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Anticipation in sociomotor actions: Similar effects for in- and outgroup interactions

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ABSTRACT

In social interactions, own actions often trigger a particular response from another person. The sociomotor framework proposes that this consistent behavior of others can become incorporated into own action control. In line with this idea, recent studies have shown that own motor actions are facilitated if they are predictably being imitated rather than counterimitated by a social interaction partner. In the present study, we investigated whether this finding is influenced by the relationship between the interacting persons. To that end, we manipulated whether a participant was being imitated and counterimitated by an ingroup or by an outgroup member. In two experiments, we found a beneficial influence of being imitated irrespective of group membership. The results suggest that, while people incorporated their partner's behavior into own action control, this was not further qualified by group membership as a higher-order social variable. This finding points to a universal account of action control for actions with social action effects and actions with inanimate action effects alike.

1. Introduction

Interactions with other people constitute an important part of our everyday life. They can take many forms, ranging from casual chats to concentrated joint task performance, and they can involve different kinds of social partners. In these interactions, our behavior often evokes particular responses from the other person, and taking into account how the other person will react to our actions is essential to ensure that the interaction runs smoothly and successfully. Anticipating the other's responses, however, is not only relevant for efficient decision-making and coordination. Accumulating evidence suggests that anticipating another person's responses to our actions even affects basic mechanisms of immediate action control. This hypothesis lies at the heart of the sociomotor framework which assumes that another person's behavior can be used to represent and control our own actions if social responses follow our actions predictably (Kunde, Weller, & Pfister, 2018).

This idea is an extension of general ideomotor approaches to action control, which propose that our actions are represented in terms of the sensory consequences they trigger (i.e., *action effects*; see e.g., Hommel, 2013; Pfister, 2019; Shin, Proctor, & Capaldi, 2010, for reviews). More precisely, ideomotor accounts assume that agents acquire associations between their behavior and following sensory action effects. For instance, they may associate a snap of the fingers with a certain snapping sound and a proprioceptive sensation of the motion. These action-effect associations are thought to be bidirectional and can thus be used for action control: A mental code of the effects automatically activates the associated behavior that has previously caused the effects. There is considerable empirical support that this rationale is applicable to any sensory effect that our actions can produce, such as proprioceptive effects of actions (Pfister, Janczyk, Gressmann, Fournier, & Kunde, 2014; Thébault, Michalland, Derozier, Chabrier, & Brouillet, 2018; Wirth, Pfister, Brandes, & Kunde, 2016), effects of our actions on objects in the inanimate world (Földes, Philipp, Badets, & Koch, 2017; Gaschler & Nattkemper, 2012; Kunde, 2001; Pfister, Janczyk, Wirth, Dignath, & Kunde, 2014; Zwosta, Ruge, & Wolfensteller, 2013), and also the behavior of other persons that our actions evoke (so-called *sociomotor actions*; Kunde et al., 2018; for related empirical evidence see Flach, Press, Badets, & Heyes, 2010; Herwig & Horstmann, 2011; Kunde, Lozo, & Neumann, 2011; Müller, 2016; Pfister, Dignath, Hommel, & Kunde, 2013). In the latter case, agents would acquire associations between their actions and the behavior of another person that consistently follows the agent's actions (i.e., *social action effects*). Subsequently, anticipation of the other's behavior can trigger the agent's actions.

Evidence for the involvement of such anticipations in action

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planning and execution has been provided by studies using dyadic imitation tasks. In these studies, one participant (the model) performs a certain action in response to an arbitrary stimulus and a second participant (the imitator[1]) follows, by either copying the model's action (imitation) or by performing a different action (counterimitation; Pfister et al., 2013). A well-established finding in this setup is that models react faster to the target stimulus when they know that the imitator will subsequently imitate rather than counterimitate their action (see also Lelonkiewicz, Gambi, Weller, & Pfister, 2020; Müller, 2016; Müller & Jung, 2018; Pfister, Weller, Dignath, & Kunde, 2017; Weller, Pfister, & Kunde, 2019). This finding is explained by assuming that the model anticipates the imitator's responses, which (according to ideomotor reasoning) activates the very same behavior in the model. This activation may speed up the model's actions when it matches the requested action (as in the imitation condition), but not when it differs from the requested action (as in the counterimitation condition).

Research on sociomotor actions is concerned with investigating action control of the agent in the context of a social interaction. Even though its basic mechanics are assumed to be grounded in principles of action control that also mediate actions with purely inanimate effects, sociomotor actions may still be subject to certain peculiarities that come along with the social situation (Kunde et al., 2018). Among others, higher-order aspects regarding the relation between the agent and the other person might influence the agent's action control. An important modifier of social interactions is group membership, which has profound consequences on how others are evaluated, even when group membership is based on minimal and arbitrary differences (Otten & Wentura, 2001; Tajfel, 1970). But group membership can also affect the agent itself. As noted in Social Identity Theory, for instance, it may account for a considerable part of one's self-concept (Tajfel & Turner, 1979). Furthermore, when directly interacting with another person who either belongs to the same group (ingroup) or to a different one (outgroup), group membership can also influence to what extent the behavior of that other person is processed. For instance, when sharing a task with another person, people normally tend to represent their own and the other person's task share (Baess & Prinz, 2015; Sebanz, Knoblich, & Prinz, 2003, 2005; cf. Dolk et al., 2014; Sebanz, Bekkering, & Knoblich, 2006; Wenke et al., 2011). However, when interacting with a person that belongs to a different social group, the effects of the social partner on own performance were found to decrease or even vanish (Aquino et al., 2015; McClung, Jentzsch, & Reicher, 2013; Müller et al., 2011; see also Iani, Anelli, Nicoletti, Arcuri, & Rubichi, 2011). These findings can be explained by assuming that people attend to the task and actions of others especially when these others are similar (like ingroup members), while attention is oriented away (e.g., on the own task and own actions) when interacting with others that are perceived to be dissimilar from oneself.

In a similar vein, group membership might influence sociomotor action control, that is, the finding that anticipating another person's actions can affect basic mechanisms of immediate action control. More precisely, even though agents may represent and recollect their actions in terms of the behavior they evoke in others, as explained above, there is also reason to believe that agents may represent the same action in terms of rather different effects, for instance (but not limited to), the proprioceptive effects of an action (for a corresponding review and discussion see, Pfister, 2019). This representational switch (i.e., representing one and the same action predominantly in terms of proprioceptive effects rather than in terms of the behavior that is evoked in others) should depend on the agent's focus on either effect, as influenced by contextual variables, such as the relationship between interaction partners. That is, previous research indicates that the group membership of an interaction partner influences the agent's attention towards that interaction partner (e.g., Kawakami et al., 2014). Thus, agents should generally follow an ingroup member's actions, which should go along with an anticipation of that ingroup member's actions for own action control (i.e., an action representation predominantly in terms of the other person's behavior). However, in interactions with an outgroup member, agents might focus attention on their own movements, while neglecting the outgroup member's actions. In the dyadic imitation task, where model actions are imitated or counterimitated by a second person (the imitator), group membership of the imitator should thus moderate the impact of upcoming (counter)imitation on the model's actions. That is, models should react faster when anticipating an imitation response of an ingroup member rather than a counterimitation response. However, when interacting with an outgroup member, models might direct attention away from the outgroup member's action, so that model's action are less affected by imitation condition.

