

It takes two to imitate: Anticipation and imitation in social interaction

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Abstract:

Imitation is assumed to serve crucial functions in social interaction such as empathy and learning; yet these functions only apply to the imitating observer. Here, we reveal a distinct function of imitation for the action model: Anticipating to be imitated facilitates the production of own motor actions. Specifically, anticipated motor responses of social counterparts serve as mental cues to retrieve corresponding motor commands in order to orchestrate one's own actions. [70 words]

Humans tend to imitate the actions of their social partners and such imitative behavior is seen as a hallmark feature of social interaction (Heyes, 2011). Previous research in biology, neuroscience, and psychology has delineated numerous functions of imitation behavior (Bandura, Ross, & Ross, 1961; Heyes, 2011), its development (Gergely, Bekkering, & Király, 2002; Meltzoff & Moore, 1977), and its neural implementation (Heyes, 2010; Iacoboni et al., 1999). Paradoxically, however, all these studies focused on just one side of this social interaction, namely on the imitating observer, whereas the imitated model is typically considered a passive provider of the action in question.

Yet imitative behavior might have a unique function for the action model itself. Because imitation occurs automatically after model actions (Brass, Bekkering, Wohlschläger, & Prinz, 2000; Chartrand & Bargh, 1999; Dijksterhuis & Bargh, 2001), imitative responses are an immediate and predictable action consequence for the model. In turn, cumulative evidence indicates that voluntary motor actions are controlled by anticipating their to-be-expected sensory consequences (Hommel, Müssele, Aschersleben, & Prinz, 2001; Kunde, 2001; Shin, Proctor, & Capaldi, 2010). Specifically, the anticipation of such consequences automatically activates the motor pattern which normally produces them (Hommel et al., 2001; Kunde, 2001; Pfister, Kiesel, & Melcher, 2010). We suggest that imitative behavior – a reliable consequence of own actions – fulfills a similar function: It serves as mental cue for the model to retrieve its own body movements.

To demonstrate this function, two participants, a model and an imitator, sat face-to-face at a table and operated one response button each (Fig. 1A). The model viewed a computer screen and reacted as quickly as possible to a color stimulus by performing either a short or a long button press. The second participant responded to the model's action as quickly as possible by either *imitating* or *counter-imitating* the model action in separate blocks of the experiment (i.e., in the counter-imitation condition, the imitator performed a long key press in response to a short model action, and vice versa). Both participants performed in both roles. In keeping with previous findings, we expected the imitator to respond faster in the imitation condition than in the counter-imitation condition (Brass et al., 2000; Heyes, 2011; Ondobaka, de Lange, Wiemers, Newman-Norlund, & Bekkering, 2012): Seeing a particular action evokes a tendency to do the same, which speeds up actions in the imitation condition but creates response conflict in the counter-imitation condition. Importantly, however, we

expected a similar effect in the model: Anticipating the imitator's response should facilitate action selection if this anticipation matches, and thus primes, the required model action. Conversely, it should impair response selection when the anticipated action mismatches and thus competes with the to-be-produced action (Kunde, 2001, 2003). An imitation effect that occurs in the imitator by *observing* the model's action might consequently occur in the model by *merely anticipating* the imitator's response.

Methods

We tested 24 participants (mean age: 21.0 years, 7 males, 1 left-handed). During the instruction, we referred to the roles of the participants as "leader" and "follower" to avoid the terms of models and imitators. In each trial, the screen color changed from black to either red or green, prompting the model to perform either a short (1-150 ms) or a long (200-600 ms) key press. Color-response mapping was counterbalanced across participant pairs. In separate blocks, the imitator either imitated or counter-imitated the model action and the screen went blank after this response. The next trial started after 1000 ms.

Each session began with 14 practice trials to acquaint the participants with the concepts of "long" and "short" key presses. The actual experiment consisted of 20 blocks of 24 trials each and participants switched their roles after the first half of the experiment. Each half comprised 5 blocks with normal imitation responses and 5 blocks with counter-imitation responses with condition order being counterbalanced across participant pairs.

