When Triangles Become Human: Action Co-representation for Objects.

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Abstract

Until recently, it was assumed that co-representation of others' actions, an essential part in joint action, is biologically tuned. However, research demonstrated that we also simulate actions of non-biological interaction partners under certain conditions. In the present study, we investigated whether perceived intentionality or perspective taking is the underlying mechanisms of this phenomenon. Participants saw a short video fragment of a non-biological agent (i.e., a triangle) as main character. The movements of this agent were either described as intentional or as unintentional. Furthermore, participants were instructed to either take the perspective of this non-biological agent or not. Results show that perspective taking and perceived intentionality both lead to action co-representation of non-biological actions. Possible explanations for these findings are discussed.

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1. Introduction

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Joint action is essential for social interaction (Sebanz, Bekkering, & Knoblich, 2006). It has been suggested that coordinating our behaviour with others is based on co-representing their behaviour in our motor system: action observation leads to automatic activation of motor representations in the observer (Brass et al., 2001; Dijksterhuis & Bargh, 2001; Sebanz et al., 2003; 2005; Prinz, 1997). Different studies showed that action co-representation is restricted to biological actions, and does not occur if the actions are performed by non-biological agents (e.g., a robot or a wooden hand, Kilner et al., 2003; Tai et al., 2004; Tsai & Brass, 2007; Tsai et al., 2008; Ramnani & Miall, 2004; Wilson & Knoblich, 2005). Previously, it has been argued that humans have an evolutionary preference for biological action, in the sense that co-representation of biological actions are functionally and fundamentally different from representation of analogous, non-biological actions (Tsai et al., 2006).

Although there is some evidence that the common coding system has a preference for human-like stimuli (e.g., Brass et al., 2001; Press, 2011), other studies fail to show this exclusivity for biological stimuli (Castelli et al., 2000; Cross et al., 2012; Gazzola et al., 2007; Ramsey & Hamilton, 2010; Schultz et al., 2005; Wheatley et al., 2007). For example, it has been shown that simple moving shapes can elicit the attribution of mental states and activates brain regions involved in perception of biological actions (Castelli et al., 2000, Wheatley et al., 2007). Furthermore, research shows that action co-representation also depends on the observer‘s knowledge about the non-biological agent (Liepelt & Brass, 2010; Stenzel et al., 2012). Thus, top down processes influence whether people simulate actions or not, which makes it possible to co-represent actions of non-biological stimuli.

Recent research demonstrated that if we simulate actions or not is influenced by other processes, such as whether the actions of others serve as a spatial reference for one‘s own actions

(Dolk et al., 2011), group membership of the interaction partner (Müller et al., 2011b), or liking (Hommel et al., 2009). Furthermore, it has been shown that action co-representation of non-biological interaction partners can occur if people ascribe intentionality to them (e.g., Müller et al., 2011a; Stenzel et al., 2012). When participants took the perspective of the non-biological agent and ascribed intentionality to a wooden puppet, (by watching a short videoclip of Walt Disney‘s Pinocchio), they subsequently simulated actions of a wooden hand they interacted with in a social Simon task. Participants who did not have the possibility to ascribe intentionality to a wooden hand (because they watched a movie about humans) only simulated actions of a human interaction partner. Comparable results were found when participants had to interact with an artificial robot that was introduced as either intentional or non-intentional (Stenzel et al., 2012; Stenzel et al., 2013). Interestingly, when people actively took the perspective of one's interaction partner belonging to an out-group, action co-representation increased as well (Müller et al., 2011b). Moreover, pro-social behaviour towards a non-biological agent is increased after ascribing intentionality towards this agent (Müller, van Baaren, van Someren, & Dijksterhuis, in press).

There is thus increasing evidence that humans also co-represent actions of non-biological agents. However, the underlying mechanism is unclear and both perceived intentionality (Müller et al., 2011a) as well as perspective taking (Müller et al., 2011b) could be responsible for the action co-representation effects found during interaction with non-biological agents. Research has shown that people easily ascribe *intentionality* to television characters and avatars in video games, which in turn is assumed to influence later behaviour (e.g., Schneider, Lang, Shin, & Bradley, 2004). Furthermore, people tend to automatically ascribe human attributes and agency to objects and perceive them as acting intentionally (Epley, Waytz, & Cacioppo, 2007), especially when the features of the object are human-like (Burgoon et al., 2000). Additionally, narratives can strongly influence perception of the world by transportation or absorption into a story, which leads to increased *perspective taking* and understanding of the observed character (Appel & Richter, 2007; Green & Brock, 2000; Green, Brock, & Kaufman, 2004). Research on perspective taking has shown furthermore, that people not only tend to spontaneously take the perspective of their interaction partner (e.g., Böckler, Sebanz, & Knoblich, 2012; Böckler & Zwickel, 2013); they also take the perspective of a person in a picture, no matter whether this person is another human (Tversky & Hard, 2009), a human-like avatar (Samson et al., 2010), or a non-biological agent (Zwickel, 2009).