Several previous studies investigating the influence of group membership on imitation have addressed the imitator's perspective. An intuitive hypothesis along this line would be that imitation of another's actions is stronger when responding to an ingroup member than when responding to an outgroup member. Evidence in favor of this hypothesis has been reported by some studies investigating spontaneous mimicry or motor priming by automatic imitation (Bourgeois & Hess, 2008; Gleibs, Wilson, Reddy, & Catmur, 2016; McIntosh, 2006; Yabar, Johnston, Miles, & Peace, 2006). Although both paradigms do not necessarily correlate (Genschow et al., 2017), both have also identified a number of moderating factors for the influence of group membership on imitation. For instance, in studies on spontaneous mimicry only people with a high motivation to affiliate with the ingroup imitated models of their own group more often than models of an outgroup, whereas people with a low motivation to affiliate showed no difference (Genschow & Schindler, 2016). Studies on automatic imitation use a setup that is similar to the imitator's task in the dyadic imitation setup presented above. That is, participants typically have to perform cued actions (e.g., a keypress with the index or middle finger), while observing a model performing either the same action (imitation) or the opposite action (counterimitation; e.g., Brass, Bekkering, Wohlschläger, & Prinz, 2000; Kilner, Paulignan, & Blakemore, 2003; Stürmer, Aschersleben, & Prinz, 2000). Here, studies have shown that imitation effects (i.e., faster responses when performing the same action as the model rather than a different action) can be modulated by group membership under certain preconditions. More precisely, imitation effects were found to be larger for models of the ingroup compared to models of an outgroup when participants expected that they would subsequently have to cooperate with this model. In contrast, no difference between ingroup and outgroup was found if participants expected a subsequent competitive situation (Gleibs et al., 2016). Likewise, smaller imitation effects for models of an outgroup compared to the ingroup were found when models directly looked at the participant, but not if gaze was averted (Marsh, Bird, & Catmur, 2016).

Taken together, previous research suggests that group membership might influence to what degree another person's actions are cognitively represented, but the observation of such a moderating impact of group membership is neither trivial nor universal. We therefore intended to gather first evidence regarding the role of group membership for sociomotor action control. That is, we hypothesized that the anticipated behavior of an ingroup member would bias the agent's action control, whereas this effect should be weaker or even absent when interacting with a member of the outgroup.

We invited four participants to each session and assigned two participants to one group and the remaining two participants to a different group (see the description of the experiments for details on how group membership was established and communicated). Both groups wore colored T-shirts to reinforce group membership throughout the session.

[1] We use the term “imitator” in accordance with previous studies (e.g., Pfister et al., 2013), even though the person imitates (i.e., copies) the actions of the model only in some parts of the experiment, while he/she performs a different action in the remaining parts.

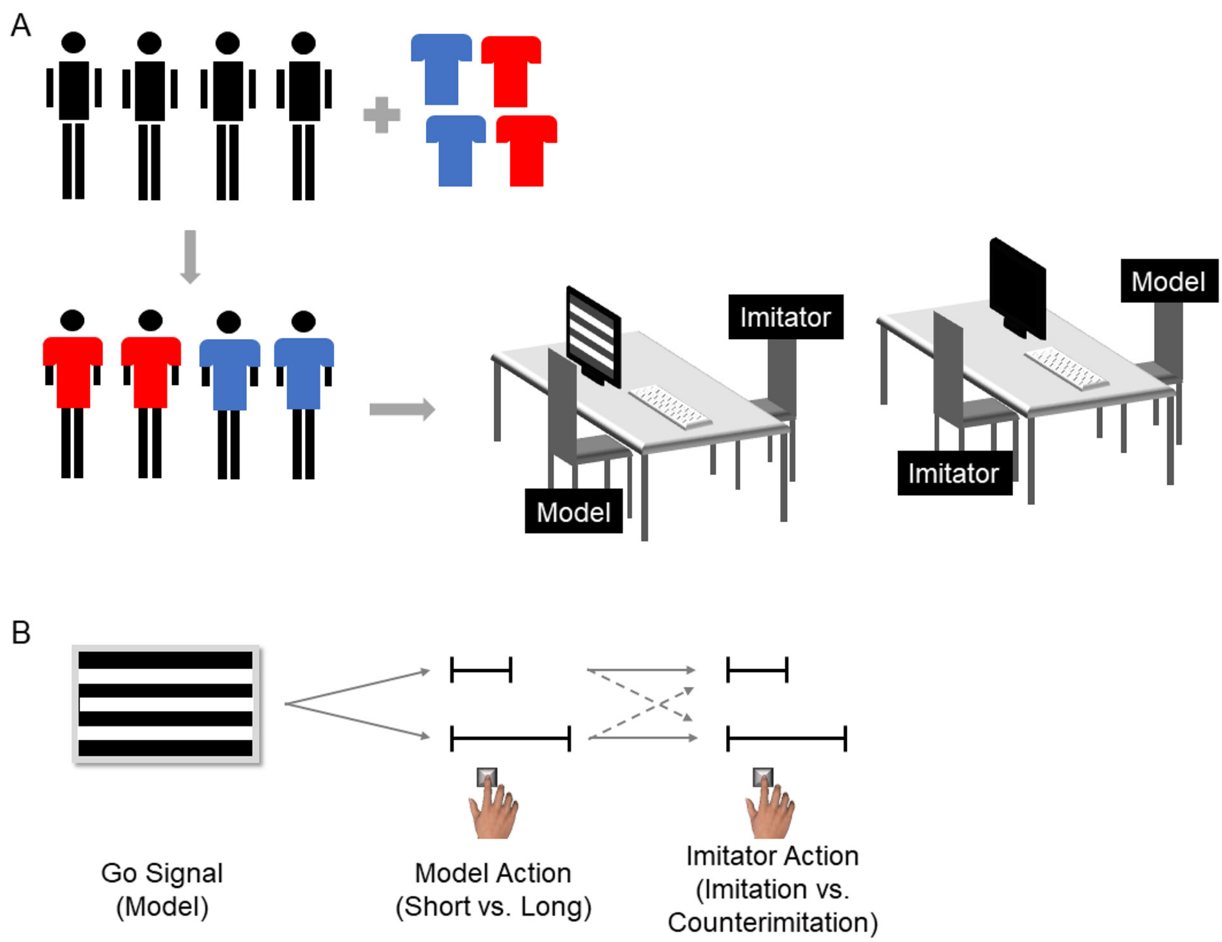

Fig. 1. A) Setup of both experiments. Four participants were invited to each session. They were divided into two groups and wore colored T-shirts to reinforce group membership. They worked either together with their ingroup member or with one of the outgroup participants. Two participants assumed the role as model, the other two the role as imitator. Participants switched roles during the experiment (see the method section of Experiment 1 for more details). One model and one imitator sat at each table and operated separate keys of a joint keyboard. A screen which displayed instructions and target stimuli faced the model, but could not be viewed by the imitator. Both participants could see the upper body of each other as well as the other's hand operating the response key. B) Trial structure of both experiments. The models received a go signal, prompting them to perform a long or short keypress. Depending on the current block, imitators responded with the same (imitation) or the opposite keypress (counterimitation).