The first block of each condition was considered practice. For analysis of the model RT data, we further excluded trials with errors of the model (6.1%). For the analysis of the imitator RT data, we excluded trials with errors in either response (13.2%). RTs were then subjected to an outlier-correction with outliers being defined as deviating more than 2.5 standard deviations from the mean of the analyzed design cell, calculated separately for each participant (< 2.5% for all analyses). To avoid violations of sphericity, we used the multivariate approach to within-subjects analyses of variance (ANOVA) for all reported ANOVA statistics. All pairwise comparisons were performed via paired-samples *t*-tests.

Results

As predicted, models indeed initiated their actions significantly faster when these actions were to be imitated rather than counter-imitated (Fig. 1B, left plot), $t(23) = 4.35$, $p < .001$, $d = 1.26$. In line with prior findings (Brass et al., 2000; Heyes, 2011), this difference was also present for the imitator (Fig. 1B, right plot), $t(23) = 4.49$, $p < .001$, $d = 1.30$. Follow-up analyses showed that these effects occurred for each type of response and did not result from different speed-accuracy trade-offs (Fig. S1).

[Figure 1 about here]

Furthermore, we performed a more detailed distribution analysis of the RT data to ensure that the above effects were not just driven by a small subset of trials with extremely delayed responses, e.g., in which participants were confused by the incompatible consequences of their actions. This 2 x 5 repeated-measures ANOVA with the factors imitator response (normal imitation vs. counter-imitation) and distribution quintile indeed confirmed that the imitation effects in both roles were reliable across the entire RT distribution (cf. Fig. S2). For the model, this distribution analysis showed both main effects to be significant ($ps < .001$). A significant interaction indicated larger imitation effects for longer response times (Kunde, 2001), $F(4,20) = 4.34$, $p = .011$, $\eta_p^2 = 0.46$, but a reliable difference between imitation and counter-imitation responses was present from the first quintile onward. The same was true for the imitator (Fig. S2).

Although superficially similar, the imitation effects in the model and the observer are conceivably determined by different mental processes, namely action observation for the imitator, and action anticipation for the model (Paelecke & Kunde, 2007). To support this distinction, we correlated the imitation effect of each participant in the role of the model and the imitation effect for the very same participant in the role of the imitator (Fig. 2). Statistical dependency would suggest shared mechanisms whereas independency would indicate distinct processes. The data clearly support the latter hypothesis, $r = 0.04$, $t(22) = 0.20$, $p = .840$ (Keller & Koch, 2006; see also Fig. S3). Conceivably, action priming by action observation (when acting as imitator) is a process distinct from action priming by action anticipation (when acting as model).

[Figure 2 about here]

Control Experiment

In a second experiment with 16 new participants (mean age: 27.4 years, 3 males, all right-handed) we confirmed that the imitation effect in the model comprises both, benefits of imitation and costs of counter-imitation. We replaced the counter-imitation condition by a *neutral condition* where the imitator freely chose whether to imitate or to counter-imitate in each trial. This rendered the response unpredictable for the model (overall 48.3% counter-imitation responses vs. 51.7% imitation responses). Still, models reacted faster in the predictable imitation condition than in the neutral condition (424 ms vs. 442 ms), $t(15) = 2.40$, $p = .030$, $d = 0.60$. A non-significant effect in the same direction was observed in error rates (8.8% vs. 11.5%), $t(15) = 0.95$, $p = .356$, $d = 0.24$, which excludes a speed-accuracy trade-off.

Discussion

The present experiments investigated the function of imitative behavior for action models. Model actions were facilitated when they were predictably imitated rather than counter-imitated by an observer (Experiment 1). A reliable facilitation effect was also present when comparing imitation to unpredictable responses of the imitator (Experiment 2). These findings demonstrate that models build a representation of an observer's imitative response prior to executing their own actions. Thus, not only do anticipated consequences in the inanimate environment guide motor actions (Hommel et al., 2001; Kunde, 2001; Pfister & Kunde, 2013; Shin et al., 2010), but so do consequences in the social environment, that is, in other people's behavior (cf. also Kunde, Lozo, & Neumann, 2011).

