

# How imitation moves:

## Effects of movement congruency and temporal contingency on affiliation, social influence, empathy and prosocial behavior

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## **Abstract**

Being imitated has profound effects on social affect and behavior, but it is still unclear how it produces these effects. According to one view the effects are grounded in covert movement simulations and therefore require the movements of the individuals to be bodily congruent. Yet, imitation could also have its positive effects because of the rewarding experience of perceiving temporal contingencies between one's own and others' movements, implying that these effects would also occur if the imitator's movements are temporally contingent, but not bodily congruent.

In two experiments, we assessed whether bodily congruency is necessary for increasing empathy and prosocial behavior, or whether temporal contingency alone can also produce such effects. Participants made spontaneous joystick movements while engaging in a feigned webcam interaction with two confederates, one of whom made imitative movements, while the other (the control actor) made unrelated movements. In two experimental groups, we varied whether the imitator made bodily congruent or temporally contingent movements.

Participants reported more affiliation to the congruent actor compared to the control actor, and conformed more to this actor's judgments. Besides, participants showed a higher skin conductance response (SCR) when perceiving the congruent actor in pain, and favored this actor in prosocial behavior, with increase in SCR predicting whether the imitator was favored. Imitation that was merely temporally contingent did not evoke such effects. Together, these findings suggest that the social effects of imitation seem grounded in motor and affective resonance processes, and that they can be selectively targeted at specific interaction partners.

## **Keywords**

Imitation; Mimicry; Chameleon Effect; Empathy; Prosocial behavior

## Introduction

During social interactions people tend to spontaneously mimic each other's movements and gestures. Although these subtle forms of imitation are typically not consciously noticed, research has shown that people who are imitated by their interaction partner tend to experience the interaction as smoother and more pleasant (Chartrand and Bargh, 1999). Moreover, being imitated may influence one's opinion about the interaction partner, who is seen as more likable (e.g. Bailenson and Yee, 2005; Chartrand and Bargh, 1999; Dabbs Jr, 1969; Meltzoff, 2007; Suzuki et al., 2003; Van Baaren et al., 2009). Besides affecting explicit affiliation ratings, being imitated may also shape actual behavior: for instance, it may promote later prosocial behavior towards the imitator (Müller et al., 2012; Van Baaren et al., 2004). This suggests that, despite its implicit nature, imitation seems to strengthen our sense of social connection with others (Fawcett and Liskowski, 2012; Meltzoff, 2007; Van Baaren et al., 2009).

While evidence for the effects of imitation on social attitudes and behavior is extensive, it is still not fully resolved how imitation produces these effects. Based on a vast body of research, it is generally assumed that individuals engage in automatic simulations of observed actions of others by covertly activating the motor programs involved in the first-person execution of these actions (Blakemore and Frith, 2005; Brass and Heyes, 2005; Georgieff and Jeannerod, 1998; Knoblich and Sebanz, 2006). It has been proposed that such covert motor resonance may entail a default, effortless processing mode which gets disinhibited during smooth, pleasant interactions, resulting in a facilitation of actual imitative movements (Cross and Iacoboni, 2014; Heyes, 2013). The affiliative effects of being mimicked by an interaction partner, then, might arise from a congruency between one's own current motor programs and the covertly simulated movements of the other: the resulting self-other overlap in motor representations may denote a neural and behavioral state of being "tuned in" to the other, which may enhance affiliative and prosocial tendencies and which may also facilitate embodied simulations of the other's emotional state (de Waal, 2007). Thus, according to this view, the prosocial effects of imitation are

ultimately grounded in embodied movement simulations, and therefore require the movements of the mimicker and the mimicked to be structurally congruent.

Yet, the affiliative and prosocial effects of imitation could also be driven by other mechanisms, which may either provide a more comprehensive explanation or work in parallel with motor resonance-based processes. In particular, the mere detection of a reliable predictive relationship or temporal contingency between one's own actions and certain perceptual events may be intrinsically rewarding, irrespective of whether it involves imitation or not (Catmur and Heyes, 2013). Supporting this notion, it has been shown that infants enjoy watching temporal contingencies between external events (Bahrick, 1983) and, more specific to action-perception contingencies, that the reliable occurrence of a perceptual event following one's action induces positive affect (Gunnar et al., 1984; Tarabulsy et al., 1996). This might be due to the fact that noticing that one's actions have predictable effects evokes a sense of agency or causality (Meltzoff, 1990), i.e., a "feeling of causing something to happen" (Dewey and Knoblich, 2014), which satisfies effectance motivation - the basic motivation to predict and attain control of one's environment (Waytz et al., 2010; White, 1959). With respect to imitation, (subconsciously) detecting that the interaction partner reliably reacts to one's movements may thus fulfill a basic desire for predictability and control, resulting in positive feelings about this person. In addition, the other's responsiveness to one's behavior might be understood as a social signal that he or she is deliberately "tuning in" to oneself. This view of mimicry as an implicit expression of affiliative intent has been proposed before (Lakin et al., 2003), but may not necessarily be confined to anatomically congruent movements; indeed, it may as well apply to non-congruent but temporally contingent movements. Altogether, this account would imply that temporal contingency is a necessary condition for the social effects of imitation to occur, but strict movement congruency is not.

A few studies have attempted to disentangle the roles of temporal contingency and movement congruency in explaining the social effects of imitation. Two independent studies have shown that infants prefer an actor who performs bodily congruent movements over an actor who

performs temporally contingent, but different movements (Agnetta and Rochat, 2004; Meltzoff, 2007). Although this suggests that movement congruency drives at least part of the effects, it does not exclude the possibility that a contingently moving actor would still be preferred over an actor whose movements are not in any way related to the infant's behavior. A more recent study which independently varied the similarity and temporal contingency of feet and hand stimuli moving in response to participants' self-initiated movements found that contingency (i.e. how reliably the participant's movement was followed by a stimulus movement), not similarity (i.e., whether the body part shown was the same or different), increased ratings of closeness and task enjoyment as well as prosocial behavior (Catmur and Heyes, 2013). Although this study provided novel insights into the role of contingency, it also had some limitations. First, while in the contingent conditions all trials showed a moving body part, in the non-contingent condition, only half of the trials showed a movement of any kind, which implied that in this condition, part of the similar and dissimilar trials did not contain a motion component, arguably a crucial aspect of imitative movements. This may have had the additional effect of making the non-contingent condition less engaging overall, irrespective of the degree of action-perception contingency per se, given the assumption that trials with movements are likely more engaging than still trials. Second, due to the fact that this task fully relies on animated stills of body parts, it remains to be clarified how these findings generalize to experimental settings involving a real-time interaction with an intentionally moving agent, which in that respect bear more resemblance to naturalistic interactions. Thus, the question to what extent temporal contingency accounts for the prosocial tendencies of imitation in interactional settings still needs to be resolved, using an approach in which contingent movement is accurately contrasted with similarly frequent but non-contingent motion.

A second open issue involving the prosocial effects of imitation is the question whether the effects reflect a general change in prosocial orientation, or can be tailored towards specific interaction partners. Besides evidence for effects on prosocial behavior towards the individuals that have imitated (Müller et al., 2012; Van Baaren et al., 2004) there is also evidence that

being imitated enhances prosocial behavior towards third parties (Ashton-James et al., 2007; Carpenter et al., 2013; Fischer-Lokou et al., 2011; Van Baaren et al., 2004), possibly reflecting a shift towards more interdependent self-construal (Brewer and Gardner, 1996). On the other hand, it has been shown that perspective taking, which is also believed to engage self-other merging mechanisms, typically yields target-specific prosocial effects (Galinsky et al., 2005). Although in the domain of imitation it has been shown that sequentially inducing imitative and non-imitative encounters can flexibly enhance and diminish socio-affective responses in individuals (De Coster et al., 2013), it has, to our knowledge, never been tested whether simultaneously interacting with multiple individuals of whom one is imitating and one is not, can evoke prosocial effects restricted to the imitator. This is an important question as target-specific effects may indicate that, in addition to inducing an interdependent or prosocial mindset, mimicry may also foster social bonding processes between two specific agents.

A third open issue is the question to what extent the effects of imitation on prosocial behavior are mediated by changes in empathy, i.e. by sharing others' affective states. Like automatic imitation, empathy is also assumed to be mediated by embodied simulations (Bernhardt and Singer, 2012; Decety and Jackson, 2006; Lamm et al., 2011; Lamm and Majdandžić, 2015; Preston and de Waal, 2003; Rütgen et al., 2015a; Rütgen et al., 2015b), and therefore a state of being bodily tuned in to others in the motor domain may also facilitate such simulation in the affective domain. Furthermore, prosocial behavior can be driven by increases in empathy, although it is not a necessary nor a sufficient precondition (Batson et al., 1997; Batson and Shaw, 1991; Cialdini et al., 1987). While several correlational studies have shown a link between dispositional empathy and spontaneous imitation (Chartrand and Bargh, 1999; Müller et al., 2013), there has only been one experimental study demonstrating that being imitated facilitates subsequent empathic responses (De Coster et al., 2013). In this study, participants performed voluntary finger lifting movements which were, in block-wise fashion, either imitated or counter-imitated by an animated hand stimulus. Compared to non-imitation blocks, imitation blocks evoked increased responses on several empathy measures during video

clips in which the hand was harmed. Yet, as the authors note themselves, due to the egocentric presentation of the hand and the synchronous presentation of the imitative movements, the manipulation seemed to primarily induce a sense of self-other confusion between the participant's hand and the hand on the screen, equivalent to a rubber hand illusion (Botvinick and Cohen, 1998), which suggests that the observed affective responses might have reflected self-related distress rather than empathic responses. Thus, it remains to be established whether the reported effects on empathy can be generalized to imitative settings in which such self-other confusion is unlikely.

In the present study we tested the effects of being imitated on empathy and prosocial behavior in two separate experiments. More specifically, we aimed to assess whether strict congruency between one's own movements and those of the imitator is necessary to evoke such effects, or whether temporal contingency alone is sufficient. In addition, we sought to determine whether increases in empathy and prosocial behavior can be tailored to a specific individual in situations where people are simultaneously interacting with multiple interaction partners of whom one is imitating them and one is not.

To address our research questions, we designed a motor task in which we varied the extent to which participants were imitated by two confederates, and used this task in both experiments. In the task, participants made spontaneous decisions about whether or not to move a joystick while engaging in an ostensible live webcam interaction with two co-players. In one experimental group, one of the co-players tended to move the joystick in a manner that was both temporally contingent and spatially congruent to the movements of the participant (congruent condition), that is, equivalent to full imitation in naturalistic interactions; the other co-player made unrelated movements (control condition). In a second experimental group, one co-player moved in a manner that was only temporally contingent, but not spatially congruent, with the participants' movements, while the other co-player moved in an unrelated way. Thus, in one group (congruent versus control) the imitation condition was fully congruent, both spatially and temporally, while in the other group (contingent versus control) it was only temporally contingent. This design

allowed us to separately assess effects of movement congruent and temporally contingent imitation relative to a control condition matched for movement output, and hence, to examine whether full movement congruency is necessary for eliciting socio-affective effects, or whether temporally contingent movement alone can also evoke such effects.

In both experiments, we assessed the effects of this manipulation on empathy and prosocial behavior in subsequent tasks (see Table 1). In Experiment 1 we measured empathy by assessing participants' self-reported positive and negative vicarious affect in response to monetary gains or losses by the co-players in a gambling task. Preference in prosocial behavior was assessed by probing participants' willingness to donate part of their earnings to their co-players, thereby requiring them to favor one co-player over the other. In this experiment we additionally assessed whether imitation induced a tendency to conform to the imitator's judgment in a number estimation task. Subjectively experienced self-other merging may increase social identification, which may in turn trigger assimilation to behavioral standards set by a person (de Cremer, 2004). Although imitation has been shown to increase assimilation to opinions and group norms (Leander et al., 2011; Parton and Priefert, 1975), it is unclear whether these effects require motor congruency or can also be elicited by mere temporal matching, and whether they reflect a general change in social orientation or can be specifically linked to one imitator.

In Experiment 2, we focused on effects of imitation on empathy for pain, using a task in which participants observed their co-players receive painful shocks (Hein et al., 2010; Rütgen et al., 2015a; Singer et al., 2006). Empathic responses were quantified by complementing self-reports with a set of psychophysiological measures, consisting of skin conductance measures and facial electromyography (EMG) measures of corrugator supercilii muscle activity and startle blink reflex. This was motivated by the fact that the underlying physiological responses have been shown to be sensitive to noxious stimuli and negative affect, not only when these are self-related but also when observed in others. More specifically, amplitude of the startle blink response, a reflex in the orbicularis oculi muscle in response to sudden, intense stimuli (Miller et al., 2002), is specifically increased by stimuli with a negative affective valence (Bradley, 2009;

Vrana et al., 1988), including pain in others, which also enhances corrugator activity, a measure of “frowning” (Caes et al., 2012). Skin conductance response (SCR), an index of autonomic arousal, is sensitive to negative emotional stimuli (Bradley et al., 2001); notably, it also responds to the observation of pain in others and is modulated by the social relation with the person empathized with (Krebs, 1975; Lanzetta and Englis, 1989). More in general, assessing physiological responses as an index of empathy for pain fits with evidence that people who feel socially connected to each other tend to automatically synchronize a range of bodily processes (Butler, 2011; Konvalinka et al., 2011) and that the extent of physiological synchrony with the observed other is indicative of empathic accuracy (Levenson and Ruef, 1992). After the empathy for pain task we assessed participants’ preference in prosocial behavior by probing participants’ decision to take over or pass on a further series of painful shocks from their co-players (Hein et al., 2010), thereby requiring them to favor one co-player over the other.

