expectancies about the sequence of events in a related task (the diagnostic task). Such finding again indicates that instructions can influence behavior in more than one way.

A final side-note relates to Experiment 3. The results of Experiment 3 indicate that maintaining instructions for future recall may be sufficient to elicit an instruction-based congruency effect but only under very stringent conditions. This finding is in line with the proposals by Liefooghe et al. (2013), who suggested that instruction-based congruency effects depend on the amount of preparation to execute the inducer task. Experiment 3 suggests that the degree by which participants are prepared with respect to the inducer task is of importance to find instruction-based congruency effects not only when the inducer task requires the application of instructions, but also when the inducer task requires the mere recall of instructions. Clearly, this issue is beyond the scope of the present study and will require additional research.

In summary, contrary to previous studies, which mainly focused on S–R mappings, the present study offered first insights into the implementation of a different type of instructions, namely R-E contingencies. The obtained results suggest that instruction-based congruency effect can be obtained on the basis of instructed R-E contingencies. Based on these results, we propose that the implementation of instructions results in a representation that allows for the backward of activation of response representations. Importantly, such representation is formed even though instructions explicitly specified a particular relation. Such finding may suggest that the implementation of the different types of instructions, such as S–R mappings or R-E contingencies, may result in similar functional representations, which include bi-directional associations. It becomes clear that future research on instruction implementation, will also need to focus on the communalities and differences between the types of instructions that are implemented.

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