Participants then completed a task to measure the impact of anticipated imitation (modeled after Pfister et al., 2013). During the task, each participant either worked with the other participant of their group or with a member of the opposing group. The two dyads worked in the same room and one participant of each dyad (the model) performed an action in response to an arbitrary stimulus while the second participant (the imitator) followed by either imitating or counterimitating the model's actions. Participants switched partners halfway throughout the session, so that each participant provided data once with a member of their ingroup and once with a member of the opposite group. Additionally, participants assumed both roles during the experiment, model and imitator. That is, both group membership of the interaction partner (ingroup vs. outgroup) as well as participant role (model vs. imitator) were manipulated within-subjects.

We expected to observe a beneficial effect of anticipated imitation (i.e., faster model responses in the imitation compared to the counterimitation condition) when participants interacted with the ingroup member, but no or a reduced effect when participants interacted with the outgroup participant. We conducted two similar experiments, which differed only with regard to what participants believed to determine group membership. Because all participants acted both as model and as imitator, we additionally analyzed reactions of the imitator. In line with previous studies using a similar setup, we expected faster imitator reactions and fewer errors when imitators copied the models' actions compared to when they performed a different action (Boyer, Longo, & Bertenthal, 2012; Pfister et al., 2013; Weller et al., 2019). As for the model responses, we expected these effects to be more pronounced for ingroup than for outgroup interactions (for a conceptually similar setting, see Gleibs et al., 2016).

2. Experiment 1

In Experiment 1, we manipulated group membership of the participants by letting them complete an ostensible personality questionnaire. They were informed that the questionnaire was analyzed online to match two participants each for their personality (though group assignment was arbitrary in reality). After assigning two participants to a "blue group" and two participants to a "red group", we provided them with a colored T-shirt according to their group membership. Participants wore these T-shirts throughout the session and completed the imitation task twice, once with an ingroup and once with an outgroup member.

2.1. Method

2.1.1. Subjects

We recruited 40 participants (mean age: 22.6 years, range 19-57 years, 15 male); in each session four participants were tested together.

An a priori power analysis suggested a sample size of 32 participants for a medium effect size of $d_z = 0.5$ and a power of 1-β = 0.8. We assumed a generic medium-sized effect because the hypothesized role of group membership for the impact of anticipated imitation had not been studied in previous work. Note that this sample size also ensures a high power of 1-β > .99 to detect main effects of response compatibility (imitation versus counterimitation) for the model and the imitator data alike (e.g., $d_z = 0.89$ and $d_z = 0.92$ for the model and the imitator data of Pfister et al., 2013, respectively). However, in one session, the error rate of one participant was extraordinarily high (> 50%), so that no data remained for one cell of the reaction time (RT) analysis. The data of all four participants of this session (i.e., all four participants participating at the same time) was excluded, because the high number of errors not only compromised that participant's data, but also the data of the interaction partners. In another session, one person had already participated in the experiment at a previous occasion. Because we could not replace the data of a single participant (but only of four participants at a time), we excluded and replaced the data of all four participants of this sessions as well. The final sample used for statistical analysis thus comprised 32 participants. All participants gave written informed consent at the beginning of the experiment and received course credit for compensation.

2.1.2. Stimuli and apparatus

The experiment took place in a room with two computers which were situated on two tables about 1.5 m apart (see Fig. 1A). Two participants were seated face to face at each table so that both dyads could perform the experiment at the same time. Participants could see the upper body of each other as well as the other's hand operating a response key. A 17" monitor was placed midways on the table so that one participant (the model) could see the screen, while the other participant (the imitator) could not see the screen. Both participants operated the same German QWERTZ-keyboard (facing the model); models used the key "1" and imitators the key "7" of the number pad. Target stimuli for the model were white stripes or white circles presented on a black background. Stimuli were spread over the entire screen to be easily visible for the model even when attending to the imitator's actions (see Fig. 1B). All participants wore headphones during the imitation task and received error feedback via these headphones.

2.1.3. Procedure

Four participants were invited for each session. At the beginning of the experiment, participants completed a mock personality questionnaire with 50 questions. The questions were loosely based on common Big Five personality questions (Goldberg et al., 2006), but they solely served the purpose of motivating the grouping manipulation. Participants were informed that they would be paired with another participant who scored most similarly to them on this questionnaire. In fact, the questionnaires were not evaluated, but participants were divided into two groups according to the seats they chose in the laboratory (participants who chose the two seats closest to the door were grouped together). Participants received T-shirts in their group color (blue or red). Additionally, participants were informed that either the blue or the red group would win a small reward when their combined performance (i.e., the performance across all experimental parts, when interacting with their partner and when interacting with a participant of the opposite group) was faster and more accurate than the combined performance of the members of the opposite group.

Then, participants completed the imitation task at the computer. That is, two participants each were seated at a computer with one participant acting as model and the other as imitator. The two participants seated together could be either of the same group or of different groups. The model's task was to react to target stimuli with a short (0-150 ms) or long (200-600 ms) keypress as fast and accurately as possible. The mapping of target stimulus (stripes/circles) to keypress duration (long/short) was counterbalanced across subjects. As soon as the model had reacted, the imitator was to perform the same keypress (imitation) or to perform the opposite keypress (counterimitation) depending on the current block. After the imitator's reaction the display was colored black for 1500 ms before a new target stimulus was presented. In case of errors of either participant, i.e., keypresses of the opposite duration or of wrong duration (150-200ms or > 600 ms), participants received verbal error feedback via headphones. Error feedback was only audible for the two participants sitting at one computer and helped them to identify, who had committed an error.

The imitation task was divided into four parts, after each part participants switched places. After the first part, the two participants sitting at one computer switched seats and thus the former model now acted as imitator and vice versa. After the second part, the two participants currently acting as imitator switched seats (i.e., moved to the other table), thus they now worked together with a different participant. After the third part, the two participants sitting at one computer again switched seats and the former model now acted as imitator and vice versa. In total, participants acted twice as imitator and twice as model, interacting with two different participants. Importantly, in one half of the experiment (either part 1 and 2 or part 3 and 4) the other participant was a member of the same group (ingroup) and in the other half of the experiment the other participant was a member of the opposite group (outgroup). Across all participants, we counterbalanced whether participants started to interact with an ingroup or an outgroup member.

Each of the four parts contained four blocks with 50 trials (two imitation blocks and two counterimitation blocks). That is, each part consisted of 200 trials and the entire experiment consisted of 800 trials. The experiment parts started with two imitation blocks for half of the participants and with two counterimitation blocks for the other half. Across all four parts (and for all four participants participating in one session), the order of imitation and counterimitation blocks, as well as the mapping of target stimuli to keypress duration was constant.

