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Exploring cross-task compatibility in perceiving and producing facial expressions using electromyography

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ABSTRACT

Using a dual-task methodology we examined the interaction of perceiving and producing facial expressions. In one task, participants were asked to produce a smile or a frown (Task 2) in response to a tone stimulus. This auditory-facial task was embedded in a dual-task context, where the other task (Task 1) required a manual response to visual face stimuli (visual-manual task). These face stimuli showed facial expressions that were either compatible or incompatible to the to-be-produced facial expression. Both reaction times and error rates (measured by facial electromyography) revealed a robust stimulus–response compatibility effect across tasks, suggesting that perceived social actions automatically activate corresponding actions even if perceived and produced actions belong to different tasks. The dual-task nature of this compatibility effect further testifies that encoding of facial expressions is highly automatic.

1. Introduction

In research on action perception and imitation it is assumed that perception and action have representations in common and share processes (e.g., Hommel, 2009; Prinz, 1997; Prinz, Aschersleben, & Koch, 2009). This common coding framework is based on the ideomotor principle that states that actions are coded in terms of their anticipated sensory consequences (e.g., Prinz et al., 2009). This framework is supported by neuroimaging work on motor imagery, where it has been shown that perceiving an action partially activates the same neural circuits as actually executing the action (Cattaneo & Rizzolatti, 2009; Rizzolatti & Craighero, 2004). The notion of common coding of perception and action contrasts with sensorimotor accounts, such as traditional stimulus–response translation models, that assume a discrete processing stage mediating between perception and action (for a review see, e.g., Proctor & Vu, 2006). The notion of common coding is particularly apt to explain compatibility phenomena based on action observation because observing an action should produce a representation that resembles the representation (i.e., the anticipated sensory consequences) underlying actual performance of this very action, so that action observation should activate this action in the observer.

Most previous cognitive behavioral studies on action perception and imitation have used simple finger movement tasks while observing finger movements as stimuli. For example, Brass, Bekkering, Wohlschläger, and Prinz (2000) found that in a simple response task producing finger movements while observing compatible finger movements led to a pronounced advantage in reaction times (RTs). This finding suggests that perceiving a movement activates the corresponding movement, leading to faster responses when the same movement is to be performed (see also Brass, Bekkering, & Prinz, 2001).

Neuroimaging studies have often examined the neural correlates of simply observing actions and found evidence for activation of motor areas on action observation (Wicker et al., 2003; for a review, see Iacoboni & Dapretto, 2006). However, while these studies have convincingly demonstrated that action observation can activate neural representations of effectors like arm or finger, much less is known about the role of observing action in a motor system that is ordinarily involved in social–emotional contexts, like facial expressions.

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In a previous study, we showed that the perception of socially relevant facial actions (e.g., happy vs. angry facial expressions) interacts with the execution of such actions: Producing a facial expression in response to the gender of a stimulus person was strongly influenced by the task-irrelevant facial expression of that stimulus. That is, we found shorter RTs on stimulus–response compatible trials than on incompatible trials (Otte, Habel, Schulte-Rüther, Konrad, & Koch, 2011). Thus we showed that even though the perceived facial expression is irrelevant to the task at hand, it still has an influence on the production of a facial expression (see also Lee, Dolan, & Critchley, 2008).

In the present study, we extend these findings by investigating the facial compatibility effect in conditions in which the facial expression is not only task-irrelevant (as in Otte et al., 2011) but actually part of a different task. For this purpose, we used a dual-task paradigm, in which the perception of facial expressions was part of the first task, whereas facial expressions had to be produced in another, second task. Participants viewed pictures of males and females showing a happy or angry facial expression. The first task was to judge whether the shown person was male or female. This task was non-speeded and responses were executed at the end of the trial. The second task required participants to produce a facial expression (i.e., a smile or frown) in response to a high or low tone. For example, participants had to smile in response to a high tone. The two stimuli (i.e., picture and tone) were presented in very short succession. Participants were instructed to first respond to the tone (i.e., Task 2) with the appropriate facial expression, and then determine via a left or right key press whether the shown image was male or female. We instructed participants to first respond to the tone to allow accurate RT measurements of the facial expression production using electromyography.

Note that the facial expression is part of the stimulus shown in Task 1 and is irrelevant for both Task 1 and Task 2. This situation is different from a classical Simon task (Proctor & Vu, 2006) or an affective Simon task (De Houwer, Hermans, & Eelen, 1998), where the irrelevant stimulus dimension is part of the actual task-relevant stimulus.