We predicted that if potential effects of imitation on empathy and prosocial behavior are driven by embodied movement simulations and self-other overlap, these effects would only occur in the experimental group in which the imitator was congruently moving. If, on the other hand, the effects of imitation are (partly) driven by the rewarding effects of experiencing temporal contingencies between one’s own and another person’s movements, we would also find effects in the group in which the imitator made different movements but moved in a temporally contingent way.

# Experiment 1

## METHOD

### Participants

64 healthy right-handed volunteers participated in Experiment 1 (34 female, 30 male, age 25.9  $\pm$  5.3 years, mean ( $M$ )  $\pm$  standard deviation ( $SD$ )). Participants were pseudo-randomly assigned to one of two experimental groups: the CONGRUENT group or the CONTINGENT group, resulting in a sample of 31 participants (18 female, 13 male) in the CONGRUENT GROUP and 33 participants (16 female, 17 male) in the CONTINGENT group. In the CONGRUENT GROUP data from two participants on the Prosocial Preference measure were not recorded, resulting in a final sample of 29 participants (17 female, 12 male) for this measure. All participants had normal or corrected-to-normal vision, and gave written informed consent. Participants were paid a reimbursement of €9.00 for their participation, which was increased with a variable further amount between €3.00 and €7.00, depending on participants' decisions in the prosocial preference task. This resulted in a final fee between €12.00 and €16.00. The experiments was performed in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of Vienna.

### Experimental procedures and design

The experiment consisted of four consecutive tasks: the Motor Task (I), the Social Influence Measure (II), the Empathy Task (III), and the Prosocial Preference Task (IV). During all tasks, participants were led to believe that they were part of a live webcam-based interaction with two other participants, who were in fact confederates who had been filmed in advance.

**Table 1.** Overview of experimental design and time course of experiments 1 and 2. For each experiment, two groups of participants were tested. In group 1 we tested for effects of fully congruent imitation (i.e., both bodily congruent and temporally contingent) with respect to a control condition; in group 2, we tested for effects of imitation that was merely temporally contingent (not bodily congruent), with respect to a control condition.

<b>Experimental manipulation</b>	<b>Dependent measures</b>		
<b><u>Experiment 1</u></b>			
<b>Motor task</b>	<b>Social influence measure</b>	<b>Empathy Task (monetary version)</b>	<b>Prosocial Preference Task (monetary version)</b>
Group 1: congruent imitation versus control	congruent vs. control	congruent vs. control	congruent vs. control
Group 2: contingent imitation versus control	contingent vs. control	contingent vs. control	contingent vs. control
<b><u>Experiment 2</u></b>			
<b>Motor task</b>	<b>Empathy Task (pain version)</b>	<b>Prosocial Preference Task (pain version)</b>	<b>Affiliative ratings</b>
Group 1: congruent imitation versus control	congruent vs. control	congruent vs. control	congruent vs. control
Group 2: contingent imitation versus control	contingent vs. control	contingent vs. control	contingent vs. control

### ***Cover story and confederates***

The experiment was preceded by an instruction session during which participants read and signed an informed consent form, and received written and oral instructions about the tasks. They were informed that throughout the experiment they would interact over a live network connection with two other participants, who were said to be in a different part of the research institute. Participants were then given a yellow coat to wear over their normal clothing, ostensibly to make them easily recognizable for the other two participants, who in turn would wear a red or blue coat for the same reason. Participants were then seated behind a computer. Before start of the Motor Task, they were introduced to the other two participants with two short video clips, seemingly to test the live webcam connection, after which participants were ostensibly recorded in a similar way. The videos lasted 4 seconds each and showed two confederates, one of whom was wearing a red coat (the “red participant”) and the other a blue coat (the “blue participant”). Of both confederates, only the upper body was visible; this was done to prevent factors related to facial appearance (e.g. facial attractiveness, facial expression) to interfere with imitation-

related effects on participants' evaluations and behavior. Both confederates were females; however, due to the wide coats this could not be discerned from the videos, as had been confirmed in an online survey that preceded the study, using a 5-point rating scale ranging from "certainly male" to "certainly female" (N = 61, Mean rating confederate A = 3.13; B = 3.27). Assignment of the two confederates and coat colors (red and blue) to the conditions (CONGRUENT/CONTINGENT or CONTROL) was counterbalanced across the 32 participants per group.

### ***Tasks***

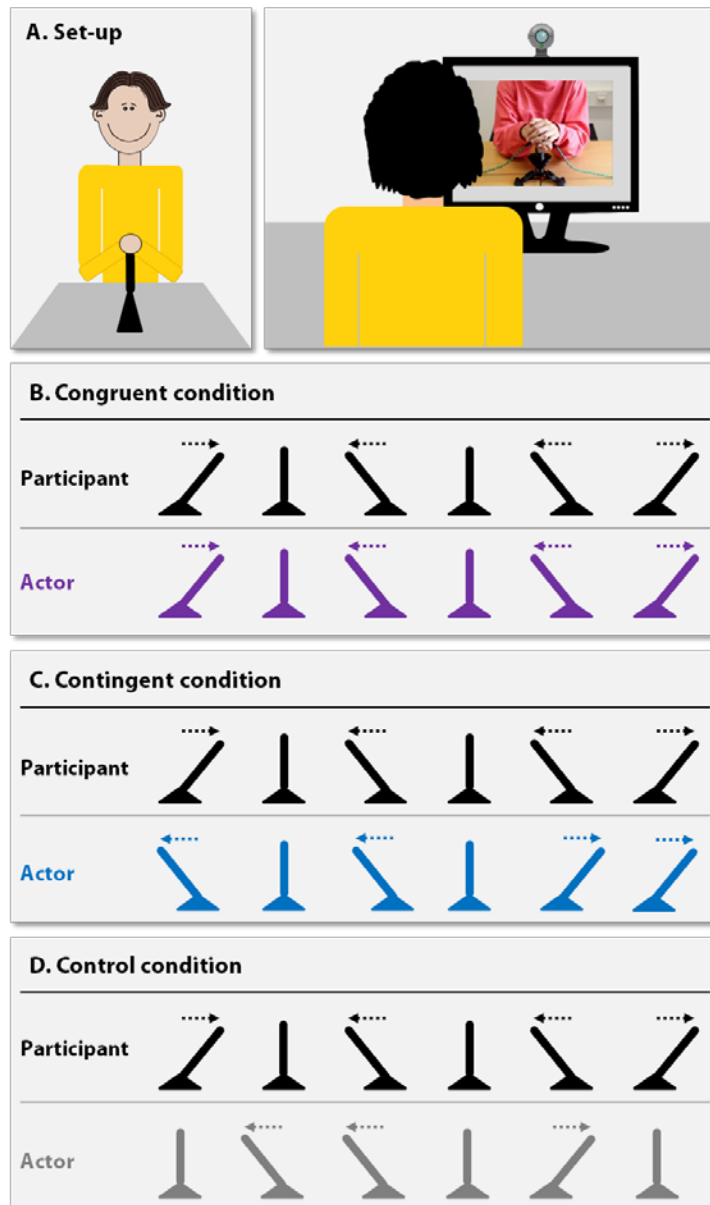
#### *Motor Task*

The Motor Task was designed as an implicit imitation manipulation in which participants were imitated by one interaction partner and not by another. During the task participants had to make spontaneous movement decisions while ostensibly interacting over a webcam connection with the two co-participants who were seemingly performing the same task. In experimental group 1 one of the feigned co-participants tended to copy the participant's movement decisions in a manner that was both spatially congruent and temporally contingent (the CONGRUENT actor, see below for details) while the other actor made movement decisions unrelated to those of the participant (the CONTROL actor). In experimental group 2 one actor made movement decisions which were temporally contingent but not spatially congruent to the participant's movement decisions (the CONTINGENT actor) while the other actor again made unrelated movement decisions (the CONTROL actor).

Participants were seated behind a joystick and a computer screen and were told to keep both hands on the joystick throughout the task (see Fig. 1). They were instructed that in each trial, they could either move the joystick to the left or right, or remain still. They were asked to decide this spontaneously, but to move or keep still the joystick about equally often across all trials.

They were told that the other two participants would perform the task simultaneously, that in each trial they would be connected over the webcam with one of them, and that the movement decision of this participant would be shown immediately after the participants' decision. After a training block in which the joystick movements were practiced, the experiment began. A trial started with a video of one of the two actors, who was, like the participant, ostensibly waiting for a movement cue. After a variable time interval of 2 to 5 s, a "GO?" text cue was projected onto a still of the last video frame, after which participants had to carry out their movement decision as quickly as possible. This was followed by a video of the ostensible movement decision of the other actor, which was selected based on the participant's joystick manipulation. In CONGRUENT trials (i.e., the experimental condition of group 1) the actor performed mostly the same movement decision: if the participant moved the joystick, in 80% of cases the actor moved it too, and in that case, with a 80% probability moved it in a spatially congruent direction, that is, the movement mirrored that of the participant, in line with evidence that automatic imitation in face-to-face orientations tends to be mirrored rather than rotational ([Avikainen et al., 2003](#); [Bavelas et al., 1988](#); [Brass et al., 2000](#); [Koski et al., 2002](#)). Similarly, in non-movement trials, the actor mostly (80%) kept the joystick still, too. We did not use a 100% imitation rate to prevent participants from noticing the manipulation, consistent with the implicit character of mimicry in naturalistic settings. The CONTINGENT actor (representing the experimental condition of group 2) also mostly (80%) moved the joystick when the participant moved it, but moved it in a spatially congruent way in only half of these cases. Thus, the movements of this actor were only temporally, not spatially, corresponding to those of the participant. In CONTROL trials (the control condition for both groups) the actor moved the joystick in 50% of the cases in which the participant moved it, and

## Motor Task



**Fig. 1. Motor Task.** (A) Experimental set-up. The participant (in yellow) was instructed to keep both hands on a joystick (right panel) and in each trial, to make a spontaneous decision to either keep the joystick still or to move it to the left or right. Participants were told that they were part of a live webcam interaction with two other participants. On each trial, a video of one of two presumed other participants was shown, who seemingly performed the same movement task. (B) Example trials for the CONGRUENT condition. Both participant's decisions whether to move the joystick or not and the movement direction (left or right) tended to be imitated by the video actor. (C) Example trials for the CONTINGENT condition. Participant's decisions whether to move the joystick or not tended to be copied by the video actor, but movement direction (left or right) was not copied. (D) Example trials for the CONTROL condition, which was used as a baseline condition in both experimental group 1 (CONGRUENT versus CONTROL) and group 2 (CONTINGENT versus CONTROL). The movements of this actor were unrelated to those of the participant, both in terms of the decision whether to move the joystick, and in which direction to move it.

if so, moved it in a congruent direction with only 50% probability; conversely, non-movement decisions were followed by a movement in 50% of the cases. For each actor, a set of ten videos per movement decision had been recorded, from which the video to be shown was randomly selected. Trials were separated by a screen with fixation cross shown for 1 s. Order of the conditions (i.e., the two actors) was pseudo-randomized across trials, omitting repetition of a condition more than twice. Each condition comprised 60 trials, amounting to 120 trials for the whole task. Duration of the Motor Task was approximately 20 minutes.

### *Social influence measure*

To test whether participants showed a tendency to assimilate their estimations more to those of the imitator than to those of the control actor we presented them with a number estimation task. Participants were shown a screen with “A” characters, of which they had to estimate the number (between 100 and 300). They were told that the player whose guess was closest to the correct number would play first in the subsequent gambling task. The participant then saw the ostensible estimations of the other two participants, which appeared successively on the screen under a screenshot of each actor, after which the participant had to enter his/her own estimation. The feigned estimations of the two actors were fixed (152 and 245); order and number estimated by each actor (imitator or control) were counterbalanced across participants and conditions. Absolute distance between the participant’s estimation and the one of each actor was used to assess social influence: a smaller distance to one actor’s estimation, as compared to the other actor’s estimation, was taken as an indication of social influence by this actor.

### *Empathy Task (monetary version)*

To assess participants’ empathic responses to pleasant and unpleasant affect experienced by their presumed co-players, they were presented with a feigned gambling task. In this task, the three players engaged in a series of gambling trials that either resulted in monetary gain or

loss. A trial started with a snapshot indicating which participant was on turn, after which two colored geometrical figures were presented. If it was their turn, participants had to select one of the figures and were then shown feedback on whether they had won or lost money in this trial. In other trials, participants saw the decisions and outcomes of their presumed co-participants.