Before the first block of the imitation task participants could train the short (0-150 ms) or long (200-600 ms) keypresses. That is, after a short demonstration of the short and long keypresses by the experimenter, each participant individually practiced the long and short keypresses and received feedback from the computer about the duration of the keypress (i.e., short, long, or erroneous duration).

The entire experimental session lasted about 90 minutes. At the end of the experiment, participants were fully debriefed about the purpose of the experiment, the experimental procedure, the ostensible personality questionnaire, and the fact that group assignment had been arbitrary and had not relied on the questionnaire. All participants received a small reward (sweets) irrespective of group performance.

2.2. Results

2.2.1. Data treatment

The data and syntaxes for statistical analyses of all experiments are publicly available on the Open Science Framework (https://osf.io/jceh7/). For RT analyses of model and imitator reactions, all trials with errors of either participant (models: 4.3%, imitators: 6.7%) and all trials following these erroneous trials were excluded, as well as the first trial of each block. Then, trials were excluded when RTs deviated more than 2.5 standard deviations from the corresponding cell mean (1.8% for model RTs, 1.3% for imitator RTs), calculated separately for each participant, role (model/imitator), partner's group, and compatibility. For error rate analysis of the model's data, only trials with either correct responses or commission errors (i.e., keypresses of opposite or wrong duration) of the model during model action were analyzed, but not trials in which the imitator had responded prematurely. For error rate analysis of the imitator's data, only those trials were included where the model had responded correctly and the imitator had responded correctly or committed a commission error.

RTs and error rates were analyzed with 2 x 2 within-subject analyses

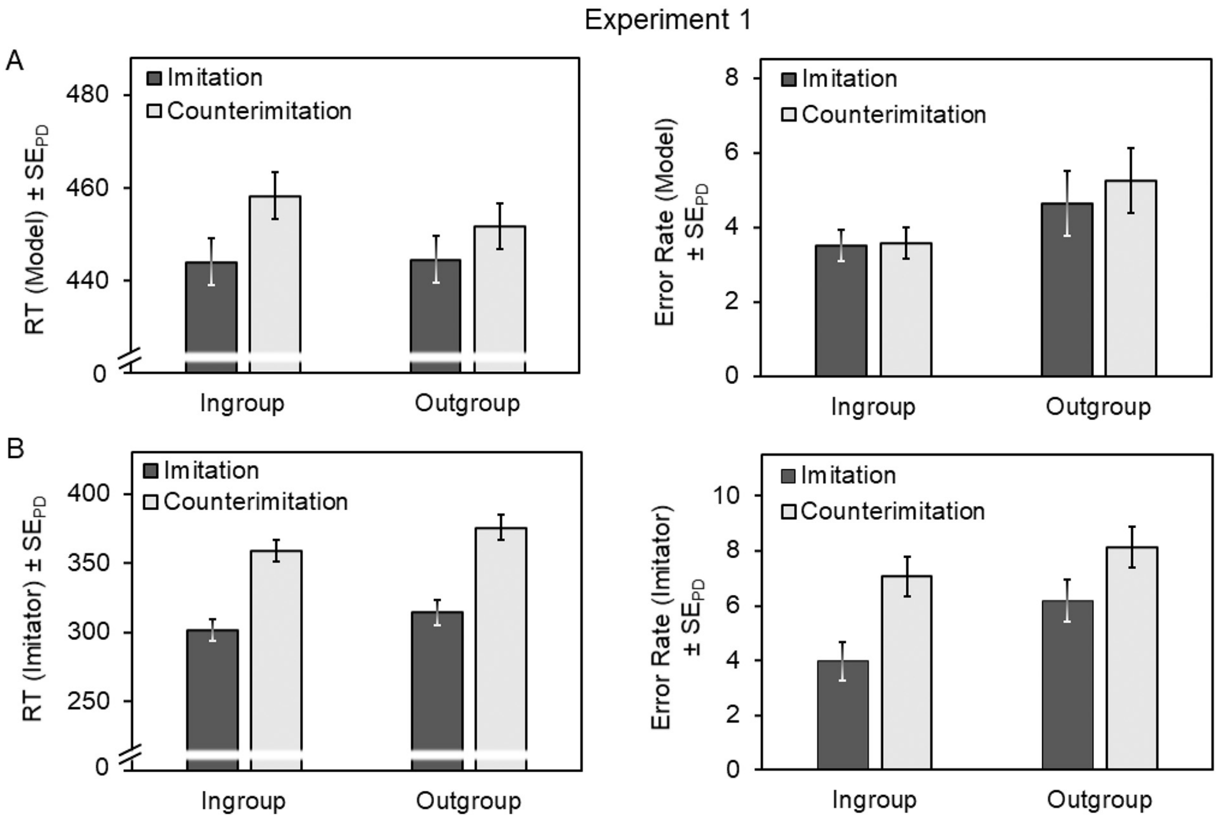

Fig. 2. A) Upper panels show the mean response times (RT; left panel) and error rates (right panel) for models in Experiment 1. B) Lower panels show the mean RT (left panel) and error rates (right panel) for imitators in Experiment 1. Error bars indicate standard errors of paired differences (SE_{PD}; see Pfister & Janczyk, 2013) for the comparison of imitation and counterimitation, separately for interaction with an ingroup and an outgroup member.

Table 1
Mean reaction times (RT; in ms) and mean error rates (in %) together with the respective standard errors (*SE*) for models and imitators in both experiments, calculated separately for the imitation and the counterimitation condition, as well as for interactions with an ingroup and an outgroup member.

	Ingroup		Outgroup	
	Imitation	Counterimitation	Imitation	Counterimitation
Experiment 1				
Model				
RT (*SE*)	444 (13)	458 (14)	445 (14)	452 (16)
Error rate (*SE*)	3.5 (0.5)	3.6 (0.5)	4.6 (1.0)	5.2 (1.5)
Imitator				
RT (*SE*)	301 (14)	359 (16)	314 (15)	376 (18)
Error rate (*SE*)	4.0 (0.6)	7.1 (0.8)	6.2 (1.0)	8.1 (1.1)
Experiment 2				
Model				
RT (*SE*)	508 (19)	535 (24)	515 (17)	527 (17)
Error rate (*SE*)	4.8 (0.7)	6.0 (1.2)	5.4 (0.9)	5.1 (0.8)
Imitator				
RT (*SE*)	366 (21)	465 (29)	396 (26)	493 (33)
Error rate (*SE*)	5.4 (1.0)	9.8 (1.5)	6.1 (1.0)	8.9 (1.2)

of variance (ANOVAs) with the factors compatibility (imitation vs. counterimitation) and partner's group (ingroup vs. outgroup). The main results of the RT and error rate analyses are depicted in Fig. 2, descriptive statistics can be found in Table 1.