The results also point toward notable differences between the anticipation of consequences in the inanimate and the social environment. Compared to studies with the same motor actions (short vs. long key presses) but inanimate action consequences (short or long tones, Kunde 2003), the present imitation effects were considerably larger, which reminds of generally stronger influences of social as compared to inanimate stimuli on motor priming. Such priming effects refer to the facilitation of motor responses that are carried out to biologically similar target stimuli (such as the imitator

responses in the present imitation condition; cf. Brass et al., 2000). These effects have been shown to consist of two components: Action priming by spatial compatibility on the one hand, and action priming by imitative compatibility on the other hand (Bertenthal, Longo, & Kosobud, 2006; Boyer, Longo, & Bertenthal, 2012; Cooper, Catmur, & Heyes, in press). Conceivably, this distinction might also apply to the present anticipatory effect which is certainly an interesting question for future research.

Further questions relate to consequences of being imitated that go beyond the implications for action control on which we focused here. For instance, being imitated might have a direct impact on the model's mood, similar to the affective consequences of mimicry for both, mimicker and mimickee (e.g., Chartrand & Bargh, 1999; Stel & Vonk, 2010; van Baaren, Holland, Kawakami, & van Knippenberg, 2004). In contrast to these studies, however, the present experiments explicitly targeted effects of anticipated imitation and similar anticipative effects have not yet been studied in the field of mimicry either. Furthermore, based on the described anticipative mechanism, merely knowing to be imitated, without actually making the corresponding experience, might suffice to produce the reported effects, at least to a certain extent. The necessary amount of learning experience is certainly an open question.

Anticipated social consequences of own actions conceivably also contribute to "imitative games" between infants and their parents that have been studied in developmental psychology (Agnetta & Rochat, 2004). Even neonates tend to repeat actions that were previously imitated by a human agent. Furthermore, neonates use cycles of reciprocal action initiation and imitation as an early form of communication with their parents (Nagy, 2006; Nagy & Molnar, 2004). This type of communicative action might be mediated by anticipative mechanisms as demonstrated in the present study. Observed changes of other people's behavior thus seem to be readily included in the human motor system and are directly relevant for controlling own actions. Moreover, changes of other people's behavior are perceivable cues for a change of their minds, which according to philosophical approaches is the very essence of truly communicative action (Grice, 1969). It is therefore important for the understanding of communicative action to study the cognitive processes in acting models in addition to those in imitating observers.