After each trial a visual analogue scale was shown, on which participants had to indicate their affect on a continuous scale that ranged from “not at all” to “very much”. For each of the two presumed co-players, they had to indicate, in case of a loss trial 1) How unpleasant they felt the outcome was for the other player (OTHER AFFECT) and 2) How unpleasant it felt for them to witness the other players’ result (SELF AFFECT); in case of win trials, the ratings concerned pleasant affect. They also had to rate how pleasant or unpleasant their own gambling outcomes felt for them. The rating scale stayed on screen until a response was given.

The task consisted of 30 trials, corresponding to 10 trials for each presumed player. Trials were presented in a fixed order, in which Target Persons were alternated (e.g. 1-2-3-1-3-2-1-2-3) and win and loss trials were pseudorandomized, which was balanced across participants. Win and loss trials were pre-defined and did not depend on the shape or color of the figures, which were randomly selected from a set of nine. The participant won in 6 trials and lost in 4 trials, while the other players each won in 4 and lost in 6 trials. The amount of money won or lost per trial varied between €3.00 and €3.85.

#### *Prosocial Preference Task (monetary version)*

In the Prosocial Preference Task we assessed which actor was favored by the participants in a one-shot prosocial decision measure. Directly after the gambling task, participants were presented with a screen showing their own result, i.e. a total gain of €6.00, as well as the ostensible results of the two other participants (a gain of €1.00 each). On the next screen, participants were informed that they had the option to either take the €1.00 euro gain away

from one of the others participants, or to donate a part of their own gain to the others. They were then asked to indicate the total amount they would like to take away or donate by selecting one of four options: 1) take €1.00 2) donate €0.75; 3) donate €1.50; or 4) donate €3.00. After this, participants were required to indicate how their decision would affect each of the two participants. They had to choose from two options, both of which implied an unequal distribution: in one option the imitating (i.e., congruent or contingent) actor was favored (i.e. could either keep his/her gain or would receive a donation twice as high as the other actor) while in the other option the non-imitating control actor was favored.

### **Data analysis**

Data were analyzed using PASW 18.0 (SPSS Inc., Chicago, IL, USA). For each experimental group, the ratings obtained during the Monetary Empathy Task were entered into a 2 x 2 x 2 repeated measures ANOVA with factors Target Person (CONGRUENT/CONTINGENT, CONTROL), Outcome (WIN, LOSS), and Rating Scale (SELF AFFECT, OTHER AFFECT). In addition, planned paired *t* tests were applied to assess pairwise comparisons between the two Target Person conditions, separately for WIN and LOSS trials and SELF AFFECT and OTHER AFFECT ratings.

For the Prosocial Task we assessed for each participant which actor (CONGRUENT/CONTINGENT or CONTROL) was assigned the smaller amount of money (either because more money was donated to this player or because more money was taken off from the other player). For each group, we entered these values into a chi-square goodness-of-fit test to determine whether there was a preference for one actor over the other across participants. We then applied a further chi-square test to formally test whether the observed proportions differed between the two experimental groups.

The extent of social influence was quantified by calculating the absolute distance between participants' estimations and the ostensible estimations of both actors (CONGRUENT/CONTINGENT or CONTROL), and by entering these values into a paired *t*-test. To assess the significance of

observed differential effects between experimental groups, the difference scores (CONGRUENT/CONTINGENT > CONTROL) of the participants in each group were entered into a one-sided two-sample t-test.

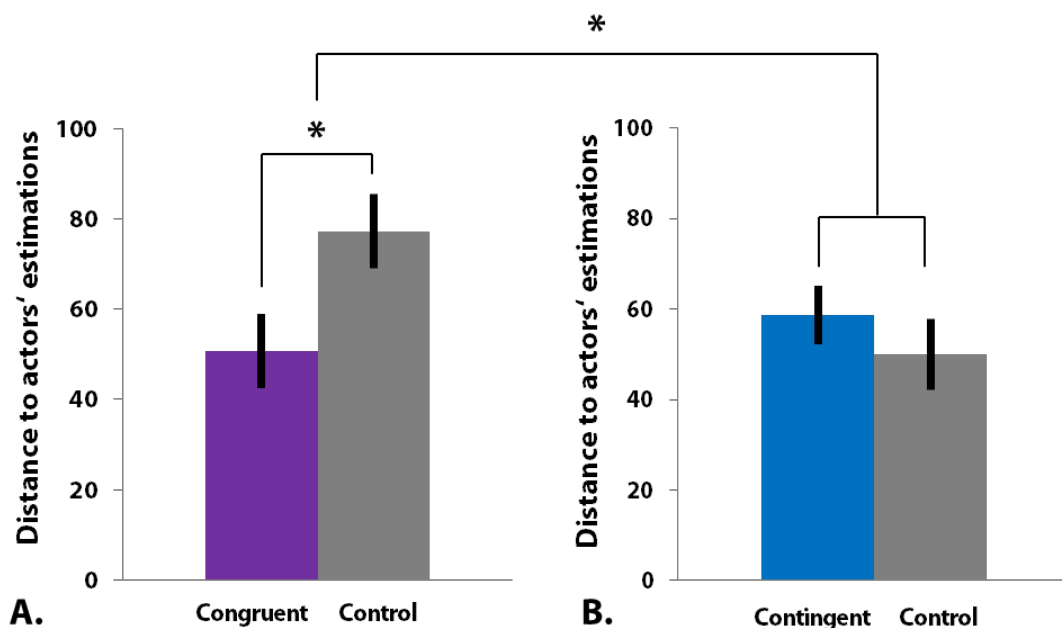
Alpha level was set to .05 for all analyses of behavioral data. Greenhouse-Geisser corrections were applied to ANOVA  $p$ -values if the assumption of homogeneity of covariances was violated (as determined by Mauchly tests of sphericity). If multiple tests were used to test the same hypothesis in the same data,  $p$ -values were Bonferroni-corrected to correct for multiple comparisons.

## RESULTS

### Social influence

The extent of social influence in the number estimation task was quantified by calculating the absolute distance between participants' estimations and the ostensible estimations of both actors (CONGRUENT/CONTINGENT or CONTROL), and by entering these values into a paired t-test. For experimental group 1 (CONGRUENT, CONTROL) we observed a significantly smaller distance to estimations of the CONGRUENT actor (mean distance ( $M$ ) = 50.7) than to those of the CONTROL actor ( $M$  = 77.3;  $t(30) = 2.13$ ;  $p = .042$ ;  $d = 0.38$ ; see Fig. 2). We did not observe any effect in experimental group 2 (CONTINGENT, CONTROL;  $t(32) = 0.73$ ;  $p = .47$ ). Testing whether the effect of imitation on social influence differed between experimental groups, by conducting a two-sample t-test on the difference scores (CONGRUENT / CONTINGENT > CONTROL) of the participants in each group, confirmed a significant groups difference ( $t(64) = 2.03$ ;  $p$  (one-sided) = .023;  $d = 0.51$ ).

## Conformity in number estimation task



**Fig. 2. Conformity in number estimation task (experiment 1).** Difference between participants' estimations and those of the two actors in the number estimation task. A smaller difference indicates more similar estimations. (A) In group 1 participants' estimations were closer to those of the CONGRUENT actor than to those of the CONTROL actor. (B) In group 2, there was no difference in how close participants' estimations were to those of the CONTINGENT and the CONTROL actor. Experimental groups significantly differed as to whether participants conformed more to the imitating actor than to the control actor.

### Empathy ratings

VAS ratings obtained during the Monetary Empathy Task were recoded (with 1 representing the lower extreme and 5 representing the upper extreme) and for each experimental group entered into a 2 x 2 x 2 repeated-measures ANOVA with factors Target Person (CONGRUENT/CONTINGENT, CONTROL), Outcome (WIN, LOSS), and Rating Scale (SELF AFFECT, OTHER AFFECT). For experimental group 1 (CONGRUENT versus CONTROL) this revealed main effects of Rating Scale ( $M_{\text{SELF}} = 3.03$ ;  $M_{\text{OTHER}} = 3.96$ ;  $F(1,30) = 27.7$ ;  $p < .001$ ;  $\eta_p^2 = .48$ ) and Outcome ( $M_{\text{WIN}} = 3.78$ ;  $M_{\text{LOSS}} = 3.20$ ;  $F(1,30) = 27.3$ ;  $p < .001$ ;  $\eta_p^2 = .48$ ), but no main effect of Target Person ( $F(1,30) = 0.21$ ;  $p = .65$ ). We furthermore found a Target Person x Rating Scale

interaction ( $F(2,30) = 4.84; p = .036; \eta_p^2 = .14$ ); this effect was driven by a smaller discrepancy between self-related and other-related affect ratings involving the congruent person ( $M_{\text{SELF,CONGRUENT}} = 3.08, M_{\text{OTHER,CONGRUENT}} = 3.93$ ) compared to the control person ( $M_{\text{SELF,CONTROL}} = 2.98, M_{\text{OTHER,CONTROL}} = 3.98$ ). Planned pairwise comparisons between CONGRUENT and CONTROL for each specific combination of Rating Scale and Outcome separately did not reveal any significant effects (all  $p \geq .16$ ).

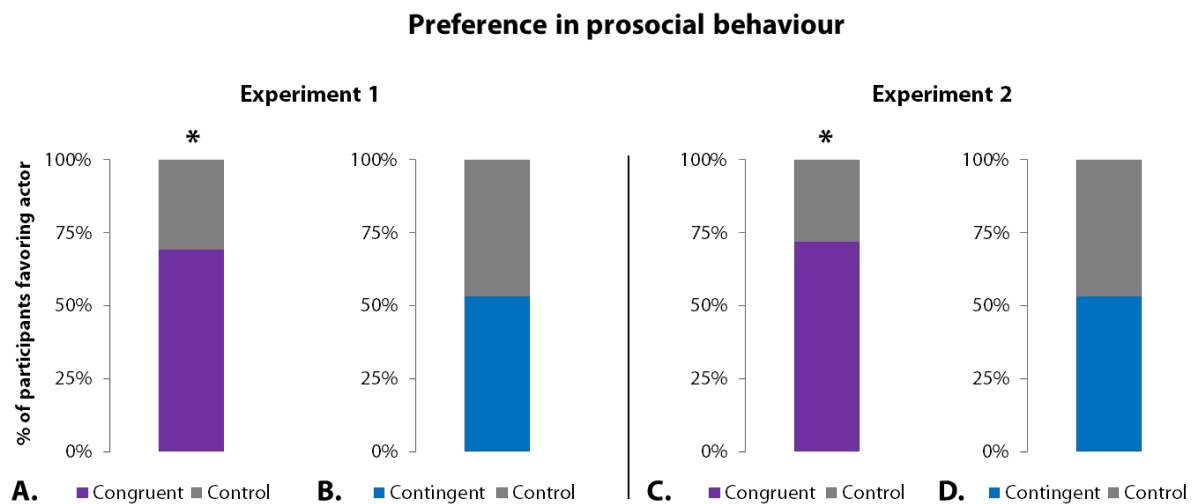
For experimental group 2 (CONTINGENT versus CONTROL) we also found main effects of Rating Scale ( $M_{\text{SELF}} = 2.95; M_{\text{OTHER}} = 3.93; F(1,32) = 25.8; p < .001; \eta_p^2 = .45$ ) and Outcome ( $M_{\text{WIN}} = 3.77; M_{\text{LOSS}} = 3.11; F(1,32) = 23.0; p < .001; \eta_p^2 = .42$ ), but no main effect of Target Person ( $p = .46$ ), nor any significant interactions (all  $p \geq .13$ ). Pairwise comparisons between CONTINGENT and CONTROL for each specific combination of AFFECT and OUTCOME did not yield any significant effects (all  $p \geq .094$ ).

### **Preference in prosocial behavior**

In experimental group 1 (CONGRUENT versus CONTROL) the CONGRUENT actor was favored in the prosocial decision measure by significantly more participants (69%) than the CONTROL actor ( $\chi^2(1, N=29) = 4.17; p = .041; \phi = .38$ ); see Fig. 3 A. To examine this result in more detail, we splitted our sample according to whether participants decided prosocially (i.e., donated money, 55% of participants) or egoistically (i.e., took away money from one of the other participants). Applying chi-square tests to these sub samples revealed that the tendency to favor the CONGRUENT actor was only present in the prosocial sub sample (i.e. by 81% of this sample;  $\chi^2(1, N=16) = 6.25; p = .012; \phi = .63$ ) and not in the egoistic sub sample (i.e. by 54%;  $\chi^2(1, N=13) = 0.08; p = .78$ ). However, the difference in preference between these sub samples did not reach significance ( $\chi^2(1, N=29) = 2.52; p = .11$ ).

In contrast to experimental group 1, group 2 (CONTINGENT versus CONTROL) did not show a preference for one of the actors over the other (52% preference for the CONTINGENT actor;

$\chi^2(1, N=33) = 0.03; p = .86$ ); see Fig. 3 B. Although experimental group 1 showed a clear preference for the CONGRUENT actor whereas experimental group 2 did not show a preference for the CONTINGENT actor, post-hoc formal testing of the disparity in preference between experimental groups did not yield a significant group difference ( $\chi^2(1, N=62) = 1.95; p = .16$ ).