2.2.2. Model responses

Models reacted faster when they were consistently imitated rather than counterimitated, $F(1,31) = 9.42$, $p = .004$, $\eta_p^2 = .23$. There was no main effect of the partner's group, and no interaction of compatibility and partner's group, $Fs < 1$.

Models' error rates were not affected by compatibility, $F < 1$. The main effect of partner's group was also not significant, $F(1,31) = 1.44$, $p = .240$, $\eta_p^2 = .04$, as was the interaction of compatibility and partner's group, $F < 1$.

2.2.3. Imitator responses

Imitators were faster at imitating the model rather than performing the opposite reaction, $F(1,31) = 80.57$, $p < .001$, $\eta_p^2 = .72$. Neither the main effect of the partner's group reached significance, $F(1,31) = 2.78$, $p = .106$, $\eta_p^2 = .08$, nor the interaction of compatibility and partner's group, $F < 1$.

Imitators committed less errors when imitating the model rather than performing the opposite action, $F(1,31) = 20.99$, $p < .001$, $\eta_p^2 = .40$. The main effect of partner's group did not reach significance, $F(1,31) = 3.18$, $p = .084$, $\eta_p^2 = .09$. The interaction of compatibility and partner's group was not significant, $F(1,31) = 1.36$, $p = .253$, $\eta_p^2 = .04$.

2.2.4. Exploratory analysis: observed post-error slowing

As an exploratory analysis, we further computed performance adjustments to observed partner errors. Recent observations from our lab indicated that errors of a social partner in sociomotor actions trigger sustained monitoring processes. These observations emerged in a study in which partner errors were fed back to the participants in a computer-mediated environment (to be able to match a condition with social partner errors to a condition with non-social machine malfunctions; Pfister, Weller, & Kunde, 2020). Here we aimed to extend these findings to a setting with a direct social interaction and we further aimed to explore a potential moderation by group membership. To this end, we analyzed model RTs as a function of the imitator response in the preceding trial (correct vs. error). Some imitators responded almost always correctly with error rates close to 0%. We therefore included only participants who had observed more than two errors from each imitator in each condition (i.e., for interactions with the ingroup and outgroup member), which amounted to 27 participants. A 2 x 2 within-subject ANOVAs with the factors imitator response in the previous trial (correct vs. error) and partner's group (ingroup vs. outgroup) revealed that models reacted slower when they had just observed an error of the imitator (M = 527 ms, SE_M = 27) compared to a correct reaction (M = 454 ms, SE_M = 15), $F(1,26) = 35.61$, $p < .001$, $\eta_p^2 = .58$. Neither the main effect of group, $F < 1$, nor the interaction were significant, $F(1,26) = 1.70$, $p = .204$, $\eta_p^2 = .06$.

2.3. Discussion

In Experiment 1, we investigated whether group membership influenced the effects of anticipated imitation. To that end, participants worked together in pairs and the two participants either belonged to the same group or to different groups. In both cases, the model reacted to target stimuli and the imitator responded by either imitating or counterimitating the model's action. Models reacted faster when they were subsequently being imitated rather than counterimitated, replicating previous findings (e.g., Müller, 2016; Pfister et al., 2013). This finding was independent of group membership. The imitator also reacted faster and committed fewer errors when imitating rather than counterimitating the model's actions. This finding is in line with previous results on automatic imitation (Brass et al., 2000; Stürmer et al., 2000; see Cracco et al., 2018, for a recent meta-analysis). As for model actions, the RT-difference between imitation and counterimitation was not further qualified by group membership. In the exploratory analysis, we found that models' RTs were influenced by partner errors, that is, models reacted slower when they had just observed an error of the imitator compared to a correct response. This finding is in line with previous studies (Pfister et al., 2020; Weller, Schwarz, Kunde, & Pfister, 2018), suggesting that in sociomotor actions, partner errors trigger sustained monitoring processes that affect models' subsequent responses. Again, this finding was not further qualified by group membership. Before drawing further conclusion from these results, we decided to replicate the experiment with a different manipulation of group membership, to ensure that the absence of any moderating effect of group membership was not due to an insufficient identification with the group.

3. Experiment 2

In Experiment 2, we manipulated group membership by assigning participants randomly to either the blue or the red group (signified by colored T-shirts) at the beginning of the experiment and participants knew that this assignment was random. We then aimed to foster identification with the group by letting participants complete two tasks with their ingroup member, in which group members had to interact and find similarities between each other. Participants then completed the imitation task twice, once with an ingroup and once with an outgroup member. Additionally, as a check of the ingroup/outgroup manipulation we included a measure to assess closeness between participants of the same and participants of different groups.

3.1. Method

3.1.1. Subjects

We recruited 36 participants (mean age: 28.8 years, range: 19-62 years, 7 male). In one session, the error rate of one participant was extraordinarily high (> 50%). The data of all participants of this session was excluded. The final sample used for statistical analysis thus comprised 32 participants, as for Experiment 1. All participants gave written informed consent at the beginning of the experiment and received course credit for compensation.

3.1.2. Stimuli, apparatus, and procedure

The experimental setup and procedure of Experiment 2 was equivalent to Experiment 1, except for the procedure of how group identification was induced. In this experiment, participants did not complete a questionnaire at the beginning of the experiment. Instead they were arbitrarily divided into two groups as in Experiment 1, but in this case this fact was evident to the participants. Participants again received T-shirts in their team color (red or blue). Then, participants completed two group tasks with their team member. First, participants had to find as many similarities between each other as possible in five minutes (at least 10 similarities). Second, participants had to complete a blind drawing task, where one participant had to close his or her eyes while drawing an object that the other participant was explaining to them. That is, the other participant was not allowed to name the object, but had to describe the movements of the pen. After these two tasks, participants started with the imitation task as in Experiment 1. Participants were again informed that one group could win a small reward when their combined performance was faster and more accurate than the performance of the opposite group. In contrast to Experiment 1, in Experiment 2 the number of trials per block was reduced (40 trials per block, 640 trials in total for the entire experiment) to keep the experiment feasible. That is, because the tasks to induce group membership required more time in Experiment 2 compared to Experiment 1, we reduced the number of trials per block for the imitation task to keep the overall duration of the entire experimental session similar. An entire experimental session for Experiment 2 lasted about 90 minutes.[2]

To test how much participants identified with their team member, participants completed the "inclusion of others into the self" (IOS) scale (Aron, Aron, & Smollan, 1992) for their team member and for the outgroup member with whom they interacted. The scale comprises seven Venn diagrams with two circles that vary from no overlap to overlapping almost completely. In this visualization, one circle depicts the self and the other circle depicts the other person. Participants are instructed to select the Venn diagram that best represents their relationship with the other. The IOS scale was completed just after participants had finished the imitation task with the person they rated.

3.2. Results

3.2.1. Data treatment

Data analysis was performed as for Experiment 1. For RT analyses, 13.1% of trials were excluded due to errors (models: 5.7%, imitators: 7.4%). For model RT analysis, 2.0% of trials were excluded because RTs deviated more than 2.5 standard deviations from the corresponding cell mean; for imitator RT analysis this amounted to 1.8%. The main results of RT and error rate analyses are depicted in Fig. 3, descriptive statistics can be found in Table 1.

