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Authors

Pierce, Devin
Kadiyala, Mani
Ives, Christian

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Perceiving Bodily Expressions: Differential Effects of Human & Non-human Forms

Devin Pierce (Devin.Pierce@tamuc.edu)
Mani Kadiyala (mkadiyala@leomail.tamuc.edu)
Christian Ives (cives@leomail.tamuc.edu)

Department of Psychology, Counseling, and Special Education, Texas A&M University-Commerce
Commerce, TX 75428 USA

Abstract

Theories in embodied cognitive science emphasize the importance of self-other mapping during emotion perception. This implies the body form through which an emotion is expressed may impact how the emotion is perceived. Research in human computer interaction has demonstrated that people can reliably label emotions of virtual characters; however, it has hardly examined how people perceive the emotions of virtual characters at a visceral level. Here, we asked participants to identify under time pressure for action, whether an observed bodily movement is angry or happy. Our research provides evidence that emotions conveyed by non-human virtual characters and humans are indeed perceived differentially, at the visceral level. This work carries implications for theories of embodied cognition and the design of virtual environments.

Keywords: body; mapping; emotion; virtual character

Introduction

Often times, it is imperative to quickly identify emotional body movements undertaken by other humans, so that adaptive action plans can be executed swiftly by the perceiver. For example, observing someone stomp their feet and wave their arms frenziedly may lead perceivers to both identify the behavior as threatening and retreat from the aggressor. Inherent in identifying threatening behaviors is that there is time pressure for action, given that if such behaviors are not identified injury may result if appropriate actions are not executed quickly. Non-verbal emotional expressions conveyed by humans are thus fundamental to social interactions (Ekman 1992); serve as a valuable signal for guiding one's behavior (Darwin 1872/1965); and are an integral part of the phylogentic development of the human species (de Gelder 2006). Technological advancements have now made it possible to create non-human virtual characters that precisely replicate human body movements conveying emotions (e.g., McDonnell et al, 2009).

How might emotion perception be impacted when observing expressive body movements displayed by different body forms, such as a non-human virtual body as opposed to a human body? Reeves and Nass (1996), in their media equation theory, maintain that human brains have not evolved to deal with modern technology and that perceivers will consequently treat media representation of people as real. However, they draw this conclusion based on studies using stimuli that did not differ from humans in terms of body form (e.g., pictures of humans). It is thus unclear as to whether media representations that have body forms different from the human body could trigger differences in

emotion perception. Studies in embodied cognition point to the possibility that such dissimilarities may indeed surface.

Embodied approaches to body perception stress the mappings that occur between the bodies of perceivers and those being perceived (e.g., Wilson 2001). Reed (2002) maintains that specialized long-term body representations referred to as *body schemas* are central to self-other mapping. These schemas contain information common to the human body, such as its physical appearance and biomechanics, thereby allowing them to be used for representing the form and dynamics of one's own body as well as the bodies of other humans (Reed et al. 2005). This suggests that observing actions carried out by different body forms could impact self-other mapping and how movements are perceived. Perani et al (2001) recorded brain activity as participants watched movements performed by a human body or a virtual body modeled after it. Results showed that the human body selectively activated the right inferior parietal cortex and the superior temporal sulcus. Whereas the former brain region may involve relating with others as members of the human species (Decety & Chaminade 2003), the later involves perceiving movements as biological (Allison et al. 2000). This suggests that even though the virtual hand exhibited biological motion, perceivers did not relate with the virtual body as a conspecific and it was perceived as non-biological.

There is reason to believe that self-other mapping may also be important for emotion perception. Theories of embodied simulation maintain that the perceived actions and emotions of others are mapped by the same neural circuits that are involved when observers act or feel the same (Gallese 2010). Evidence for these shared neural circuits in humans has been demonstrated in the domain of actions (Grezes & Decety 2001), as well as emotions (Wicker et al. 2003). Embodied simulation allows the actions and emotions of others to be directly understood because they are grounded in the perceivers' own motor and emotional circuits (Gallese 2009). Because affective states are internal and thus invisible, some have raised the possibility that mapping others' emotions may rely in part on mapping their behavior (Bastiaansen et al. 2009). The idea is that people have a history of performing actions (e.g., waving arms frenziedly) while experiencing emotions (e.g., anger) that lead to associations between specific states of motor and emotion circuits. Accordingly, when an observed action is mapped onto one's own motor circuits involved with executing the same action, neural activity will cascade to its associated emotional circuits and provide insight concerning the observed person's emotional state. Neuroimaging

research has shown that when observing the same biological movements performed by a human body or animated body, the animated body triggers less activity in cortices associated with mental state attribution and emotional processing (Mar et al. 2007).