**Fig. 3. Preference in prosocial behavior for the imitating or control actor.** (A) Percentage of participants favoring the CONGRUENT versus the CONTROL actor in distributing monetary gains in experiment 1. The CONGRUENT actor is favored significantly more often over the CONTROL actor than vice versa. (B) Participants do not favor the CONTINGENT actor over the CONTROL actor in distributing monetary gains. (C) In decision about how to distribute a series of painful shocks (experiment 2), participants favor the CONGRUENT actor significantly more often over the CONTROL actor than vice versa. (D) Participants do not favor the CONTINGENT actor over the CONTROL actor in distributing painful shocks. Across the two experiments (data pooled), participants favored the CONGRUENT actor significantly more often than the CONTINGENT actor.

## DISCUSSION

In Experiment 1 we showed that participants who have been imitated by an actor who copied their movements in a bodily congruent manner respond differently to this person in subsequent social behavior. First, participants adapted their responses in a number estimation task more to standards set by this person than to those set by a non-imitating control person, indicating that they were more prone to social influence by the congruent imitator. We did not find such a conformity effect for the actor who copied the movements of participants in a merely temporally contingent way, suggesting that bodily congruent, but not temporally contingent, imitation increases participants' social identification with the imitator.

In addition, participants favored the bodily congruent imitator over the control actor in a subsequent monetary donation decision, while the contingent actor did not evoke such a preference. This suggests that movement similarity is necessary for the prosocial effects of imitation to occur, while a predictive temporal relationship between one's own and the imitator's movements is in itself not sufficient for such effects. However, the difference in preference between experimental groups did not reach significance when we formally tested it, which might be due to the use of a dichotomous measure along with the small size of our sample. This prevented us from drawing strong conclusions from this finding and prompted us to replicate the effect in a further experiment.

We did not find any effects of movement congruency or temporal contingency on the intensity of self-reported empathy in response to gains and losses experienced by the actors in a gambling game. Although we did find that self- and other-related affect tended to be more similar in response to congruent imitators than control actors, which might suggest that imitation causes representations of one's own and the other's affective state to become merged or confused to a greater extent, overall our data suggest that empathic responses to imitators were not experienced as more intense than to non-imitators. Yet, it is possible that such responses require a more salient aversive affective state than is induced by winning or losing a small monetary amount. In addition, explicit self-reports may lack the sensitivity to pick up on subtle

or implicit changes in empathic responses. To overcome these limitations, we decided to carry out a second experiment. In this experiment, we used the same imitation paradigm, but assessed participants' empathic responses with an empathy for pain paradigm. In addition to collecting self-reports of empathy, we also acquired several psychophysiological measures as physiological indices of empathic responding.

## Experiment 2

### METHOD

#### Participants

We analyzed data from 64 healthy right-handed volunteers (36 female, 28 male, age  $25.1 \pm 4.6$  years, mean  $\pm$  standard deviation). Data from 9 further participants (age  $28.2 \pm 3.8$ ) had to be discarded due to technical problems during data collection. Participants were pseudo-randomly assigned to one of two experimental groups: the CONGRUENT group or the CONTINGENT group. This resulted in a final sample of 32 participants (18 female, 14 male) per experimental group. During analysis of the psychophysiological measures, data from a number of further participants had to be excluded due to missing data or poor raw data quality. This resulted in a sample of 57 skin conductance datasets (29 in the CONGRUENT and 28 in the CONTINGENT group), 57 startle datasets (30 in the CONGRUENT and 27 in the CONTINGENT group), and 52 corrugator datasets (27 in the CONGRUENT and 25 in the CONTINGENT group).

All participants had normal or corrected-to-normal vision, and gave written informed consent before participating. Participants were paid €15,00 for their participation. The study was performed in accordance with the Declaration of Helsinki and the experiment, including the procedure for pain administration, was approved by the Ethics Committee of the University of Vienna.

## **Experimental procedures and design**

Experiment 2 consisted of four consecutive tasks. As in Experiment 1, the procedure started with the Motor Task (I), which was carried out according to the same procedures and cover story as described for Experiment 1. The Motor Task was followed by the Empathy for Pain Task (II) and the Prosocial Preference Task (III), after which a short Affiliation rating scale was administered (IV). As in Experiment 1, participants were led to believe that they took part in a live webcam-based interaction with two other participants throughout the experiment.

### ***Tasks***

#### *Empathy for Pain Task*

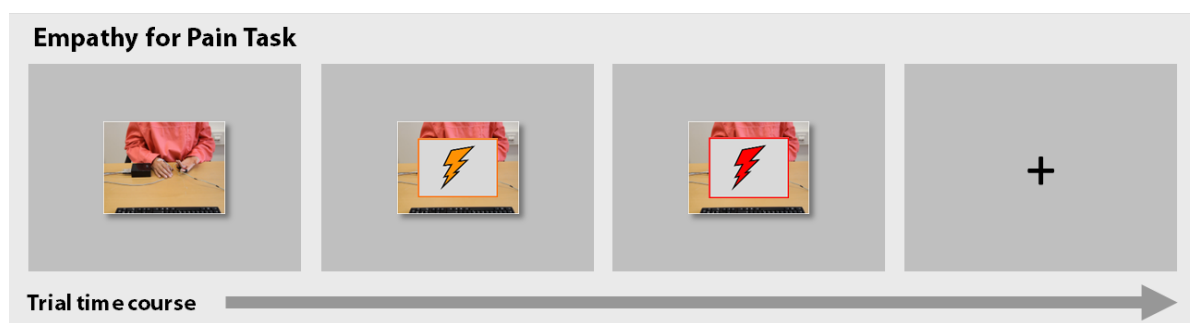
In the Empathy for Pain Task, both the participants and their presumed co-participants received a number of painful and non-painful electrodermal stimulation trains applied via electrodes to the hand. Behavioral ratings and psychophysiological recordings were acquired as indices of empathy for the alleged co-participants' pain.

Before start of the task, we assessed participants' individual detection and pain thresholds in a calibration procedure. Stimulation was delivered using a Digitimer DS5 Isolated Bipolar Constant Current Stimulator (Digitimer Clinical and Biomedical Research Instruments) via a concentric surface electrode with 7 mm diameter and a platinum pin (WASP electrode, Specialty Developments) attached to the back of the left hand using adhesive plaster. This set-up was motivated by previous empathy studies using a similar paradigm ([Hein et al., 2010](#); [Majdandžić et al., 2016](#); [Rütgen et al., 2015a](#); [Singer et al., 2004](#)), with one stimulation train lasting 1500 ms. During the calibration procedure the stimulation intensity was gradually increased to a level that participants reliably indicated as either "clearly detectable but not unpleasant" (threshold for non-painful stimulations) or "very painful but tolerable over multiple trials" (threshold for painful stimulations).

The paradigm was structured as a 3 x 2 factorial design with factors Target Person (SELF, CONGRUENT or CONTINGENT, CONTROL) and Stimulation Type (PAINFUL, NON-PAINFUL). In 50% of the trials, a startle stimulus was presented; these trials were included in the analysis of startle blink response, while the remaining 50% of trials was included in analysis of skin conductance response and corrugator supercilii activity. The task was divided into four blocks: two blocks with painful stimulation and two blocks with non-painful stimulation. Painful and non-painful blocks were alternated, their order being counterbalanced across participants. Each block consisted of 6 stimulation trials per Target Person, resulting in 18 stimulation trials per block, and a total number of 72 trials. Order of the conditions within a block was pseudo-randomized, omitting repetition of a target person in consecutive trials.

The task was preceded by detailed on-screen instructions and presentation of two probe trials without stimulation to familiarize participants with the paradigm. Participants were also presented five times with the startle stimulus, an acoustic 104 dB 50 ms white noise burst, delivered via headphones. This was done to prevent habituation effects from occurring during the task. At the start of each block it was indicated whether the block would consist of painful or non-painful stimulation trials. A trial started with the presentation of a video clip of the person who would receive stimulation (see Fig. 4). As in the motor task, only the upper body and the hands were shown. In case of a SELF trial a schematic depiction of a yellow player was shown. After a variable duration of 2000 – 3000 ms a lightning symbol was projected onto a still of the last video frame or picture, to indicate that the stimulation would start in 1 s (the anticipation cue). The color of this symbol depended on the condition, and was blue for non-painful and orange for painful stimulation trials. After 1000 ms the color of the lightning symbol changed to green (for non-painful stimulation) or red (for painful stimulation), to indicate that stimulation was applied. The symbol stayed on screen for 1500 ms, corresponding to stimulation duration. In case of a startle trial, the startle stimulus was presented after 750 ms. After stimulation the lightning symbol and picture disappeared and a grey screen with fixation cross was shown for a variable duration of 5 – 9 s (in case the preceding trial did not contain a startle stimulus) or

16 – 24 s (in case the preceding trial contained a startle stimulus, to allow SCR to return to baseline). After each block a visual analogue scale was shown, on which participants had to indicate their affect during the preceding block on a continuous scale that ranged from “not at all” to “very much”. For each of the two presumed co-players, they had to indicate 1) How unpleasant they felt the stimulation had been for the other person; 2) How unpleasant it had been for them to witness the other’s stimulation trials 3) How disturbed they had felt during watching the stimulation (as a measure of personal distress, [Batson et al., 1981](#)), and 4) How compassionate they had felt during watching the stimulation (as a measure of empathic concern). They also had to rate how unpleasant their own stimulation trials had been for them. The rating scale stayed on screen until a response was given. Duration of the whole task was approximately 32 minutes, depending on individual rating durations.



**Fig. 4. Empathy for Pain Task (experiment 2).** Timecourse of a trial with painful stimulation involving one of the video actors. After a video showing the actor waiting for stimulation (first panel), an anticipation cue was projected onto the video for 1000 ms, followed by a stimulation cue for 1500 ms (third panel) to indicate that stimulation was being applied. Trials were separated by a screen with fixation cross.

#### *Prosocial Preference Task (pain version)*

In the Prosocial Task we assessed participants’ preference in prosocial behavior for one of the two actors using a one-shot decision measure. The task was preceded by a feigned gambling task. Participants were told that all three participants would receive a further series of

maximally 12 painful stimulations, but that each participant could reduce this number with his or her performance on the gambling task. A trial started with a snapshot indicating which participant was on turn, after which two colored geometrical figures were presented. If it was their turn, participants had to select one of the figures and were then shown feedback on whether they had won or lost this trial. In other trials, participants saw the decisions and feedback of their presumed co-participants. The task consisted of 36 trials, corresponding to 12 trials for each presumed player. Trial order was pseudo-randomized and balanced across participants. Win and loss trials were pre-defined and did not depend on the shape or color of the figures, which were randomly selected from a set of nine.

Directly after the task, participants were presented with a screen showing their own result (6 win trials, resulting in 6 further painful stimulations) as well as the ostensible results of the two other participants (2 win trials each, resulting in 10 further painful stimulations). On the next screen, participants were informed that they could influence the number of painful stimulations that they and the other participants would receive, either by taking over some painful stimulations from the other participants, or by passing on some of their own stimulations to the other participants. They were asked to indicate the total number of shocks they would like to take over or pass on by selecting one of five options: 1) pass on 3 shocks; 2) pass on 1 shock; 3) take over 1 shock; 4) take over 3 shocks; and 5) take over 6 shocks. After their choice, participants were required to choose how to distribute this change in number of shocks over the two other participants. They had to choose from two options, both of which implied an unequal distribution: in one option the congruent or contingent actor was favored (i.e. this actor would receive a lower number of painful stimulations than the other actor) while in the other option the control actor was favored.

After participants' decision, the ensuing number of painful stimulations was applied to the three participants according to the same procedure as in the Empathy for Pain Task, distributed over two blocks. We did not record behavioral or psychophysiological data during this task.

### *Affiliative ratings*

At the end of the experiment, we presented participants with a brief rating task, in order to examine the effects of our manipulation on explicit measures of affiliation and interpersonal closeness (Majdandžić et al., 2016). Participants were presented with a photo of each co-participant, showing this person's upper body, as in the Motor Task. Using a on a continuous scale that ranged from "not at all" to "very much", they had to rate them on the following attributes: (1) "How likable do you find this person?"; (2) "How connected do you feel to this person?"; (3) "How similar do you find this person to yourself?"; (4) "How cooperative do you find this person?"; and (5) "How familiar does this person seem to you?". Order of the to-be-rated person and of the items was randomized across participants. After the rating task participants were debriefed and thanked for their participation.