To analyze whether participants perceived ingroup and outgroup members differently, we compared mean IOS ratings for ingroup members and mean ratings for outgroup members with a two-sided, paired-sample t-test. IOS ratings were coded from 1 (signifying low closeness, i.e., a Venn diagram where self and other do not overlap) to 7 (signifying high closeness, i.e., a Venn diagram where self and other almost completely overlap). There was no difference of IOS ratings for ingroup (M = 3.75, SE = 0.26) and outgroup members (M = 3.56, SE = 0.29), $t(31) = 0.74$, $p = .462$, $d_z = 0.13$.

3.2.2. Model responses

Models reacted faster when they were consistently imitated by the imitator rather than counterimitated, $F(1,31) = 9.25$, $p = .005$, η_p^2 =

[2] For one pair of participants and one experiment part, the old experiment version of Experiment 1 was run by accident. The data of this group was still analyzed, because the only difference to Experiment 2 was the number of trials per block (50 instead of 40).

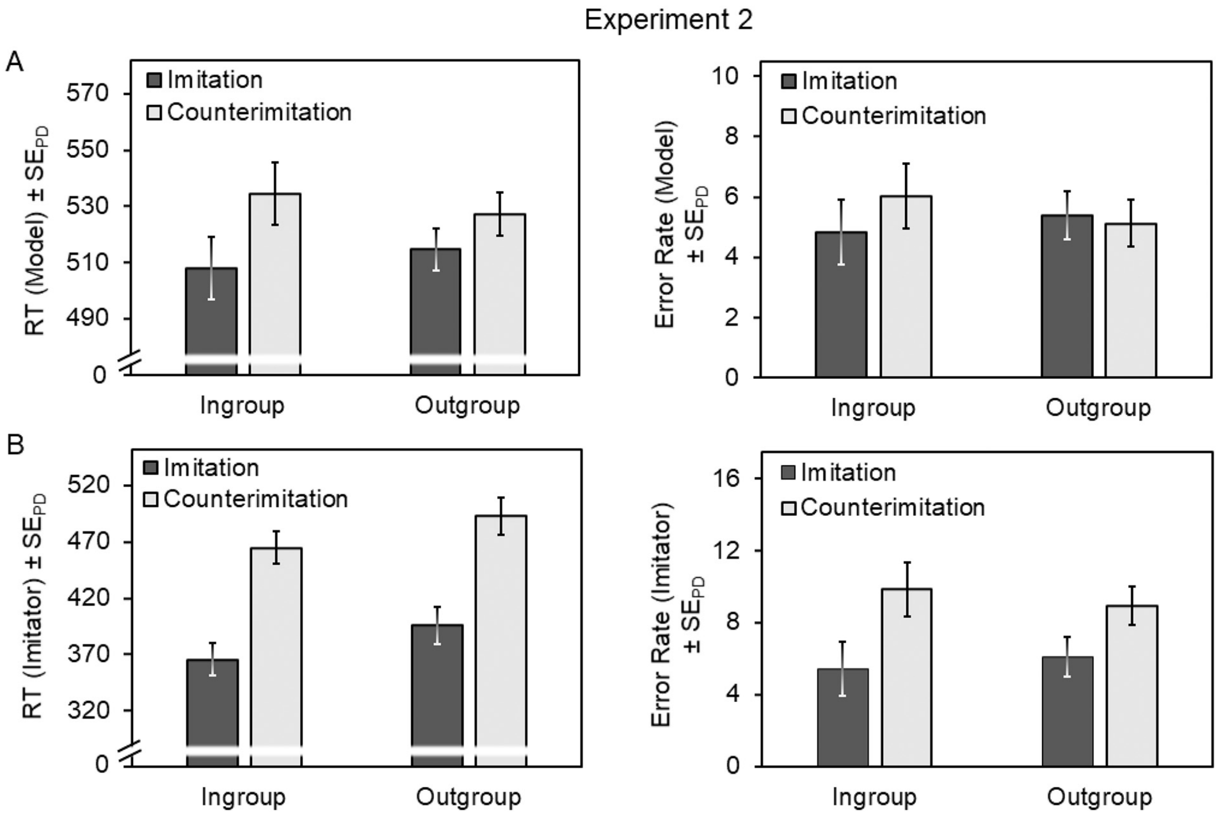

Fig. 3. A) Upper panels show the mean response times (RT; left panel) and error rates (right panel) for models in Experiment 2. B) Lower panels show the mean RT (left panel) and error rates (right panel) for imitators in Experiment 2. Error bars indicate standard errors of paired differences (SE_{PD}; Pfister & Janczyk, 2013) for the comparison of imitation and counterimitation, separately for interaction with an ingroup and an outgroup member.

.23. The main effect of the partner's group, as well as the interaction of compatibility with the partner's group were not significant, $F < 1$ and $F(1,31) = 1.07$, $p = .309$, $\eta_p^2 = .03$, respectively. Models' error rates were not affected by compatibility, partner's group or an interaction of these two factors, all Fs < 1.

3.2.3. Imitator responses

Imitators were faster when imitating the model rather than performing the opposite action, $F(1,31) = 51.84$, $p < .001$, $\eta_p^2 = .63$. The main effect of the partner's group did not reach significance, $F(1,31) = 4.09$, $p = .052$, $\eta_p^2 = .12$, and there was no interaction of compatibility and partner's group, $F < 1$.

Imitators committed less errors when they imitated the model compared to when they performed the opposite action, $F(1,31) = 13.74$, $p = .001$, $\eta_p^2 = .31$. There was no main effect of partner's group and no interaction of compatibility and partner's group, Fs < 1.

3.2.4. Exploratory analysis: observed post-error slowing

As for Experiment 1, we performed an exploratory analysis to analyze model RTs as a function of imitator response in the preceding trial (correct vs. error). Again, we included only participants who had observed more than two errors from each imitator (i.e., from the ingroup and the outgroup member), which amounted to 23 participants. The 2 x 2 within-subject ANOVA with the factors imitator response in the previous trial (correct vs. error) and partner's group (ingroup vs. outgroup) revealed that models reacted slower following an error of the imitator ($M = 583$ ms, $SE_M = 31$) compared to a correct reaction ($M = 516$ ms, $SE_M = 21$), $F(1,22) = 18.74$, $p < .001$, $\eta_p^2 = .46$. Neither the main effect of group, $F < 1$, nor the interaction were significant, $F(1,22) = 1.03$, $p = .322$, $\eta_p^2 = .05$.

3.2.5. Combined analysis of Experiment 1 and 2

A combined analysis of both experiments showed a significant main effect of compatibility for model RTs, with faster model responses when they were about to be imitated rather than counterimitated, $F(1,63) = 17.13$, $p < .001$, $\eta_p^2 = .21$. There was no main effect of partner's group, $F < 1$, and no interaction of partner's group and compatibility, $F(1,63) = 1.88$, $p = .175$, $\eta_p^2 = .03$. To further analyze this key interaction, we performed a Bayesian t-test comparing the compatibility effect (calculated as model RT in counterimitation blocks minus model RT in imitation blocks) for ingroup and outgroup interactions using the BayesFactor package (version 0.9.12-4.2) of the R software environment (version 3.6.1) with a prior of 0.707. The nondirectional Bayes factor of $BF_{01} = 3.00$ indicated evidence in favor of the null hypothesis (equal compatibility effects for ingroup and outgroup).