McDonnell et al. (2009) recently conducted a behavioral study to examine whether identical biological motions indicative of the six basic emotions (e.g., happy, angry) would be perceived differently depending on whether they were exhibited by human or virtual bodies. Participants first viewed and described the appearance of a static body image, followed by watching it perform an emotional movement as many times as desired. The data revealed no significant difference in recognizing emotions expressed by the human and virtual bodies. McDonnell et al. argued that when virtual characters are rendered with biological motion it is not the body form but the motion that governs emotion perception. However, as reviewed above, work in neuroscience suggests that cortical areas associated with perceiving motions as biological, as well as, attributing emotional states, are less involved when observing virtual characters.

There is one issue concerning the methodology of McDonnell et al. that could have contributed to their results. In particular, participants were allowed a great deal of time to analyze the body forms and movements before responding, which could have helped them identify emotions better via overcoming perceptual differences between the real body and virtual bodies. This possibility is consistent with research showing that self-other mappings and body perception can be greatly facilitated by simply increasing processing time (Reed & McGoldrick 2007). In light of this issue, we asked participants to identify emotions under time-pressure, to examine whether different body forms could impact emotion perception.

To examine whether identification of emotional body movements under time-pressure is impacted by different body forms carrying out the behaviors, an examination of false alarms for threatening and non-threatening movements performed by human bodies and non-human virtual bodies could yield insights. To begin with, consider angry human body movements, which perceivers can observe and determine if a direct physical attack is potentially being carried out (Pichon et al. 2009). As discussed in the previous section, perceivers engage in self-other mapping to gain insight into the emotional states of other humans. The observation of a human body performing angry movements may thus promote self-other mappings that contribute to perceiving the emotion as emanating from a body that experiences genuine emotional states and that is capable of inflicting physical harm. In contrast, the observation of a non-human virtual body performing angry movements may promote self-other mappings that contribute to perceiving the emotion as emanating from a body that does not experience real emotional states and that is incapable of inflicting physical harm.

It is reasonable to think that a body-specific threat bias might emerge for perceiving human emotional body movements as threatening, in order to reduce one's chance of being harmed as a result of failing to detect a potential

threat. Arguments in evolutionary psychology maintain that humans are biased towards attending to threat (Ohman et al. 2001). Additionally, research in mammals has indicated that false alarms for threat are very common, representing a significant proportion of all alarms (Beauchamp & Ruxton 2007). Therefore, when observing a human body, there may be an increased rate of false alarms misidentifying non-threatening movements as angry and relatively few false alarms misidentifying angry movements as non-threatening; however, when observing a non-human virtual body, there may be comparable false alarm rates to angry and non-threatening behaviors.

If it is found that perceivers exhibit a threat bias when observing emotional body movements performed by a human body but not a non-human virtual body, an auxiliary question arises as to whether there might also be a bias towards activating motor contingencies geared towards evading threat conveyed by the angry movements of a human body but not a non-human virtual body. According to evolutionary perspectives, humans have developed adaptive action plans that are triggered by environmental stimuli and occur without conscious awareness. Bradley and Lang (2000) argue that avoidance-related behaviors are made in response to displeasing stimuli and approach-related behaviors are made in response to pleasing stimuli.

Measuring arm movements is an established method for investigating how affective stimuli can trigger motor contingencies in perceivers (Solarz, 1960). Most often, participants will observe a negative or positive stimulus for which they are to evaluate its valence by making a response that involves either extending the arm (e.g., pushing lever away from self) or flexing the arm (e.g., pulling lever towards self). An interaction between stimulus valence and arm movement is taken as evidence for avoidance and approach-related behaviors. For example, it has been shown that people respond faster to negative stimuli when flexing the arm than extending it, but that they respond faster to positive stimuli when extending the arm rather than flexing it (Lavender & Hammel, 2007).

The current work's auxiliary question asks whether an interaction between arm movement and perceived emotion will emerge when observing a human body but not a non-human virtual body, for which the respective interaction will be driven by a greater divergence between how fast participants push and pull, when responding to an angry human (threatening) as opposed to a happy human (non-threatening) human. Work in neuroscience has demonstrated that viewing angry human body movements activate brain regions related to defensive movements (Pichon et al. 2007), but that viewing happy human body movements evoke significantly less activity in regions associated with adaptive movements (de Gelder et al. 2004). This indicates the possibility that whereas an avoidance motor contingency will be triggered by an angry human body movement, there will be no approach motor contingency triggered by a happy human body movement.