### **Analysis of behavioral data**

For each experimental group, the ratings obtained during the Empathy Task were entered into a 2 x 2 x 4 repeated measures ANOVA with factors Target Person (CONGRUENT or CONTINGENT, CONTROL), Stimulation Type (PAINFUL, NON-PAINFUL), and Rating Scale (UNPLEASANTNESS OTHER, UNPLEASANTNESS SELF, EMPATHIC CONCERN, PERSONAL DISTRESS). If applicable, post-hoc paired *t* tests were applied to assess specific effects in more detail. The explicit affiliation and interpersonal closeness ratings of the Target Persons were entered into a 2 x 5 repeated measures ANOVA with factors Target Person (CONGRUENT or CONTINGENT, CONTROL) and Scale (LIKABILITY, CONNECTEDNESS, SIMILARITY, COOPERATIVENESS, FAMILIARITY); specific effects were assessed with paired *t* tests. To assess the significance of any observed differential effects between experimental groups, difference scores (CONGRUENT/CONTINGENT > CONTROL) of the participants in each group were entered into one-sided two-sample *t*-tests. Furthermore, we calculated difference scores for the empathy and affiliative ratings, by subtracting the values for the

CONTROL Target Person from those of the CONGRUENT or CONTINGENT Target Person. The size of these difference scores was used as a measure of the extent to which the imitating person was favored over the control person, which we used in correlation analyses. Correlation analyses were performed using Spearman's rank correlation coefficient ( $r_s$ ) due to the ordinal scaling of the data.

For the Prosocial Task we obtained for each participant the actor (CONGRUENT/CONTINGENT or CONTROL) that was assigned the lowest number of painful shocks. For each group, we entered these values into a chi-square goodness-of-fit test to determine whether there was a preference for one actor over the other across participants. We then applied a further chi-square test to formally test whether the observed proportions differed between the two experimental groups.

Alpha level was set to .05 for all analyses of behavioral data. Greenhouse-Geisser corrections were applied to ANOVA  $p$ -values if the assumption of homogeneity of covariances was violated (as determined by Mauchly tests of sphericity). If multiple tests were used to test the same hypothesis in the same data,  $p$ -values were Bonferroni-corrected to correct for multiple comparisons.

## **Psychophysiological recording and analysis**

### ***Skin conductance response (SCR)***

For recording of SCR during the Empathy Task, two Ag/AgCl Easy Cap skin conductance electrodes were applied to the middle phalanx of the index and ring finger of participants' non-dominant hand. Before application participants cleansed their hands with water and soap. Data were sampled with 2048 Hz and stored on hard drive.

Data were analyzed using Ledalab (Benedek and Kaernbach, 2010). The raw data were downsampled to 128 Hz before Continuous Decomposition Analysis (CDA) was applied. CDA allows decomposition of SC data into continuous signals of phasic and tonic activity by modeling signal characteristics of the sudomotor response. While the tonic component represents the basic SC level, the phasic component represent event-related SC responses, with higher levels corresponding to higher sympathetic arousal. Data in a time window of 2-5 s after onset of the anticipation cue were used for CDA. This resulted in a series of SCR values based on the integral of the phasic driver over the response window. Given the log-normal distribution of the data, data were log<sub>10</sub> transformed to correct for skewed data distribution; zero values were accounted for by adding a small constant (a random value between 1 and 10% of the smallest non-zero value) to all zero data points.

For each experimental group, the resulting values were entered into a 3 x 2 repeated-measures ANOVA with factors Target Person (SELF, CONGRUENT/CONTINGENT, CONTROL) and Stimulation Type (PAINFUL, NON-PAINFUL). Post-hoc paired *t* tests were applied to assess single effects in more detail. More precisely, since we were specifically interested in the effects of congruency and contingency on empathy for pain, we compared, for each experimental group, responses to painful stimulation of the CONGRUENT or CONTINGENT actor and the CONTROL actor. To assess the significance of any observed differential effects between experimental groups, difference scores (CONGRUENT/CONTINGENT > CONTROL) of the participants in each group were entered into a one-sided two-sample *t*-test.

### ***Corrugator supercilii muscle activity***

For facial EMG recordings two Ag/AgCl electrodes (4mm surface) were applied over the M. corrugator supercilii region of the left side of the face in a bipolar fashion (Fridlund and Cacioppo, 1986). An electrode on the right mastoid served as ground. Before application skin

was rubbed with abrasive gel (Nu-Prep) and cleansed with alcohol to reduce impedances below 5 kOhm. EMG data were sampled with 2048 Hz and saved to hard disk.

Before analysis EMG data were filtered with a 20 Hz low pass filter to reduce blink artefacts (van Boxtel, 2001), a 500 Hz high pass filter, and a 50-Hz notch filter to reduce powerline artifacts. Visual inspection of the data showed that the pain stimulation caused technical artifacts in the facial EMG data. Thus, trials in which the participants received pain stimulation themselves were omitted from the analyses. The remaining data were full wave rectified, smoothed with a 125 ms moving average filter, and transformed into z-scores within participants (Bush et al., 1993; Winkielman and Cacioppo, 2001). Changes of EMG activations were calculated separately for each trial, by using a 50-ms baseline before the critical time interval, and then averaging the data over seven consecutive 500-ms time bins (from trial onset, i.e. onset of the stimulation anticipation cue, to 500 ms after stimulation offset). All processing steps were carried out with Matlab 8.1 (MathWorks, Inc, USA) and EEGLab Toolbox (Delorme and Makeig, 2004).

For each participant, EMG data per condition were averaged across trials to obtain a single value for each condition. These values were then subjected to a  $2 \times 2 \times 7$  repeated measures ANOVA with within-subjects factors Target Person (CONGRUENT or CONTINGENT, CONTROL), Stimulation Type (PAINFUL, NON-PAINFUL) and time interval (1-7). If applicable, post-hoc paired *t* tests were applied to assess specific effects in more detail. In case of observed differential effects between experimental groups, significance was tested by entering the difference scores (CONGRUENT/CONTINGENT > CONTROL) of the participants in each group into a one-sided two-sample *t*-test.

### ***Startle blink magnitude***

Electrodes for the startle response (two Ag/AgCl electrodes, 4 mm surface) were attached over the lower orbital portion of the *M. orbicularis oculi* (Blumenthal et al., 2005). Startle responses were sampled with 2048 Hz and filtered offline with a 20Hz high pass filter.

Trial-by-trial peak amplitudes were extracted from a 200-ms time window (121-320 ms after startle tone onset). A reference window of 20 ms (0-20 ms from startle tone onset) was used as a baseline. Peaks were defined as values with amplitudes exceeding three standard deviations from mean baseline value and occurring no later than 95 ms after onset. Mean baseline value was then extracted from the peak amplitude to obtain baseline-corrected peak values. Trials without a startle response were omitted from analysis. Non-responders, defined as participants with less than three startle responses per condition, were excluded from the sample. For each participant, the trial-by-trial values were outlier-corrected by winsorizing, i.e. by replacing values larger than the upper quartile plus 1.5 times the interquartile range, or smaller than the lower quartile minus 1.5 times the interquartile range, by the largest or smallest remaining values. Values were then T-transformed to each participant's mean to account for the notoriously large individual differences in absolute blink magnitude and variance (Blumenthal et al., 2005).

For each participant the mean response amplitude per condition was calculated. The resulting values were then, separately for each experimental group, entered into a 2 x 2 repeated measures ANOVA with factors Target Person (CONGRUENT/CONTINGENT, CONTROL) and Stimulation Type (PAINFUL, NON-PAINFUL). If applicable, post-hoc paired *t* tests were applied to assess specific effects in more detail. In case of observed differential effects between experimental groups, significance was tested by entering the difference scores (CONGRUENT/CONTINGENT > CONTROL) of the participants in each group into a one-sided two-sample *t*-test.

## RESULTS

### *Empathy Task*

#### **Empathy ratings**

To test for effects of our imitation manipulation on empathy ratings, empathy ratings for both groups were entered into a 2 x 2 x 4 repeated measures ANOVA with factors Target Person (CONGRUENT/CONTINGENT, CONTROL), Stimulation Type (PAINFUL, NON-PAINFUL), and Rating Scale (UNPLEASANTNESS OTHER, UNPLEASANTNESS SELF, EMPATHIC CONCERN, PERSONAL DISTRESS). For experimental group 1 (CONGRUENT versus CONTROL) we found, as can be expected, a main effect of Stimulation Type ( $F(1,31) = 48.1; p < .001; \eta_p^2 = .61$ ), with higher ratings on painful than non-painful trials ( $M_{\text{PAINFUL}} = 2.42; M_{\text{NON-PAINFUL}} = 1.56$ ) and a main effect of Rating Scale ( $F(1,31) = 6.41; p = .001; \eta_p^2 = .17$ ), but no main effect of Target Person ( $p = .17$ ). We furthermore found a Stimulation Type x Rating Scale interaction ( $F(1,13) = 23.6; p < .001; \eta_p^2 = .51$ ) but no other significant interactions (all  $p \geq .26$ ). Since for each target person the ratings for painful trials on the different scales were highly correlated (all  $r_s$  between .70 and .95; all  $p < .001$ ), we subsequently combined the ratings for painful trials into one pain measure. From this we calculated, for each participant, a difference value (CONGRUENT > CONTROL) in empathy for pain ratings and used this for post-hoc correlation analyses.

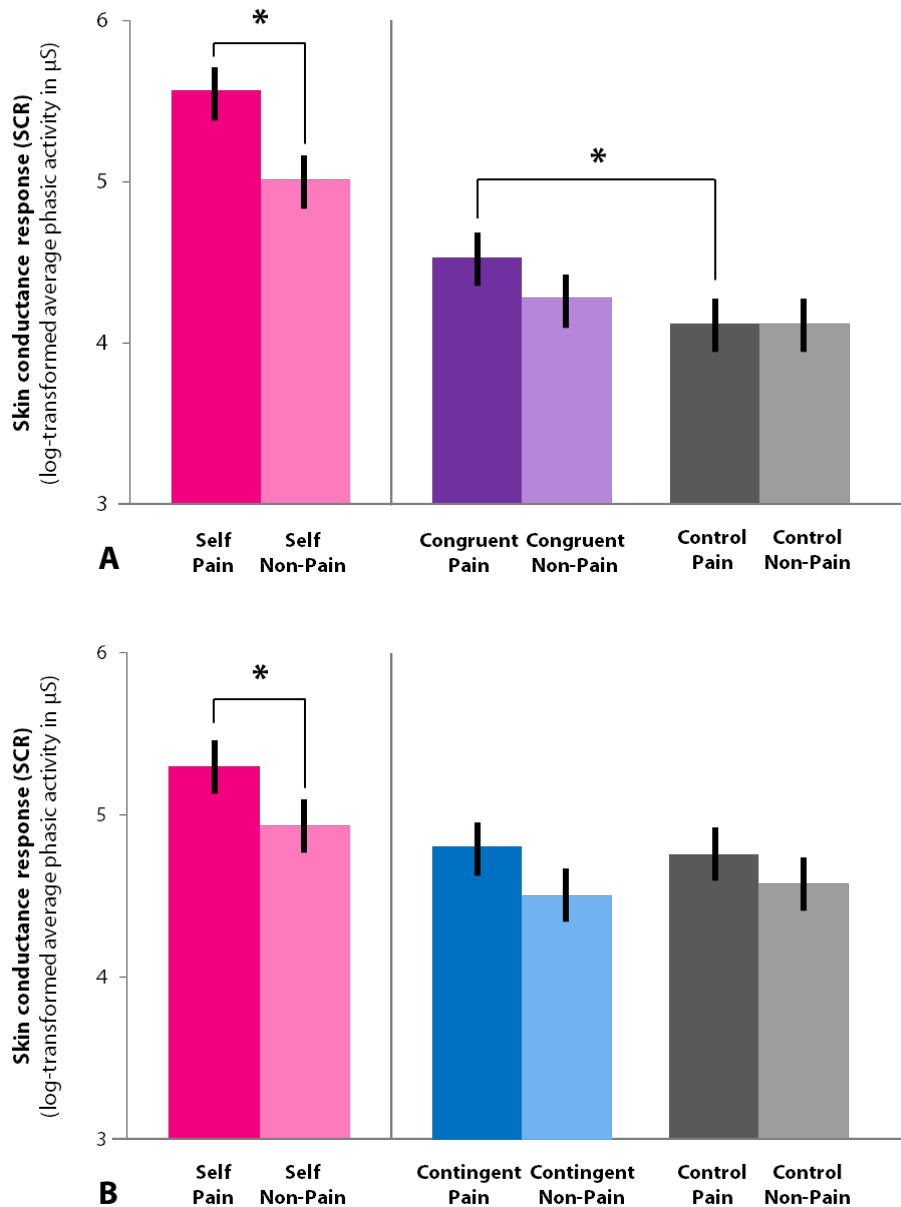
For experimental group 2 (CONTINGENT versus CONTROL) we observed a main effect of Stimulation Type ( $F(1,31) = 78.6; p < .001; \eta_p^2 = .72$ ) and Rating Scale ( $F(1,31) = 6.55; p < .001; \eta_p^2 = .17$ ), but no main effect of Target Person ( $p = .99$ ); we furthermore observed a Stimulation Type x Rating Scale interaction ( $F(2,31) = 26.4; p < .001; \eta_p^2 = .46$ ) but no other significant interactions (all  $p \geq .20$ ).