The analysis of models' error rates did not reveal an influence of compatibility, $F(1,63) = 1.25$, $p = .268$, $\eta_p^2 = .02$, partner's group or an interaction of these factors, both Fs < 1.

For imitator RT, the analysis revealed a significant main effect of compatibility, $F(1,63) = 99.30$, $p < .001$, $\eta_p^2 = .61$, and a main effect of partner's group, $F(1,63) = 6.77$, $p = .012$, $\eta_p^2 = .10$. The interaction of partner's group and compatibility was not significant, $F < 1$. The analysis of imitators' error rates show a significant influence of compatibility with imitators committing less errors when imitating rather than counterimitating the model, $F(1,63) = 30.05$, $p < .001$, $\eta_p^2 = .32$. The main effect of partner's group and the interaction of compatibility and partner's group were not significant, $F(1,63) = 1.13$, $p = .292$, $\eta_p^2 = .02$, and $F(1,63) = 1.86$, $p = .178$, $\eta_p^2 = .03$, respectively.

3.3. Discussion

Experiment 2 replicated the findings of Experiment 1. Models again reacted faster when they were subsequently being imitated rather than counterimitated by the other participant and this difference was not further influenced by group membership. In addition, a combined analysis pooling data from Experiment 1 and Experiment 2 showed no significant influence of group membership on the compatibility effect either.

Imitators were also faster and committed fewer errors when imitating rather than counterimitating the model and again, this was not further qualified by group membership. The combined analysis of Experiment 1 and 2, however, revealed a significant influence of group membership on RTs. That is, imitators generally reacted faster when interacting with an ingroup rather than an outgroup member.

In the exploratory analysis, we found that models RTs were influenced by previous partner errors, but no influence of group membership on this effect. The implication of these results will be elucidated in the general discussion together with the results of Experiment 1.

4. General discussion

In two experiments, we investigated the influence of group membership on anticipated imitation in sociomotor actions. To that end, we split the participants of each experimental session in two groups of two participants each and asked them to perform an imitation task, either with a member of their ingroup or a member of the outgroup. We found that participants reacted faster to arbitrary stimuli when their actions were subsequently imitated rather than counterimitated, but there was no evidence for a modulation of this effect by group membership. These results indicate that models anticipated the imitators' reactions irrespective of the imitator's group membership.

Taken together these findings suggest that actions can be retrieved by anticipating another person's behavior, but that this process is not susceptible to higher order social variables, such as group membership. In this sense, sociomotor action control does not seem to differ from action control in form of other, non-social effects. This interpretation is in line with a recent study suggesting that anticipated actions of another person are represented in the same manner as inanimate action effects, i.e., mainly in terms of spatial features, whereas anatomical features as a genuinely social component are not readily incorporated in action representations (Weller et al., 2019). Similar findings also come from studies investigating action control of eye movements. Accumulating evidence suggests that eye movements, just like manual actions, can be controlled by anticipating the corresponding effects, with similar processes for action effects of a social nature and effects in the inanimate environment (Herwig & Horstmann, 2011; Huestegge & Kreutzfeldt, 2012; Riechelmann, Pieczykolan, Horstmann, Herwig, & Huestegge, 2017; Riechelmann, Raettig, Böckler, & Huestegge, 2019).

In both experiments of the present study, not only model responses were faster in imitation blocks, but also imitator responses. That is, in imitation blocks, model responses were not only followed by the same reaction of the imitator, but in addition the delay between model and imitator action was shorter compared to the counterimitation blocks. For models, imitation and counterimitation blocks thus differed regarding the identity of the social action effect (i.e., same vs. different imitator action) but also regarding the delay of the imitator action. Previous research indicates that the delay between actions and inanimate effects plays a critical role in action control and is also anticipated when initiating an action. That is, actions are initiated faster when a short action-effect delay is anticipated compared to a long delay (Dignath & Janczyk, 2017; Dignath, Pfister, Eder, Kiesel, & Kunde, 2014). The present results may therefore also be explained by assuming that models reacted faster in the imitation condition because they anticipated a short delay rather than a compatible response. Previous research however indicates that while the delay of the imitator's response can influence model reactions if delays are sufficiently long or salient (Lelonkiewicz & Gambi, 2017), it is predominantly the identity of the imitator's action that drives the anticipated imitation effect in model responses. This is suggested by a previous study which compared the influence of the delay and the identity of the imitator's response on model actions (Pfister et al., 2017). In this study, the delay between model and imitator actions was either held constant for imitation and counterimitation blocks (Experiment 1) or was manipulated orthogonally to imitation and counterimitation (Experiment 2) by introducing a virtual avatar as imitator. Models reacted faster when they were subsequently imitated rather than counterimitated in both experiments, while the manipulation of the delay in the second experiment showed no effect. These results indicate that the identity of the imitator's action influences models' actions, whereas the delay does not seem to influence models' actions (at least within the typical range of delays in the imitation task). Because models were imitated and counterimitated in different blocks, another explanation for faster model reactions in the imitation condition compared to the counterimitation condition could be that the perception of consequently being imitated facilitates models' responses compared to the perception of never being imitated. This means that faster model responses would be a consequence of previous imitation instances rather than anticipated future imitation. Previous research has indicated that task performance in a subsequent task might be enhanced after experiencing a social situation in which one is consequently mimicked for a sustained period of time (Dalton, Chartrand, & Finkel, 2010; Finkel et al., 2006). A recent study, however, suggests that the present results cannot be attributed to such effects alone (Lelonkiewicz, Gambi, Weller, & Pfister, 2020). In this study, models were imitated and counterimitated within the same block. That is, imitators copied models' actions in some trials and performed the opposite action in other trials in a random sequence. In each trial, a cue indicated whether imitators would imitate or counterimitate the model's action, so that models could still anticipate the imitator's upcoming response. Again, models' actions were faster when they anticipated to be imitated rather than counterimitated. Taken together, these previous studies suggest that in the present experiments, models' actions were indeed influenced by anticipated imitation, however, not differently so for ingroup and outgroup interactions.