We examined whether having a human body might impact perceiving emotional body movements expressed through different body forms. To accomplish this, we had participants categorize emotional body movements under

time-pressure for action, as being angry or happy, for which the respective movements were performed by either a real human body (Experiment 1) or non-human virtual bodies (Experiments 2a & 2b)¹. As a preview, Experiment 1 demonstrated that when observing the movements performed by a human body, participants exhibited biases for identifying behaviors as threatening and executing avoidance motor contingences. It was expected that if perceiving emotional body movements conveyed by different body forms does not impact emotion perception, then participants in Experiments 2a and 2b who observe the same movements performed by non-human virtual bodies should reveal the same biases. In contrast, if different body forms do impact the perception of emotional body movements, the biases found in Experiment 1 would not be expected in the subsequent experiments.

Experiment 1

We first examined whether a threat bias would emerge during the perception of emotional human body movements. Participants were shown one of two short video clips corresponding to a human whose bodily movements either conveyed happiness or anger. Under the instruction to do so as quickly as possible, some participants were required to push a lever if they considered the emotion happy and to pull the same lever if they considered the emotion angry, whereas other participants received the opposite directions. Each participant thus made one response to one video. This method of identifying emotions under time-pressure for action allowed us to measure false alarm rates, given that an incorrect response to one behavior (e.g., happy) corresponded to categorizing it the other behavior (e.g., angry). To the extent that the human body triggered a threat bias, there should be more false alarms misidentifying the happy behavior as angry than false alarms misidentifying the angry behavior as happy. In addition, there should be a greater tendency to activate avoidance motor contingencies in response to the angry behavior than approach motor contingences in response to the happy behavior.

Method

Participants Ninety-five undergraduates.

Materials Two videos approximately 3s in length were used that contained a male human actor behaving either happy or angry, respectively. They were taken from previous research that used these exact behaviors to create virtual characters exhibiting the same body movements, and which also demonstrated that people reliably identified the movements as corresponding to the two emotions (McDonnell et al. 2009). The virtual characters that were created from the human body motions and that were used in Experiments 2a and 2b will be discussed in more detail below.

The filming took place during a motion capture session so that the video and virtual stimuli would be identical in all respects except for changes in body type. Forty-one sensors were placed on the actor who wore a black jumpsuit. The motion capture environment consisted of a floor area that was 4.5m long x 2m wide and a backdrop was 3m high x 2m wide. A Vicon optical system consisting of 10 cameras was used for the motion capture and a digital camcorder was used for the filming. The videos were then edited so that the actor's face and hands were blurred, in order to prevent participants from relying on facial or hand gestures to identify emotions. Stimuli can be viewed at the following website: <http://gv2.cs.tcd.ie/mcdonner/APGV08.htm>. Aside from our critical stimuli, an optical illusion picture that can be perceived as either a young or old woman was used for a practice trial (see Hill 1915).

Design and Procedure Participants sat at a desk equipped with a joystick and 16-inch monitor. They were told that they would be categorizing some items presented on the computer by pushing or pulling the joystick, with their right hand, as quickly as possible. Participants first completed a practice trial, for which they were told that they would be viewing a picture of a woman and that they should push the joystick if they thought she was old, and to pull the joystick if they thought she was young.

Participants received one critical trial, for which emotion (happy, angry) and arm movement (push, pull) was manipulated using a 2 X 2 factorial design, with each factor varying between-subjects. Participants were told that they would be moving the joystick to categorize a short video of a behavior that is either happy or angry. They received one of two versions of instructions that manipulated arm movement direction. One version stated, "If you believe the emotion in the video is angry, push the joystick all the way forward; however, if you believe the emotion in the video is happy, pull the joystick all the way backward." The other version stated, "If you believe the emotion in the video is happy, push the joystick all the way forward; however, if you believe the emotion in the video is angry, pull the joystick all the way backward." E-prime 2.0 (Schneider et al. 2007) was used to record accuracy and the amount of time that elapsed between the presentation of the video and when the joystick reached its maximal point from the baseline position.