## Psychophysiological measures

### *Skin conductance response*

For each experimental group skin conductance data were entered into a 3 x 2 repeated-measures ANOVA with factors Target Person (SELF, CONGRUENT/CONTINGENT, CONTROL) and Stimulation Type (PAINFUL, NON-PAINFUL). For experimental group 1 (CONGRUENT versus CONTROL) we found a main effect of Stimulation Type ( $F(1,28) = 6.00$ ;  $p = .021$ ;  $\eta_p^2 = .018$ ), with higher SCR values for painful ( $M = 4.73$ ) than non-painful ( $M = 4.46$ ) trials. This confirmed that skin conductance response was sensitive to the aversiveness of the stimulation, with painful trials eliciting a stronger response. We also found a main effect of Target Person ( $F(2,28) = 40.4$ ;  $p < .001$ ;  $\eta_p^2 = .59$ ) and a trend Stimulation Type x Target Person interaction ( $F(2,31) = 2.73$ ;  $p = .074$ ;  $\eta_p^2 = .09$ ). Post-hoc testing showed that overall, SCR was highest to SELF stimulation trials ( $M = 5.29$ ), which significantly differed from SCR during stimulation of the CONGRUENT ( $M = 4.39$ ;  $F(1,28) = 61.8$ ;  $p < .001$ ;  $\eta_p^2 = .69$ ) and the CONTROL person ( $M = 4.11$ ;  $F(1,28) = 61.9$ ;  $p < .001$ ;  $\eta_p^2 = .69$ ); this is in line with the presumption that self-related stimulation evokes the strongest autonomic arousal. Finally, a planned pairwise comparison between painful trials involving the CONGRUENT and CONTROL person showed that SCR to painful stimulation was higher for the CONGRUENT ( $M = 4.52$ ) than the CONTROL ( $M = 4.11$ ) target person ( $t(28) = 2.33$ ;  $p = .028$ ;  $d = 0.43$ ). Results are shown in Fig. 5A.

## Skin conductance response during hand stimulation



**Fig. 5. Skin conductance response (SCR) during painful and non-painful electrodermal stimulation (experiment 2).** Log-transformed average phasic activity in  $\mu\text{S}$  in a time window of 2-5 seconds after onset of the anticipation cue. SCR in trials in which participant received stimulation themselves are shown on the left for reference. (A) Group 1: SCR in response to painful stimulation of the CONGRUENT actor was significantly higher than during painful stimulation of the CONTROL actor. (B) Group 2: SCR in response to painful stimulation of the CONTINGENT actor did not differ from response during painful stimulation of the CONTROL actor.

For experimental group 2 (CONTINGENT versus CONTROL) we also found main effects of Stimulation Type ( $F(1,27) = 15.0$ ;  $p = .001$ ;  $\eta_p^2 = .36$ ) and of Target Person ( $F(2,27) = 22.1$ ;  $p < .001$ ;  $\eta_p^2 = .45$ ), but no interaction effect ( $p = .191$ ). In this group too, painful stimulation trials evoked a stronger SCR ( $M_{\text{PAINFUL}} = 4.96$ ;  $M_{\text{NON-PAINFUL}} = 4.67$ ), and overall, SELF trials elicited a stronger SCR ( $M = 5.12$ ) than CONTINGENT ( $M = 4.65$ ;  $F(1,27) = 42.2$ ;  $p < .001$ ;  $\eta_p^2 = .61$ ) or CONTROL trials ( $M = 4.67$ ;  $F(1,27) = 19.5$ ;  $p < .001$ ;  $\eta_p^2 = .42$ ), confirming that our manipulation was effective. A planned paired  $t$  test to test for differences in SCR during painful trials involving the CONTINGENT versus CONTROL person, did not yield an effect ( $p = .41$ ) – see Fig. 5B.. Thus, painful trials involving the CONTINGENT person did not evoke stronger SCR than those involving the CONTROL person.

We then formally tested whether the effect in experimental group 1 was indeed stronger than in experimental group 2, by entering the difference values per participant (CONGRUENT > CONTROL and CONTINGENT > CONTROL) between the groups into a one-sided two-sample  $t$  test. This confirmed that painful stimulation of the CONGRUENT actor evoked a stronger SCR than painful stimulation of the CONTINGENT actor, with respect to a non-imitating CONTROL actor ( $t(55) = 1.92$ ;  $p$  (one-sided) = .030;  $d = 0.51$ ).

#### *Corrugator supercilii muscle activity*

For both groups, individual EMG corrugator supercilii muscle activity values were entered into a  $2 \times 2 \times 7$  repeated measures ANOVA with within-subjects factors Target Person (CONGRUENT/CONTINGENT, CONTROL), Stimulation Type (PAINFUL, NON-PAINFUL) and Time Interval (1-7). For experimental group 1 (CONGRUENT versus CONTROL) we found a main effect of Time Interval ( $F(6,26) = 2.87$ ;  $p = .049$ ;  $\eta_p^2 = .40$ ), but no main effects of Stimulation Type or Target Person (all  $p \geq .128$ ), nor any interaction effects between these factors (all  $p \geq .32$ ). For experimental group 2 (CONTINGENT versus CONTROL) we also found a main effect of Time Interval ( $F(6,24) = 3.24$ ;  $p = .022$ ;  $\eta_p^2 = .61$ ), but no main effects of Stimulation Type or Target Person

(all  $p \geq .22$ ). We also did not find any interaction effects in this group (all  $p > .21$ ). Thus, for both groups, our imitation manipulation did not have an effect on corrugator activity during trials in which the two actors received electrodermal stimulation.

#### *Startle blink magnitude*

Startle blink magnitude values were entered, for each group, into a 2 x 2 repeated measures ANOVA with factors Target Person (CONGRUENT/CONTINGENT, CONTROL) and Stimulation Type (PAINFUL, NON-PAINFUL). For group 1 (CONGRUENT versus CONTROL) we did not find any main effects or interaction effects (all  $p \geq .794$ ). Applying the same analysis to group 2 (CONTINGENT versus CONTROL) did not yield any main effects or interaction effects either (all  $p \geq .102$ ). Taken together, we did not find any effects of our imitation manipulation on startle blink magnitude during electrodermal stimulation of the two actors.

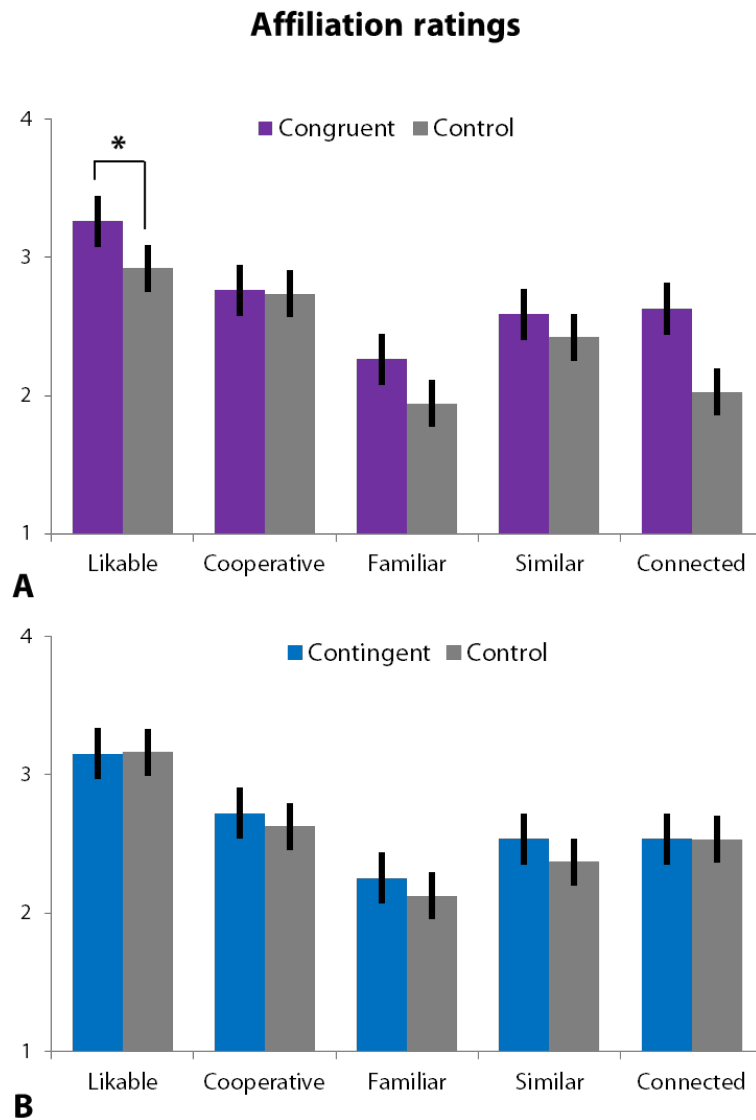
#### ***Preference in prosocial behavior***

In experimental group 1 (CONGRUENT versus CONTROL) the CONGRUENT actor was favored in the prosocial decision measure by significantly more participants (72%) than the CONTROL actor ( $\chi^2(1, N=32) = 6.13$ ;  $p = .013$ ;  $\phi = .44$ ; see Fig. 3C). We did not find such a difference group 2 (CONTINGENT versus CONTROL), where 53% of participants favored the CONTINGENT actor over the CONTROL actor ( $\chi^2(1, N=32) = 0.13$ ;  $p = .73$ ; see Fig. 3D). Although we thus found an effect in group 1 and no effect in group 2, formal testing did not reveal a significant difference in preference between experimental groups ( $\chi^2(1, N=64) = 2.40$ ;  $p = .12$ ). However, when we combined the samples from both studies we did find a significant group difference in preference, with the experimental groups in the CONGRUENT versus CONTROL manipulation showing a stronger preference for the imitating actor than the CONTINGENT versus CONTROL groups, although the effect size was modest ( $\chi^2(1, N=126) = 4.38$ ;  $p = .036$ ;  $\phi = .18$ ).

As in Study 1, we then explored whether this preference for the CONGRUENT actor in group 1 was confined to participants who decided prosocially, rather than egoistically. Like in study 1, sample splitting revealed that prosocially deciding participants favored the CONGRUENT actor more often (75%) than the CONTROL actor ( $\chi^2(1, N=20) = 5.00; p = .025; \phi = .50$ ), but that egoistic deciders did not favor the CONGRUENT actor more often (67%) than the CONTROL actor ( $\chi^2(1, N=12) = 1.33; p = .25$ ), suggesting that a preference for the CONGRUENT actor manifests itself only in truly prosocial behavior, not in egoistic decisions. Yet, when directly tested, the difference in preference between prosocially versus egoistically deciding participants was not significant ( $\chi^2(1, N=32) = 0.26; p = .61$ ), also not when data from group 1 from both experiments were pooled ( $\chi^2(1, N=61) = 2.24; p = .13$ ).

### ***Affiliation ratings***

We tested for effects of our imitation manipulation on affiliation ratings using a 2 x 5 repeated measures ANOVA with factors Target Person (CONGRUENT or CONTINGENT, CONTROL) and Rating Scale (LIKABILITY, CONNECTEDNESS, SIMILARITY, COOPERATIVENESS, FAMILIARITY). For experimental group 1 (CONGRUENT versus CONTROL) this revealed main effects of Rating Scale ( $F(1, 31) = 14.6; p < .001; \eta_p^2 = .32$ ) and Target Person ( $F(1, 31) = 5.43; p = .026; \eta_p^2 = .15$ ) with the congruently moving target person receiving higher ratings ( $M = 2.70; SD = 0.89$ ) than the control person ( $M = 2.41; SD = 0.72$ ). We also observed a trend Target Person x Rating Scale interaction, but with a small effect size ( $F(2, 31) = 2.26; p = .081; \eta_p^2 = .07$ ). Post-hoc paired *t* Tests comparing ratings for the CONGRUENT versus CONTROL target person on individual scales showed that participants felt more connected with the CONGRUENT than with the CONTROL person ( $M_{\text{CONGRUENT}} = 2.63; M_{\text{CONTROL}} = 2.03; t(31) = 2.70; p = .011; d = 0.48$ ); see Fig. 6A. Although the CONGRUENT target person was also rated as marginally more likable ( $M_{\text{CONGRUENT}} = 3.26; M_{\text{CONTROL}} = 2.92; t(31) = 2.14; p = .040; d = 0.38$ ) and more familiar ( $M_{\text{CONGRUENT}} = 2.26; M_{\text{CONTROL}} = 1.94; t(31) = 2.19; p = .036; d = 0.39$ ) than the CONTROL person, the *p*-values of these



**Fig. 6. Affiliation ratings for the congruent and control actor in experiment 2.** Ratings of how likable, cooperative, familiar and similar participants found each actor, and how connected they felt to him/her. (A) Experimental group 1: participants felt more connected with the CONGRUENT actor than with the CONTROL actor. Ratings of likability and familiarity showed a marginal difference that did not reach Bonferroni-corrected significance level. (B) Experimental group 2: there were no differences between ratings of the CONTINGENT and the CONTROL actor.

comparison did not withstand Bonferroni correction for multiple testing, and hence are not interpreted.

We did not find differential effects on ratings of SIMILARITY and COOPERATIVENESS (all  $p \geq .401$ ).