If perception of facial expressions is highly automatic, then we should observe perception–action compatibility effects even between tasks, as performance benefits in cases of compatible S1–R2 combinations (i.e., perceiving a smiling face in Task 1 and producing a smiling facial expression in response to the tone in Task 2) and interference effects in cases of incompatible *cross-task* stimulus–response conditions.

In a related dual-task study, Koch and Rumiati (2006) investigated whether participants automatically encoded the spatial orientation of the graspable part of daily objects (e.g., a coffee pot, hairbrush etc.) while responding manually to the pitch of a tone. The authors observed an effect of cross-task compatibility (see also Koch & Prinz, 2002), meaning when an object was observed with a handle oriented towards the right, and the tone indicated a right manual response (i.e. cross-task compatible) then RTs were shorter than in incompatible trials (see also Koch, 2009). However, whereas this study investigated compatibility of objects and manual responses, the present study, by using facial expressions, examined dual-task “priming” of a response system that is primarily relevant in social emotional interactions.

To this end, we measured facial expressions directly using facial electromyography (EMG), which measures activity in the facial muscles relevant for emotional expressions. More specifically, for smiling we measured responses on the Zygomaticus Major and for frowning on the Corrugator Supercillii (see Fridlund & Cacioppo, 1986).

If we find a compatibility influence of a facial expression across tasks this would further underline the high automaticity with which facial expressions are processed (Dimberg, Thunberg, & Grunedal, 2002; Esteves, Dimberg, & Öhman, 1994) and also support the view of common processes for perceiving and performing actions (Hommel, Müsseler, Aschersleben, & Prinz, 2001; Prinz, 1992).

In addition to examining the basic cross-task compatibility effect on producing facial expressions, we further explored its degree of automaticity by running two additional analyses. First, we investigated whether the compatibility effect diminishes with increasing reaction times. This time-course analysis was motivated by Hommel (1994) suggesting that the compatibility effect should become smaller with slower reaction times due to decay of the automatically activated but task-irrelevant response code. De Jong, Liang, and Lauber (1994) showed, with respect to the standard Simon task that the compatibility effect did in fact decrease with slower RTs, supporting the notion that automatic activation of responses decays over time.

Second, we analyzed whether the compatibility effect depends on previous experience (i.e., on whether the previous trial was compatible or incompatible). This analysis is based on previous studies showing that the Simon effect is reduced in trials following incompatible trials (e.g., Stürmer, Leuthold, Soetens, Schröter, & Sommer, 2002). This sequential effect might suggest that the automatic response activation is subject to cognitive control and can be suppressed based on trial-to-trial modulations of processing conflicts (e.g., Egner, 2007; Verguts & Notebaert, 2008). In the present study we also examined our cross-task compatibility effect on facial expressions in terms of its potential sequential modulation to see whether there is evidence for the involvement of cognitive control in the sense of conflict adaptation.

2. Methods

2.1. Participants

We recruited and tested 16 students of the RWTH Aachen University. Six were male and 10 were female (mean age was 23.8 years). The study was approved by the local ethics committee and each participant gave written informed consent. All participants had normal or corrected-to-normal vision and were naïve as to the purpose of the study. Participants received either credit points or a small fee for participating. Two participants were excluded from data analysis due to missing responses and error responses in a large number of trials (more than 35% in one of the conditions). The final sample contained 14 students of which 6 were male and 8 were female (with age $M = 23.9$, $SD = 3.5$).

2.2. Stimuli and task

For Task 1 pictures showing two male and two female faces were used as stimuli (S1). Moreover, the faces also differed in emotional expression (i.e., smiling or frowning, leading to 8 different pictures; see Fig. 1). The pictures were constructed by videotaping actors when producing angry and smiling facial expressions. Static images of the emotional expressions were extracted at their peak. All pictures were rated high in a rating procedure by 69 students on scales regarding affect, clarity, and realism of the emotions and emotional expressions (for details on stimulus construction, see Otte et al., 2011). The picture stimuli were presented full screen on a 19 in. monitor (35 cm × 25 cm) at a distance of approximately 70 cm from the participants. Participants responded to this stimulus picture (i.e., S1) by button press responses (left and right ‘ctrl’ keys, R1) at the end of the dual-task trial. For Task 2, high and low pitch tones (500 and 1200 Hz) of 100 ms duration were presented via headphones. The task was to produce a facial expression in response to the tone (i.e., R2, either smile or frown) as fast as possible. The mapping of tone (high vs. low, S2) and the required facial response (smile vs. frown, R2) were counterbalanced across participants. The experiment was executed using MATLAB 2010, including the psychtoolbox 3.0.8 (Brainard, 1997; Pelli, 1997).