Screening & Analyses Reaction times corresponding to correct and incorrect responses were screened separately, using a 2.5 standard deviation criterion from each condition's respective mean. One incorrect response did not meet this criterion and was thus excluded from analyses, which accounted for losing 1% of the data. Two factorial analyses of variance (ANOVA) were carried out, each based on the following design: 2 (emotion: happy, angry) X 2 (arm movement: push, pull). Whereas one ANOVA was carried

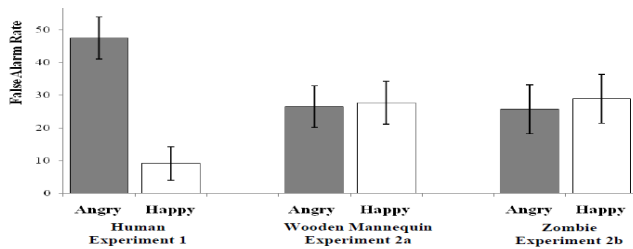
¹ A pilot study was conducted with an independent group of participants (n = 25) to ensure that the bodily movements could be perceived as exhibiting the respective emotions, when they were viewed only once and there was no time-pressure. Participants watched an expression in its entirety and verbally identified at their own pace, the basic emotion they felt was displayed. Each participant did this for each body form and emotion. Results revealed high accuracy, as no errors were made.

out on false alarm rates, the other ANOVA was carried out on reaction times corresponding to correct responses.

Results & Discussion

As illustrated in Fig. 1, the ANOVA on false alarm rates revealed a main effect for emotion, $F(1, 90) = 15.74, p < .001$, indicating that more false alarms were made misidentifying the happy behavior as angry ($M = 47.5; SE = 6.4$), than misidentifying the angry behavior as happy ($M = 9.1; SE = 5.1$). The analysis on false alarm rates revealed no main effect for arm movement, $F(1, 90) = .37, n.s.$, nor interaction between arm movement and emotion, $F(1, 90) = .01, n.s.$

Figure 1: Mean false alarm rates in misidentifying movements as angry when they were happy (solid bars) and misidentifying movements as happy when they were angry (clear bars). Error bars represent standard errors of means.



The ANOVA on reaction times for correct responses revealed no main effects for emotion, $F(1, 58) = 1.30, n.s.$, or movement direction, $F(1, 58) = 1.03, n.s.$, but did reveal an interaction, $F(1, 58) = 4.03, p < .05$ (see Table 1). This interaction is not likely due to a speed-accuracy trade-off given that the ANOVA conducted on false alarm rates revealed no interaction. Participants were faster at pulling than pushing the lever in response to the angry behavior, $t(28) = 2.35, p < .05$; however, although they were also faster at pushing than pulling the lever in response to the happy behavior, this was not significant, $t(30) = .66, n.s.$

Table 1: Means and standard errors for reaction times (in milliseconds) corresponding to correct responses.

	Push		Pull	
	M	SE	M	SE
<i>Human (Experiment 1)</i>				
Happy	2418	(301)	2709	(327)
Angry	2673	(283)	1785	(243)
<i>Wooden Mannequin (Experiment 2a)</i>				
Happy	2151	(261)	2201	(281)
Angry	2542	(252)	2490	(282)
<i>Zombie (Experiment 2b)</i>				
Happy	2791	(277)	2657	(366)
Angry	2373	(289)	2658	(335)

The results extend previous research in emotion and body perception when observing humans. First, the high rate of false alarms in categorizing happy movements as angry, accompanied by the low false alarm rate in categorizing the angry movement as happy, suggest that people exhibit a bias towards identifying emotional body movements performed by humans as threatening. Second, that the angry movement triggered a motor contingency but the happy movement did not, suggests that the identification bias had a downstream influence on behavior via biasing adaptive action plans in the direction of avoidance. These findings are consistent

with the idea that perceivers often act on caution when observing other humans whose bodily movements are emotional, as doing so can help perceivers avoid potential harm. Our data is also compatible with the neuroscience evidence reviewed, which demonstrated that angry but not happy body movements trigger adaptive motor programs.

These results are not likely due to the specific stimuli used in the current experiment. The results of our pilot study, where there was no time-pressure, indicated that people were very accurate at identifying the emotions. Furthermore, for those observing the happy movement, it took longer for making correct responses ($M = 2563; SE = 220$) than incorrect responses ($M = 1764; SE = 101$), $F(1, 59) = 10.18$. This is precisely what would be expected if people were indeed false alarming happy movements as angry, as it suggests that participants had to overcome the threat bias to correctly identify the happy human.

Experiments 2a and 2b

Here, we investigated whether perceiving the same body movements embodied by non-human virtual characters would reproduce the findings of Experiment 1, for which the movements made by a real human body triggered biases in perceiving the movements as a potential threat and executing avoidance motor contingencies. Experiments 2a and 2b used the same method as Experiment 1, but with non-human virtual characters. For Experiment 2a, we chose to present participants with a wooden mannequin, because we wanted to begin with a virtual character that had no obvious positive or negative associations. In contrast, for Experiment 2b, we presented participants with a virtual zombie, reasoning the character might be even more likely to elicit biases towards threat due to the negative connotations associated with zombies.