In experimental group 2 (CONTINGENT versus CONTROL) we found a main effect of Rating Scale ( $F(1,31) = 13.0; p < .001; \eta_p^2 = .65$ ) but no main effect of Target Person ( $F(1,31) = 0.19; p = .66$ ) nor an interaction between these factors ( $p = .79$ ), see Fig. 6B. Formal testing for a differential effect between experimental groups in CONNECTEDNESS ratings of the target persons, by entering the difference value (CONGRUENT vs. CONTROL and CONTINGENT vs. CONTROL, respectively) on this measure into a post-hoc one-sided two-sample t test, confirmed a significant group difference for this measure ( $t(62) = 1.88; p$  (one-sided) = 0.032;  $d = 0.47$ ).

### ***Correlations and predictive analyses***

To more closely examine potential links between the imitation manipulation in experimental group 1 (CONGRUENT versus CONTROL) and the observed behavioral and physiological responses during the Empathy and Prosocial Preference tasks, we performed several post-hoc analyses. First, although ratings during the Empathy Task did not show a significant effect of imitation across participants, we explored whether within participants, the extent of differentiating between the target persons in ratings of likability, familiarity and connectedness predicted differentiating in empathy ratings. Therefore, we calculated difference scores (i.e., CONGRUENT > CONTROL) for each participant, and performed a number of correlation analyses. This revealed that differentiating in empathy between the CONGRUENT and CONTROL target person (all ratings for painful stimulation trials collapsed) correlated positively with differentiating in familiarity ( $r_s = .36; p = .042$ ), likability ( $r_s = .38; p = .030$ ) and connectedness ( $r_s = .43; p = .014$ ) ratings, suggesting that effects of CONGRUENCY on affiliative ratings predicted the extent of differentiation in self-reported empathy. We also assessed whether differentiating between the CONGRUENT and CONTROL target person in affiliative ratings correlated with the extent of SCR modulation during painful stimulation trials of these target persons. We found that differentiating in familiarity ratings (CONGRUENT > CONTROL) correlated with differentiating (CONGRUENT > CONTROL) between these persons in SCR during the Empathy Task ( $r_s = .41; p =$

.029), but differentiating in likability and connectedness ratings did not (all  $p \geq .17$ ). Thus, both differentiating in subjectively experienced empathy and in autonomic arousal (SCR) were correlated with differences in self-reported affiliation.

We also assessed whether participants' preference in prosocial behavior was predicted by differential values on empathy and affiliative measures. More specifically, we performed a binary logistic regression to assess the effects of differential (i.e., CONGRUENT > CONTROL) responses in SCR, empathy for pain ratings, and likability, familiarity and connectedness ratings on the likelihood that participants favored the CONGRUENT person in prosocial behavior. The model explained 41.6% (Nagelkerke  $R^2$ ) of the variance in choosing the congruent person and correctly classified 82.8% of cases. A higher difference in SCR to the CONGRUENT as compared with the CONTROL actor in pain was associated with an increased likelihood of favoring the CONGRUENT person in prosocial behavior (odds ratio 9.43,  $p = .021$ , Wald Chi square = 5.33). The other factors were not predictive of this preference (all  $p \geq .101$ ). Thus, the size of the difference in skin conductance response when watching the CONGRUENT versus the CONTROL actor in pain predicted which target person was preferred in prosocial behavior later on.

## **DISCUSSION**

In Experiment 2 we assessed the effect of bodily congruent versus temporally contingent imitation on behavioral and physiological responses during subsequent empathy for pain, on preference in prosocial behavior involving the distribution of painful shocks between the participant and the imitating and non-imitating co-actors self-affiliation measures, and on ratings of affiliation. We tested two groups of participants: in group 1, a bodily congruent imitating and a non-imitating control actor were contrasted, while in group 2 an actor who made temporally contingent (but not spatially congruent) movements was contrasted with a non-imitating control actor.

Bodily congruent imitation, as assessed in group 1, did not enhance self-reported empathy with the imitator, but did increase skin conductance response during observation of painful stimulation involving this person, indicating that it did affect vicariously induced autonomic arousal. Corrugator muscle activity and startle blink magnitude recorded during the empathy task were not affected by our manipulation, though. Furthermore, consistent with the findings from experiment 1, the congruently imitating target person was favored over the control person in later decisions involving the distribution of further painful shocks. This preference for the congruent actor seemed to be restricted to participants making prosocial decisions (i.e., taking over shocks from others), and was not observed in participants deciding egoistically (i.e., passing on their own shocks to others), but formal testing of this effect did not confirm a significant difference in preference between egoistically and prosocially deciding participants. Bodily congruent imitation was furthermore associated with an increase in ratings of connectedness with this actor, with respect to the non-imitating control actor.

Although we did not find a significant effect of congruent movement on explicit empathy ratings across participants, more fine-grained correlation analyses showed that the extent to which participants from group 1 differentiated between the actors in affiliation (likability, familiarity and feelings of connectedness) predicted the extent to which they differentiated in empathy ratings. Thus, the stronger a preference in affiliation participants showed for the congruent actor, the higher was their self-reported empathy for pain for this person, with respect to the control person. Furthermore, how familiar the congruent person seemed to them, as compared to the control actor, was correlated with the size of their SCR increase during painful stimulation of the congruent person, with respect to the control person. This SCR increase in response to the congruent actor's, versus the control actor's, pain also predicted whether this actor would later on be favored in the decision how to distribute the painful shocks. Thus, elaborating on the main effects of the congruency condition, additional positive associations between tasks suggested that effects of congruency on explicitly reported affiliation were mirrored in self-reported and physiological indices of empathy, and that this physiological

measure of differential vicarious arousal was predictive of participants' bias for the congruent actor in helping behavior.

We did not find any effects of imitation on affiliation, empathy or preference in prosocial behavior if the imitating actor performed merely temporally contingent movements, as assessed in experimental group 2. Post-hoc directional comparisons confirmed that the effects of imitation on empathy-related SCR and connectedness in the congruent group were significantly higher than the equivalent effects in the contingent group. Despite the presence of a prosocial preference for the imitating actor in the congruent group, and an absence of such a preference in the contingent group, we could not confirm a group difference in preference for study 2; yet, pooling together results from study 1 and 2 did result in such a differential effect, suggesting that across our studies, there seems to be a reliable effect of congruency, not contingency, on prosocial preference.

Thus, the findings of experiment 2 indicate that bodily congruency, not mere temporal contingency, seems to drive the effects of imitation on affiliation, empathy for pain and, to some extent, prosocial behavior. They furthermore show that these effects can be targeted to one specific interaction partner, rather than reflecting purely generalized effects on socio-affiliative attitudes and behavior. The broader theoretical implications of these findings and the findings of experiment 1 will be discussed in more detail in the general discussion.

## **General discussion**

In the present study we performed two experiments to test the effects of bodily congruent versus temporally contingent imitation on empathy and bias in prosocial behavior. In both studies, we manipulated imitation using a joystick task in which participants were instructed to make spontaneous decisions about whether and how to move a joystick, while they presumably interacted over a webcam connection with two other participants performing the same task. We included two participant groups in each experiment: in one group (CONGRUENT versus CONTROL), one of the actors copied the participant's movements in a "fully" imitative manner that was not only temporally contingent, but also bodily congruent, in contrast to a control actor who made random movement decisions; in the other group (CONTINGENT versus CONTROL), the movements of the imitating actor were temporally contingent, but not spatially congruent, with those of the participant.

In experiment 1, empathic responses were assessed with a gambling task in which participants reported their vicarious affect for the other participants' gains and losses. Preference in prosocial behavior was assessed by probing which of the target persons was favored in a decision about redistributing the earnings obtained. We also included a social influence paradigm in this experiment. In experiment 2, we used an empathy for pain paradigm to assess behavioral and psychophysiological indices of empathic responding. We assessed bias in prosocial behavior by probing how participants chose to distribute a series of painful shocks between themselves and the target persons. Participants' affiliation for the two target persons was assessed using self-reports.

### **Effects of congruent and contingent imitation on affiliation and social influence**

Participants in experiment 2 indicated that they felt more connected to the person who had imitated them in a bodily congruent way more, as compared to the non-imitating control person.

This is in line with previous evidence on the effects of being imitated on affiliation and feelings of social connection (see [Van Baaren et al., 2009](#)) and indicates that our imitation manipulation was effective in evoking the expected positive socio-affective effects. Participants whose movements had been copied in a merely temporally contingent manner did not report increased feelings of affiliation towards their imitator, as compared to the control actor. Thus, bodily congruency seemed to be required over and above temporal contingency to increase affiliation.

In addition, participants in experiment 1 who had been imitated in a bodily congruent way adapted their responses in a number estimation task to a standard set by the imitator, indicating that they were sensitive to social influence by this actor. The contingent actor did not elicit such a conformity effect. This suggests that bodily congruent, but not temporally contingent, imitation increased participants' social identification with the imitator to the extent that it induced a motivation to align themselves also to cognitive judgments by this specific actor ([de Cremer, 2004](#)).

### **Effects of congruent and contingent imitation on preference in prosocial behavior**

Participants who had been imitated by the congruent actor showed a clear bias in their prosocial decisions, favoring the congruent over the control actor. Participants who had been imitated in a merely temporally contingent way did not show a bias towards the imitating actor. We found this effect in both experiments, and although prosocial preference did not significantly differ between the groups in the single studies, we could confirm a significant group difference in preference when data from experiments were combined, suggesting a genuine effect. Thus, being imitated by one specific interaction partner seems to induce a behavioral bias in which the imitator is treated more favorably than other interaction partners.

Explorative analyses furthermore revealed that in both experiments the effect seemed to be restricted to participants who decided prosocially (i.e. sharing their earnings with others or taking over painful shocks from them) rather than egoistically (i.e. taking away earning from others or

passing on shocks to them). This suggests that being imitated might only induce favoring of the imitator in participants with an inclination towards prosocial behavior, that is, who are already tuned to others' wellbeing to a higher extent. This interpretation is speculative though, and the difference in preference between individuals deciding prosocially versus egoistically was not significant when formally tested. Therefore, future studies with larger samples sizes and a more sensitive measure of prosocial bias should confirm this observation.

### **Effects of congruent and contingent imitation on empathy**

In both experiments, we did not find any effects of bodily congruency or temporal contingency on empathy ratings. Thus, participants did not show any increases in self-reported empathy towards the imitating actor. However, correlation analyses showed that in experiment 2, individual affiliation bias towards the congruent person (i.e., the size of the difference in connectedness, likability and familiarity ratings of the congruent versus the control actor) predicted differential scores in empathy ratings, suggesting some sensitivity of the empathy ratings to the congruency manipulation.

Being imitated in a bodily congruent way did affect skin conductance response (SCR), as shown in experiment 2: SCR in response to the congruent imitator's pain was higher than in response to a control actor's pain. This effect was not observed for the contingent imitator. Manipulation checks showed that SCR was higher for painful stimulation in all actors and was highest for self-related stimulation, confirming that this measure was sensitive to the arousing characteristics of pain processing in self and others. We did not observe any effects of our imitation manipulation on startle blink magnitude or corrugator supercilii muscle activity, though. Our findings thus show that bodily congruent imitation affects physiological indices of empathic arousal (SCR) but has no effect on valence measures (startle blink, corrugator activity), nor on consciously accessible empathic responses.

Our study is in line with findings by De Coster et al. (2013), who showed that physiological indices of empathy for pain can be modulated by imitation. Yet, our findings

extend these results in several crucial ways. First, we show that imitation also has these effects in settings where they cannot be explained by “rubber hand illusion” effects in which the perceived body part in pain might be confused with one’s own. Second, we demonstrate that these effects can also be evoked in a more naturalistic, interactive imitation setting involving agents displaying voluntary behavior, rather than computer-animated body parts. And third, our results suggest that these effects can also be evoked in top-down rather than bottom-up instances of empathy, in which the empathic response is not evoked by emotion contagion (e.g. facial expressions) or visual displays of physical harm, but rather is triggered by abstract cues (the lightning symbol) and therefore presumably arises predominantly from internally generated representations of the other’s affective state.

Although we observed clear effects of our manipulation on physiological measures of empathic response, we did not find effects on ratings of subjectively experienced empathy in the same experiment. This might be due to the fact that explicit ratings are prone to inequity aversion tendencies: participants might have been reluctant to overtly indicate that they experienced more empathy for one presumed other participant than for another. Alternatively, participants’ higher vicarious arousal when the congruent actor rather than the control actor was in pain might not have been consciously accessible to them. Yet, despite not being found as a main effect, empathy ratings did show sensitivity to the imitation manipulation, as was revealed by more fine-grained analyses showing positive correlations between empathy and affiliation ratings within individual participants.

The fact that we did not observe any effects on psychophysiological valence measures (corrugator EMG activity and startle blink magnitude) is somewhat inconsistent with findings by others. For instance, De Coster et al. (2013) found effects of imitation on startle blink amplitude during pain perception, and in a study by Caes et al. (2012) anticipating pain in others augmented both corrugator activity and startle blink response. This discrepancy might be due to differences in the paradigms used. That is, in De Coster et al.’s paradigm, participants were presented with highly aversive video clips from a hand in egocentric position being injured, which

likely evoked self-related aversive responses in a bottom-up fashion. Caes et al. used a paradigm in which the face of the person in pain was visible, suggesting that also here empathic responses were mainly rooted in bottom-up emotional contagion processes. This is different from the abstract cues used to indicate pain in our empathy task. Thus, psychophysiological valence measures might be relatively insensitive to variations in top-down-generated empathic responses, as elicited in our experiment.