In the present research, we try to disentangle the influence of perceived intentionality and perspective taking. Participants performed a social Simon task (Sebanz et al., 2003), with a non-biological interaction partner, a red triangle. In the classical Simon task participants have to respond to the colour of a stimulus (e.g., pressing a left key when a red stimulus appears and pressing a right key when a green stimulus appears on the screen) while ignoring the spatial location of the stimulus. The Simon effect refers to the finding that participants respond slower when the spatial relationship between stimulus and response is incompatible (e.g., pressing a left key in response to a stimulus on the right) than when it is compatible (e.g., pressing a left key in response to a stimulus on the left). The typical Simon effect disappears when participants only respond to one stimulus (e.g., to the green stimulus with a right response but not to the red stimulus) in a go/no-go version of the task. The reason is that a left response is only coded as left when it is encoded in context of a meaningful right response (Sebanz et al., 2003). The Simon effect reappears when participants interact with somebody else who carries out the alternative response (Sebanz et al., 2003; Tsai & Brass, 2007; Tsai et al., 2006). In a social setting, participants co-represent the action of their interaction partner leading to a reappearance of the Simon effect. In the present study, we used the social Simon task to measure action co-representation. Most importantly, before performing this task, participants watched a short video fragment of moving red and blue triangles. In this movie both perceived intentionality of the triangles’ movements as well as perspective taking is manipulated. Based on earlier research (e.g., Müller et al., 2011a; Müller et al., 2011b), we expected that participants co-represent the actions of the non-biological agent when they had the possibility to ascribe intentionality to this agent. In addition, when they were instructed to take the perspective of the red triangle, we also expected action co-representation to occur.

2. Methods

2.1. Participants and design

One-hundred-and-seven students (18 men, 17 to 36 years, mean age = 20.80, *SD* = 3.32) from Radboud University Nijmegen received credit points or a financial compensation for their participation. All participants were right-handed and had normal or corrected-to-normal vision. The experiment consisted of a 2 (Description: intentional vs. random) x 2 (Instruction: perspective taking vs. objective) between-subjects design. Participants were randomly assigned to one of the four conditions. The distribution of participants was as follows: 28 participants in the intentional - perspective taking condition, 28 participants in the intentional - objective condition, 26 participants in the random - perspective taking condition, and 25 participants in the random - objective condition.

2.2. Materials and procedure

At the beginning of the experiment, participants were seated in front of a computer screen. After answering some questions concerning their demographic background, they watched a video clip of 70 sec length. The clip portrayed a red and a blue triangle, moving randomly around an abstract sketch of a ground plan of a house (see Castelli et al., 2000). The fragment was chosen in such a way that the triangles' movements would not clearly suggest underlying intentions to prevent automatic perspective taking. To manipulate the attribution of intentions to the triangles, the movie contained subtitles describing the triangles' movements in episodes of about 10 seconds. These descriptions were either emphasising the randomness of the movements (e.g., 'The geometrical shapes are programmed to randomly turn around the square') or their intentionality by integrating the triangles' movements into a story of two friends looking for their pet (e.g., 'The two friends first want to look around the house and, full of hope, they decide to split up'). To manipulate perspective taking of the portrayed triangles, participants were instructed to either take the perspective of the red triangle and identify with it, or to stay objective and distant while watching the video. After watching the fragment, participants had to indicate how well they could form an impression of the main character they had to focus on, answering two question as manipulation check ('I identified with the red triangle' and 'I had the feeling the movements of the red triangle were random'), using a 7-point Likert scale (1 = do not agree, 7 = agree).

Subsequently, all participants performed an identical Simon task with an animated red triangle. They put their right hand on a 17 inch LCD screen where a single response key was placed. At the centre of the screen, the standard Simon stimulus – a rectangle surrounding three horizontally arranged circles – was presented. On each trial, one of the circles was either coloured green or yellow (see also Tsai & Brass, 2007).

In all conditions, an image of a red triangle and an animated response-button was displayed on the left side of the screen. Participants had to respond whenever a green dot appeared on the screen. The triangle displayed on the left side 'responded' to yellow targets, pressing the button on participants' no-go trials. To give the impression of a movement, a five-frame image sequence (38 ms per frame) was presented. It showed the triangle in different positions, giving the impression to respond to the colour by jumping up and again approaching the response button. The first image of this sequence was used as fixation display.