We additionally analyzed reactions of the imitator in both experiments and found that imitation was easier (faster and less error prone) than counterimitation. As for the model data, however, we did not find an influence of group membership. This finding was further corroborated by an exploratory analysis, in which we found that models reacted slower when they had just observed an error of the imitator compared to a correct response, again with no difference between the ingroup and the outgroup. This result indicates that, for interactions with the ingroup and the outgroup, models attended to the imitators' actions, with sustained monitoring for erroneous responses. Together these findings beg the question if there is any reason why we did not find any impact of group membership whatsoever in the present data. One straightforward explanation would be that our manipulation of group membership had not been successful in the first place and participants thus did not identify themselves with the group. This explanation seems to be supported by the results of the IOS scale in Experiment 2, which did not show any differences in feelings of closeness towards ingroup and outgroup members. At the same time, the IOS scale might not have been sensitive enough to capture more subtle differences in social perceptions. Indeed, reliable effects of group membership have been shown even for minimal groups, based on novel, arbitrary categorization. For instance, anonymous members of these minimal groups are evaluated more positive (for reviews see e.g., Brewer, 1979; Dunham, 2018). Assuming that arbitrary categorizations suffice to induce some group processes, assigning participants to the two groups in the present experiment (as indicated by the colored T-shirts) should have made them identify with their group to some extent. In fact, participants' assignment to the two groups was not completely random in the present experiments, but rather relied on the seats they chose. Therefore, the groups may not have been formed on truly arbitrary aspects. For instance, participants that appeared at the same time may have sat next to each other and were thus grouped together. However, this arrangement should have even strengthened (rather than weakened) participants' identification with their ingroup member, which is proposed by findings on the relationship of liking and physical proximity (Kahn & McGaughey, 1977; Segal, 1974). Furthermore, the analysis of the imitator's data tentatively suggests an influence of group membership on the general easiness to produce a response. That is, the combined analysis of Experiment 1 and 2 revealed a significant influence of group membership on imitator RTs, with faster RTs when interacting with an ingroup member compared to interacting with an outgroup member. In summary, this may be taken to suggest that participants did in fact represent the two groups and that, consequently, group membership did influence participants' actions to some extent.

The combined analysis of Experiment 1 and 2 suggest that imitators' actions were indeed influenced by group membership, but not differently so for imitation and counterimitation. This particular finding seems to stand in contrast to findings in the literature in which particularly strong imitation effects were observed when two ingroup members acted cooperatively (as in the present design), and these effects were more pronounced than for any other condition (i.e., ingroup members competing against each other or interactions with outgroup members in general; Gleibs et al., 2016). However, the present finding becomes more plausible when considering that in the present experiments imitators were forced to pay attention to the model's actions, as they had to rely on the model's action to complete their task (i.e., imitate or counterimitate the model). This procedure is unlike usual automatic imitation tasks, in which the imitator often reacts to arbitrary stimuli that coincide with the model's actions (Aicken, Wilson, Williams, & Mon-Williams, 2007; Bertenthal, Longo, & Kosobud, 2006; Brass et al., 2000; Catmur & Heyes, 2011; Stürmer et al., 2000), making it possible to selectively direct attention away from actions of outgroup members not only for the model but also for the imitator.

Even though in present experiments participants performed the tasks with other persons, the imitation task featured only minimal interaction of the two participants. That is, in the imitation task the participants did not have to talk to each other or coordinate their actions. This was only necessary when starting a new block in the experiment. However, even though interaction was limited, model's actions were still strongly influenced by the imitator's action. This finding is particularly noteworthy because the models could have performed their share of the task (i.e., reacting to the target stimulus with long or short keypresses) without taking the imitators' actions into consideration. That is, even though the model's task did not necessitate any direct interaction with the imitator and anticipating the imitator's actions was obstructive for model's actions at least in half of the trials (i.e., in the counterimitation condition), we still found a reliable effect of anticipated imitation for ingroup and outgroup members. Evidently, it was not easy for models to ignore the imitators' actions. The present results thus suggest that another person's predictable behavior following our own actions is a particularly salient cue for our action control irrespective of the relationship with that other person. This saliency might be even higher in more enriched interactions, such as verbal or nonverbal communication and joint action. Thus, although sociomotor action control likely relies on the same mechanisms as action control in terms of inanimate effects, social action effects still appear to be somewhat special in that they are particularly salient and cannot be as easily ignored as many inanimate effects (see also Weller et al., 2019). This interpretation is in line with findings of specialized routines and neural matters for the perception of others, such as the perception of faces (Farah, Wilson, Drain, & Tanaka, 1998), biological motion (Johansson, 1973; Thompson, Clarke, Stewart, & Puce, 2005), or speech (Poeppel & Monahan, 2008). Furthermore, previous research suggests that another person's responses to our actions are monitored rather automatically (Weller et al., 2018). Consequently, higher order social variables such as group membership might come into play when processing of another person's actions is more effortful and cannot be processed automatically, e.g., when there is no direct feedback (Pfister, Pfeuffer, & Kunde, 2014). Under these conditions, models might choose to represent only an ingroup members' action.

Assuming that our manipulations were successful in inducing a sense of group membership at the beginning of the experiment, there is still another caveat to consider. That is, the imitation task itself may have eventually changed participants' evaluation of the outgroup member, analogous to previous findings of altered group representations following cooperation beyond group boundaries (Gaertner et al., 1999; Gaertner, Mann, Dovidio, Murrell, & Pomare, 1990) and synchronized movements of people belonging to different groups (Good, Choma, & Russo, 2017; Miles, Lumsden, Richardson, & Macrae, 2011). In the present task, when members of two different groups performed the imitation task together, they still reacted perfectly contingently on each other (imitating or counterimitating each other, depending on the respective block). This is especially relevant for the imitation condition, as imitation has been shown to increase social affiliation towards the other person (Chartrand & Bargh, 1999). However, recent studies suggest that this effect is driven at least partly by general predictability (Catmur & Heyes, 2013) and applies to perceived and anticipated imitation alike (Dignath, Lotze-Hermes, Farmer, & Pfister, 2018). Because predictability is high even in the counterimitation condition, the procedure of the present imitation task may have changed participants' evaluation of each other, eventually overwriting the initially induced groups and, thus, reducing the possibility to find an effect of group membership on sociomotor action control (even though imitator RTs still suggested that some differences between ingroup and outgroup interactions were present, see above). This confound cannot be easily disentangled because the imitator's actions need to be predictable for the model to anticipate the respective actions. Future studies might therefore track participants' perception of the group membership more closely (e.g., after short mini-blocks of imitation and counterimitation) to assess whether a change in group membership perception coincides with changes in effects of anticipated imitation. Notwithstanding this issue, successful sociomotor actions require some interaction between the involved persons, because one person has to respond to the other's behavior, and these actions may therefore play a part in overcoming group boundaries.

In summary, we found that participants reliably reacted faster when they were about to be imitated rather than counterimitated by a second participant, irrespective of group membership. This finding points to a rather universal account of action control for actions with social action effects and actions with inanimate action effects alike. At the same time, social action effects may be particularly salient compared to many inanimate effects.

CRediT authorship contribution statement

Lisa Weller: Conceptualization, Methodology, Investigation, Formal analysis, Data curation, Visualization, Writing - original draft. **Roland Pfister**: Conceptualization, Formal analysis, Writing - original draft. **Wilfried Kunde**: Conceptualization, Methodology, Formal analysis, Writing - original draft.

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Raw data and syntax files for reproducing all statistical analyses are publicly available on the Open Science Framework (https://osf.io/jceh7/).

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