### **Predictive links between affiliation, empathic arousal and prosocial behavior**

Several additional analyses revealed that physiological and socio-affective effects evoked by bodily congruent imitation were interrelated. First, the stronger individual participants' SCR to painful stimulation of the congruent, as compared to the control person, was, the more familiar the congruent person felt to them, with respect to the control person. Thus, effects on vicarious arousal were mirrored in subjectively experienced affiliative effects. Second, the increase in SCR during painful stimulation of the congruent person, with respect to the control person, predicted whether the congruent rather than the control person was favored in later prosocial behavior. This is an important finding, as it suggests that the prosocial effects of imitation might indeed be rooted in a process of bodily tuning in with the interaction partner, which manifests itself also on a basic physiological level. Thus, our data fit with the notion that imitation-induced modulations of the tendency to prevent a person from being harmed are shaped by stronger vicarious responses to this person's pain earlier on – in other words, that effects of imitation on prosocial behavior are at least partly driven by increases in empathy rather than by, for instance, positive affect (Hein et al., 2010). This interpretation is tentative though, and needs to be confirmed more comprehensively in future studies.

## **Implications of our findings for current views on the links between mimicry and socio-affective processing**

The findings from this study provide several new insights into the mechanisms underlying the positive socio-affective effects of imitative behaviors. First, they seem to suggest that imitation does not only enhance general prosocial orientation, as has been shown by previous findings, but can also evoke prosocial behavior directed to one specific interaction partner (the imitator), rather than another. This prosocial bias is mirrored in similarly selective enhancements in empathic arousal for the imitator, and in a tendency to conform to behavioral standards set by the imitator. These results suggest that imitation, besides causing a shift towards a more interdependent self-construal (Ashton-James et al., 2007; Brewer and Gardner, 1996), may also selectively shape one's social attitude towards a *specific* interaction partner, possibly by way of increasing one's sense of overlap with this person. As such, our findings add to the literature on the function of behavioral mimicry as "social glue" (Lakin et al., 2003) by indicating that it may also trigger or reinforce tendencies towards selective conformity, parochial empathy and favoritism in prosocial behavior.

Crucially, our study also indicates that spatial congruency of individuals' movements is necessary for the socio-affective effects of imitation, and that mere temporal contingency is not sufficient. This provides support for the view that the effects are rooted in basic motor resonance processes, rather than in the rewarding properties of experiencing effectance by causing predictable outcomes (Dewey and Knoblich, 2014; Meltzoff, 1990; Waytz et al., 2010; White, 1959). In this respect, our results seem at odds with findings by Catmur et al. (2013) which showed that temporal contingency (stimuli of non-congruent body parts reliably moving with participants' movements) has positive socio-affective effects, but bodily congruency (similar body parts which move only occasionally) has not. This inconsistency might be due to the highly different set-ups of the studies. For instance, the non-contingent conditions in the study by Catmur et al. contained many trials with no movement at all, which might have made this condition less engaging overall. In our design, the overall amount of movement was kept roughly constant

across imitative and control conditions, which we think is crucial for overcoming such confounds. Furthermore, our paradigm used video clips of agents who seemed to deliberately plan their movements in real time, rather than animated body part stimuli. Our paradigm therefore likely tapped more strongly into the socio-active processes occurring in natural interactions. However, more research is needed to clarify these inconsistent findings. Our results are more consistent with studies which showed that children prefer a congruently moving agent over one who merely moves in a temporally contingent way (Agnetta and Rochat, 2004; Meltzoff, 2007), and thus, that congruency has *stronger* effects than mere contingency. Our results also significantly extend these findings though, by showing that only congruency, and not temporal contingency, has measurable effects over and above a control condition with an unrelated movement pattern. Overall, our findings indicate that bodily congruency seems to be a crucial factor in shaping the positive effects of mimicry, and thus provide some support for self-other overlap accounts of mimicry (Ashton-James et al., 2007; Georgieff and Jeannerod, 1998).

### **Interpretational issues and limitations**

Although our findings point to a crucial role of movement congruency in driving the effects of imitation, there are some considerations with respect to the validity of our imitation induction paradigm and the interpretation of its effects that should be addressed. First, it should be noted that our imitation induction paradigm was not designed to *independently* manipulate spatial congruency and temporal contingency. Rather, we used an additive design in which we assessed whether temporally contingent behavior alone can evoke prosocial effects, or whether imitative behavior additionally has to be spatially congruent to evoke such effects – compared with a control condition where both bodily congruency and temporal contingency are at chance level. This approach differs from previous approaches, for instance, studies comparing mimicry with anti-mimicry conditions (e.g. De Coster et al., 2013; Hogeveen et al., 2014), and allowed us to assess not just whether full imitation may have stronger prosocial effects than temporally

contingent movements, but also to examine to what extent temporal contingent behavior in itself may also have such effects. It should be noted, however, that our findings do not allow strong conclusions about the potential role of spatial congruency in the absence of close temporal contingency. Future research may tackle the question of how strictly temporally contingent spatially congruent movements should be, in order to affect social behavior.

Second, we addressed our research questions not by varying the extent of congruency or contingency between the participant's and the imitator's movement decisions on a trial-by-trial basis (for instance, by varying the degree of movement similarity or the size of the temporal interval), but rather by manipulating the congruency or contingency between the participant's and the actors' behavior across all trials. Although this design does not allow us to quantify precisely *how* congruent or contingent this mapping needs to be in order to be effective, we think that our operationalization meaningfully captures a central question regarding real-life interactions – namely, whether it is 1) the fact that our interaction partners tend to *react* to our movements and mannerisms or 2) the fact that, in doing this, they also *copy* our specific movements – that is responsible for enhancing our prosocial feelings towards them.

Third, the finding that congruent movement is required for the socio-affective effects of imitation does not necessarily imply that these effects are driven by self-other overlap. It could be argued that overall, the predictability of the congruent condition is higher than that of the contingent condition. This is because in the congruent condition, both the timing and the direction of the imitator's movements are predictable, whereas in the contingent condition only their timing is predictable. According to recent suggestions, kinematically similar movements might be intrinsically rewarding because they are easier to predict, and lead to a lower prediction error signal (Hale and Hamilton, 2016). This might cause imitative encounters to be experienced as smoother and more pleasant, which may foster affiliative and prosocial tendencies. Yet, it is less clear how such reward processing could explain the finding that congruency also enhances autonomic arousal when the imitator is in pain. This latter finding seems more in line with a self-other overlap account, in which increased motor resonance with the imitator facilitates embodied

simulations in the affective domain. Which of these mechanisms drives the socio-affective effects of congruent imitation cannot be fully discerned based on our findings. The fact that temporal contingency does not have any differential effects over a completely unpredictable control condition, though, seems to suggest that degree of predictability cannot fully account for them. Future studies should attempt to further disentangle influences of bodily congruency, temporal contingency, and predictability, for instance, by using overlearned complementary actions to tap into the latter mechanism (Hale and Hamilton, 2016).

Fourth, it could be argued that our congruency condition denotes a more similar condition also on a more general, conceptual level, without necessarily involving motor simulations. Indeed, the fact that the congruent actor seems to deliberately make the same movement decisions as the participant could also be seen as a signal that she is taking efforts to align her behavior and decisions, motoric or not, to that of the participant. Since similarity per se is a strong predictor of liking (Byrne, 1997; Montoya and Horton, 2013), the effects of bodily congruency in our study could also be explained by the perception of such domain-general similarities. This is, however, an issue that more generally applies to mimicry research. In fact, according to influential accounts, both motoric and non-motoric interpersonal similarity may ultimately rely on equivalent embodied self-other overlap mechanisms, resulting in basic “like me” experiences (Ashton-James et al., 2007; de Waal, 2007; Meltzoff, 2007). The extent to which bodily congruent imitation affects empathy and prosocial behavior over and above non-bodily forms of perceived similarity is an issue for future research.

Fifth, the type of interaction induced by our imitation paradigm was inevitably somewhat artificial compared to mimicry occurring in real social interactions. This is since we aimed to address our research questions in an interactive setting involving realistic agents, rather than relying on body part stimuli, but also wanted to eliminate contributions from factors such as facial appearance, eye contact, pain expression, and bottom-up vicarious responses to visual pain stimuli in our tasks. In this way, we aimed to put the effects of imitation on empathy and prosocial behavior to a most stringent test. Future research should address whether our findings

can be extended to more naturalistic settings – or, more plausibly, whether more naturalistic settings evoke even stronger effects.

Related to the previous point, it should be noted that it was not fully evident whether participants assumed that the movements of their co-players were planned independently from theirs – and hence, that any imitation occurred by chance, or whether they believed that the co-players could see the participant's movements when planning theirs, and thus were able to deliberately copy them. Notably, the movements of the co-players were always shown with a short delay of about 1 sec after movement completion, which in timescale is more or less equivalent to naturalistic forms of mimicry. Although participants thus saw the movements of the co-players only after performing their own movement decisions, we did not explicitly tell participants that their movements were invisible for the other two players as well, when these were making their movement decisions. Therefore, it is not implausible that participants assumed that the other players could in fact adapt their movements to theirs, and thus, were deliberately imitating them. Nevertheless, it cannot be excluded that many participants assumed that all movement decisions were taken independently, and thus that any movement similarity was coincidental. A further relevant point to this issue is the possibility that not all participants fully believed the cover story: when explicitly asked after the experiment, about half of the participants indicated that they had at some point during the tasks experienced “some doubt” about the authenticity of interaction, although it should be noted that participants may have been reluctant to admit that they believed in the authenticity given that the question was suggestive of a feigned set-up. The fact that, in spite of the suggestion that imitation occurred by chance, and in spite of any doubts about the authenticity of the interaction, our imitation manipulation still had quite clear-cut effects, suggests that apparently, even if we know that others are not deliberately copying us, their imitative behavior can still be effective in influencing our social preferences and behavior. On a more speculative note, this seems to suggest that such effects arise from relatively implicit processes that are fairly robust to conscious reflection. Yet, as said, we cannot univocally discern to what extent participants assumed that the imitation was

deliberate or not, and thus, the question how deliberate versus coincidental similarity in self-initiated movements shapes imitation effects needs to be addressed in future studies.

Lastly, and importantly, although our findings show that spatially congruent imitation has positive effects on several measures of social behavior, it should be kept in mind that these effects were obtained in a relatively small sample, and that most effect sizes were modest. Furthermore, inferences about the specificity of these effects are, in both studies, based on statistical comparisons between the experimental group where the effect were present, and the group where they were absent. These comparisons yielded in some cases a small but significant difference (e.g. in the effects on social influence, sense of connectedness, skin conductance response), but in other cases the difference was less convincing (e.g., a differential effect of congruency on prosocial preference, with respect to contingency, could only be shown when samples from both studies were combined). Overall, the aggregated effect size of differential effects between experimental groups was small to medium (0.32), suggesting that caution is needed in drawing conclusions about the specificity of the effects for spatially congruent imitation. Indeed, due to the small sample size of the groups it cannot be excluded that contingent imitation might, to some extent, also be capable of affecting social behavior, but that we failed to detect such effects. Thus, we would like to emphasize that the main conclusions from our studies remain to be confirmed by future research.

## **Conclusion**

We have shown in two experiments that bodily congruent implicit imitation moderately enhances affiliation, conformity, autonomic arousal measures of empathy, and prosocial behavior. Imitation that was merely temporally contingent did not have such effects. This provides support for the view that the social effects of imitation are driven by motor resonance and ensuing self-other overlap mechanisms, rather than by the rewarding effects of experiencing that one's actions have predictable effects. Our study also demonstrates that these effects can be targeted at a specific interaction partner (the imitator) when individuals are interacting with multiple

others simultaneously. This extends evidence that imitation has global effects on prosocial attitudes, and suggests that imitation may also increase one's sense of overlap with a specific person, thereby motivating biased social affect and behavior. Lastly, our findings show that the tendency to favor the imitator over others in prosocial behavior is predicted by increased automatic arousal in response to the imitator's pain earlier on. This suggests that the prosocial effects of imitation are driven by increased affective resonance with the imitator, rather than by positive affect. Taken together, our study provides several valuable new insights into the potential mechanisms underlying the effects of imitation on social affect and behavior.

### **Author contributions**

**Jasminka Majdandžić:** Conceptualization, Methodology, Software, Formal analysis, Resources, Writing - Original Draft, Funding acquisition. **Birgit Rauchbauer:** Investigation, Resources, Writing - Review & Editing. **Gernot Gerger:** Software, Formal analysis, Writing - Review & Editing. **Marina Maksimova:** Investigation, Formal analysis. **Jakub Chromec:** Software, Formal analysis. **Christoph Huber-Huber:** Software, Writing - Review & Editing. **Claus Lamm:** Conceptualization, Methodology, Resources, Writing - Review & Editing, Supervision, Funding acquisition.

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