No-go trials were preceded by a 500 ms fixation display. Then, a yellow target was presented for 150 ms. After a variable interval (300 – 450 ms), the image sequence started. Finally, the fixation display was presented (1000 ms). Go trials also started with a 500 ms fixation display. Next, a green target was presented for 150 ms. RTs were recorded from the onset of the target. Participants were instructed to respond to the green targets as quickly as possible, without making too many errors.

There were 90 go trials and 90 no-go trials presented randomly (40 go/compatible trials; 40 go/incompatible trials; 10 go trials where the target was presented in the middle). To prevent carry-over effects, we introduced a 2-minutes break between blocks. Subsequently, participants were thanked, debriefed, and paid.

3. Results

3.1. Manipulation check

A 2 (Description: intentional vs. random) x 2 (Instruction: perspective taking vs. objective) MANOVA with perceived randomness of the movements and identification with the red triangle as dependent variable revealed a significant effect of description on the perceived randomness score, $F(1,103) = 6.07$, $p = .015$, $\eta\rho^2 = .06$, with participants who watched the random movie having a stronger impression that movements were random ($M = 3.47$, $SD = 1.16$) than participant watching the intentional movie ($M = 2.89$, $SD = 1.25$). In addition, there was a significant effect of instruction on the identification scores, $F(1,103) = 8.04$, $p = .005$, $\eta\rho^2 = .07$, with participants who took the perspective of the triangle having higher identification score ($M = 2.76$, $SD = 1.29$) than participant who did not take the perspective of the triangle ($M = 2.06$, $SD = 1.23$). All other effects were non-significant (all *F's* < 1; for random scores $F_{\text{Instruction}}(1,103) = 2.00$, $p_{\text{Instruction}} = .16$). Furthermore, no differences were found on whether participants attend more to the triangle depending on condition, $F(1,103) < 1$, n.s.

3.2. Social Simon effect

All trials with RTs below 150 ms or 2SD above the mean (0.58%) were excluded. Because of the low number of error rates, which reflects the relative ease of a simple stimulus discrimination task, error rates were not analysed further. Difference scores were calculated by subtracting the average RT of compatible trials from the average RT of incompatible trials. Five participants with a mean score more than 3SD above or below the mean were excluded from further analyses.

A 2 (Description: intentional vs. random) x 2 (Instruction: perspective taking vs. objective) ANOVA on the difference scores revealed a significant main effect of Description, $F(1,98) = 6.37$, $p = .013$, $\eta\rho^2 = .06$. Participants who watched the intentional movie showed a stronger Simon effect (M = 15ms, $SE = 4$) than participants who watched the random movie (M = 2ms, $SE = 4$). The main effect of Instruction was not significant, $F < 1$. Most importantly, a significant interaction was found between Description and Instruction, $F(1,98) = 6.11$, $p = .015$, $\eta\rho^2 = .06$, (see Fig. 1). Post-hoc analyses revealed that when participants had to take the perspective of the triangle, no differences between the intentional condition and the random condition were found, $F = 1$. However, when participants got the instruction to watch the movie in an objective way, the effect between the intentional condition and the random condition was significant, $F = 12.97$, $p < .001$.

The Comparisons of the mean RTs of compatible and incompatible trials of the four conditions revealed that there was a significant effect in the intentional - perspective taking condition (M = 10ms, $p = .047$), and a significant effect in the intentional - objective condition (M = 20ms, $p = .003$) as well as in the random - perspective taking condition (M = 10ms, $p = .008$). The compatibility effect in the random - objective condition was non-significant (M = -5ms, $p = .33$; all p-values two-sided).

Furthermore, we correlated the manipulation check scores with the RTs on compatible and incompatible trials. No significant correlations were found.

4. General discussion

In the present study, we investigated the underlying mechanism of co-representation for non-biological actions and tested whether perceived intentionality or perspective taking is responsible for the effects found in earlier research. We demonstrate that both perspective taking and perceived intentionality have an influence on action co-representation of non-biological actions. Participants co-represented actions of objects after they were instructed to take the perspective of the object, independent of whether the movements of the object were described as intentional or random. Furthermore, a social Simon effect occurred when the actions of the object were described as intentional and participants did not take the perspective of the object. Only when participants did not take the perspective of the triangle and movements were described as unintentional, no compatibility effect was found.

In sum, we could demonstrate that action co-representation also occurs for non-biological agents with a non-human appearance and that action co-representation occurs after taking the perspective of the interaction partner, or when these actions were perceived as intentional. The present findings support the assumption that perceiving a non-biological agent, such as a simple triangle, behaving in a human-like way, leads to co-representation of action. Thus, whether action co-representation occurs or not depends on higher order processes and is not solely biologically tuned (see also Liepelt & Brass, 2010; Müller et al., 2011a; Stenzel et al., 2013; Stosic, Brass, van Hoeck, Ma, van Overwalle, 2014; Teufel et al., 2010).