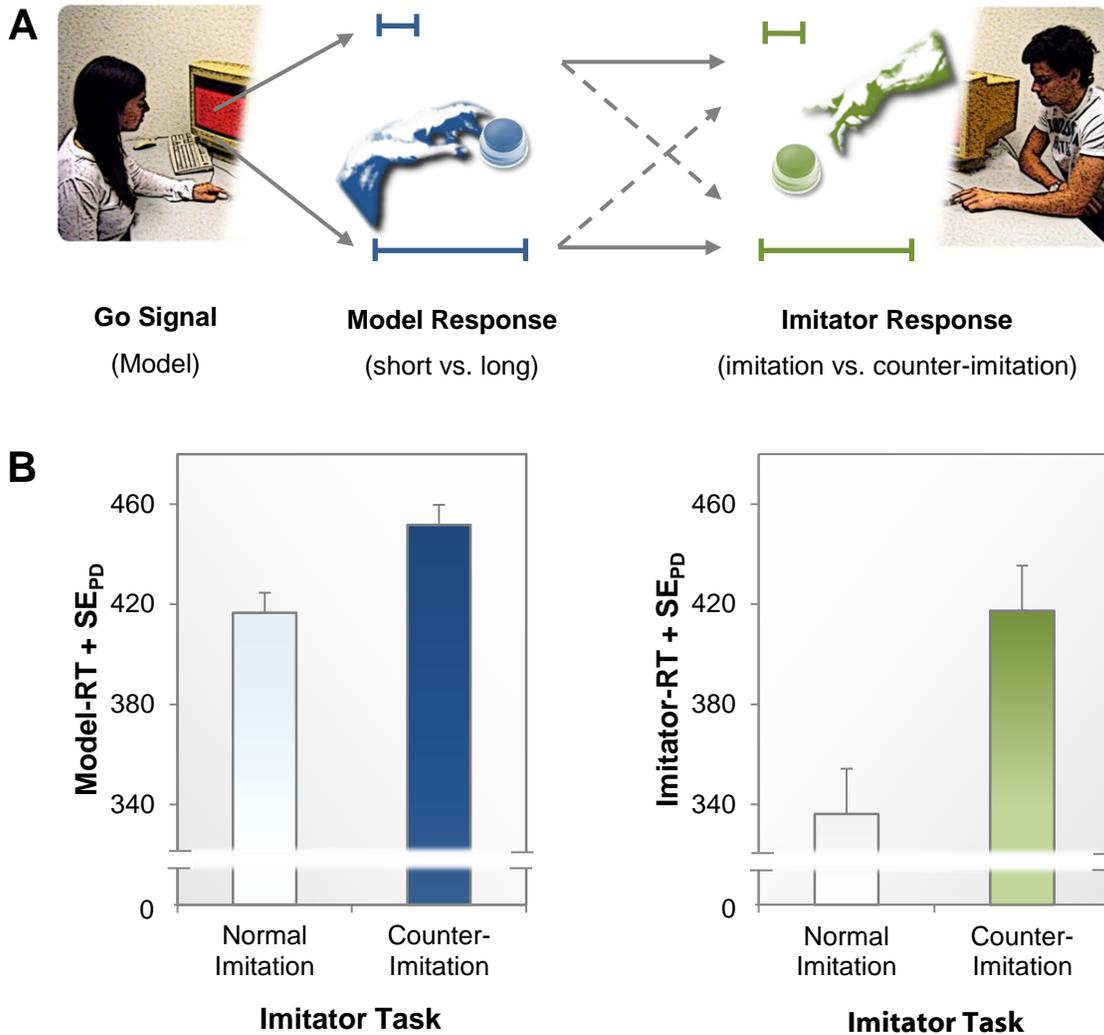


Figure 1. Design and results. **(A)** Two participants sat face-to-face at a table and operated one response button each; photographs are mirror-reversed to fit the timeline (right-hand responses thus appear to be performed with the left hand). The model watched a monitor that displayed the target stimuli and performed a short (1-150 ms) or long (200-600 ms) key press when the screen turned either red or green. In separate blocks, the imitator either imitated or counter-imitated the model action. **(B)** Model actions were faster when they were going to be imitated rather than counter-imitated. This finding suggests a functional role of imitative behavior not only for the imitator but also for the model; imitative responses serve as mental retrieval cues for own actions. In line with previous research on motor priming, participants were also faster at imitating an action than at counter-imitating it. Error bars represent standard errors of paired differences (Pfister & Janczyk, in press).

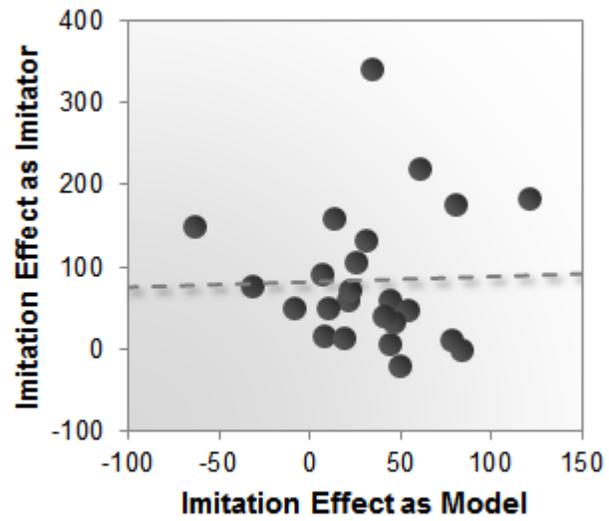


Figure 2. Correlation of the imitation effects ($RT_{\text{Counter-Imitation}} - RT_{\text{Imitation}}$) obtained for participants in their role as model and as imitator. The effects were uncorrelated, suggesting distinct processes in both roles.

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