Most importantly, we could demonstrate that perspective taking and perceived intentionality both contribute to an increase in action co-representation. This is in line with earlier studies, which showed that watching a video fragment of Pinocchio leads to action co-representation of a wooden non-biological agent afterwards (Müller et al., 2011a), assuming that perceiving Pinocchio acting intentional is responsible for these findings. Other research has demonstrated that narratives increase identification with television characters and avatars in video games, which in turn is assumed to influence later behaviour (e.g., Schneider et al., 2004), and people tend to spontaneously take the perspective of other people (e.g., Böckler & Zwickel, 2013). This could mean that even when participants were not directly instructed to take the perspective of their interaction partner, it may be possible that participants spontaneously took the perspective of the non-biological interaction partner. However, we did not find a compatibility effect in the random – objective condition, which indicates that perceived intentionality is an additional crucial factor to explain this phenomenon.

Based on the present findings both mechanisms may be responsible for these effects and it might be difficult to disentangle perspective taking and perceived intentionality, especially given the fact that perspective taking increases both perceived intentionality and self-other overlap. An increase in self-other overlap has been shown to lead to an overlap in representations of actions performed by oneself and actions performed by the interaction partner (Hommel et al., 2009). Based on the literature, both explanations are possible: It has been argued that action co-representation partly depends on the perceived overlap of one’s representation of the self and the representation of the interaction partner (Colzato et al., 2012a; Colzato et al., 2012b; Müller et al., 2011b). In addition, recent research demonstrates that the valence of the interaction influences action co-representation (Hommel et al., 2009). However, a positive relationship with an interaction partner increases self-other overlap (Aron et al., 1991). Further research is definitely needed to clarify this issue.

In follow up research it would be advisable to control for possible salience effects of non-biological movements, for example by presenting a movie of an interaction between a human and a non-biological agent. A growing body of research explores whether the social Simon effect is based on the spatial salience introduced by a co-actor rather than a measurement for action co-representation and suggests that a referential coding is more likely the reason for the normally found social Simon effect (Dittrich et al., 2012; Dolk et al., 2013; Dolk et al., 2013; Dolk et al., 2011; Guagnano et al., 2010; Liepelt et al., 2012; Liepelt et al., 2013). These studies demonstrate, for example, that a compatibility effect also occurs when a random moving or sound-making object (i.e., a Japanese Lucky Cat, a clock, or a metronome) is placed on the left side of the participant (Dolk et al., 2013), or that the social Simon effect could be found only if the interaction partner was sitting within arm reach of the participants (Guagnano et al., 2010). The given explanation for these findings is that the presence of another salient event requires distinguishing the cognitive representation of one's own action from the representation of other events, which can be achieved by the spatial coding of one's action relative to the other events.

However, we think that until now these studies could not fully eliminate the social component in their research designs. Both results could be explained by a decrease in self-other overlap with an increase in distance between actor and co-actor, which would be in line with our argumentation that an increase in self-other overlap invoked by perspective taking fosters action co-representation. The objects used in the studies mentioned above are perfectly suitable to ascribe intentionality, and research has shown that predictability increases perceived intentionality (Fukuda & Ueda, 2010; Hard, Tversky, & Lang, 2006). Although a control condition was included in which a noiseless metronome was placed next to the participant, it could still be speculated whether an object with a human-like face (i.e., a Lucky Cat), and a noisy metronome are not more prone to ascribe intentionality (see Epley et al., 2007). Additionally, the objects where placed in position by an experimenter, and therefore this action could linked the object to the experimenter, thereby giving it a social meaning. Thus, perceived intentionality and an increase in self-other overlap can be responsible for the results mentioned above. Furthermore, in our research explicit ratings of whether attention towards the triangle during the social Simon task vary between conditions did not yield any significant differences. Another explanation might be that two separate mechanisms are at work here. Both spatial salience as well as perspective taking and/or intentionality could influence the compatibility effects of the social Simon task. Thus, when two participants are performing the social Simon task, a compatibility effect occurs because actions of the co-actor are co-represented, depending on the self-other overlap between the two interaction partners. However, a compatibility effect can also occur when the left response is salient, which does not per se need to be a sign for the fact that actions are co-represented. To answer this question, further research should focus on the underlying mechanisms of the social Simon effect.

Conclusions

In the present research, we could demonstrate that action co-representation of non-human agents is not depending on human features possessed by the agent. Even if we interact with such abstract forms such as a triangle, which is very dissimilar to our own appearance, we co-represent its actions. Additionally, we could show that perspective taking and perceived intentionality both influence this process.

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Figure Caption

Fig 1. Mean different scores of the social Simon task as a function of description and instruction.

Error bars represent the standard error.