Method

Participants Whereas 96 undergraduates participated in Experiment 2a, a separate group of 73 undergraduates participated in Experiment 2b.

Materials Four virtual replicas of the human actor from Experiment 1 were used, which consisted of a wooden mannequin behaving happy or angry (Experiment 2a), as well as, a zombie behaving happy or angry (Experiment 2b). Measurements taken from the motion capture session described in Experiment 1 was for rendering the characters in 3D Studio Max. They can be found at the following website: <http://gv2.cs.tcd.ie/mcdonner/APGV08.htm>. As in Experiment 1, face and hands were blurred, in order to prevent participants from relying on facial or hand gestures to identify emotions.

Design and Procedure This was the same as Experiment 1, but those in Experiment 2a observed the wooden mannequin and those in Experiment 2b observed the zombie.

Screening & Analyses This was the same as described in Experiment 1. All responses in Experiment 2a and 2b fell within the criterion and were thus analyzed.

Results & Discussion

Experiment 2a (Wooden Mannequin) As illustrated in Figure 1, the ANOVA conducted on false alarms revealed no main effect for emotion, $F(1, 92) = .02$, n.s., indicating that participants made a comparable number of false alarms misidentifying the happy behavior as angry ($M = 26.5$; $SE = 6.4$) and misidentifying the angry behavior as happy ($M = 27.7$; $SE = 6.6$). There was no main effect for movement direction, $F(1, 92) = .15$, n.s., nor interaction between emotion and arm movement, $F(1, 92) = .33$, n.s.

The ANOVA conducted on reaction times for correct responses revealed no main effect for movement direction, $F(1, 66) = .00$, n.s., no main effect for emotion, $F(1, 66) = 1.58$, n.s., and no interaction, $F(1, 66) = .04$, n.s. (see Table 1 for data).

Experiment 2b (Zombie) As illustrated in Figure 1, the ANOVA conducted on false alarms revealed no main effect for emotion, $F(1, 69) = .10$, n.s., indicating that participants made a comparable number of false alarms misidentifying the happy behavior as angry ($M = 25.7$; $SE = 7.5$) and misidentifying the angry behavior as happy ($M = 28.9$; $SE = 7.5$). There was no main effect for movement direction, $F(1, 69) = .29$, n.s., nor interaction between emotion and arm movement, $F(1, 69) = .89$, n.s.

The ANOVA conducted on reaction times for correct responses revealed no main effect for movement direction, $F(1, 49) = .06$, n.s., no main effect for emotion, $F(1, 49) = .43$, n.s., and no interaction, $F(1, 49) = .44$, n.s. (see Table 1 for data).

There were two critical findings that differed from Experiment 1. First, perceivers exhibited no threat bias when identifying the emotional body movements of a wooden mannequin (Experiment 2a) or a zombie (Experiment 2b). Second, the emotional body movements did not trigger motor contingencies.

False Alarms in Experiment 1 vs. 2a and 2b

To the extent that participants were more biased in perceiving movements as a potential threat when observing the human (Experiment 1) than the Wooden Mannequin (Experiment 2a) or the Zombie (Experiment 2b), those perceiving the human should make the most false alarms misidentifying happy movements as angry and make the fewest false alarms misidentifying angry movements as happy. Two ANOVAs compared false alarms made in response to the happy human, to false alarms made in response to the happy wooden mannequin and the happy zombie; that is, misidentifying the happy movements as angry. Two additional ANOVAs also compared false alarms in response to the angry human, to false alarms made in response to the angry wooden mannequin and the angry zombie; that is, misidentifying angry movements as happy.

Results and Discussion

The ANOVAs conducted on false alarm rates revealed that identifying emotional body movements was affected by the type of body in which the expression was embodied. Compared to false alarms misidentifying the happy human

as angry, there were significantly fewer false alarms misidentifying the happy wooden mannequin as angry, $F(1, 108) = 5.23$, $p < .05$, or the happy zombie as angry, $F(1, 94) = 4.55$, $p < .05$. Furthermore, compared to false alarms misidentifying the angry human as happy, participants made significantly more false alarms misidentifying the angry wooden mannequin as happy, $F(1, 78) = 4.30$, $p < .05$ and the angry zombie as happy, $F(1, 69) = 4.56$, $p < .05$.

Together, these results provide additional evidence that emotional body movements expressed by humans and non-human virtual characters are not treated the same at the visceral level. In particular, they suggest that when observing non-human virtual characters, the need for perceivers to be on alert was significantly less and thus did not trigger a bias in identifying movements as angry.

General Discussion

Our findings indicate that the identification of emotional body movements is not entirely a disembodied process. As reviewed, mapping observed bodily movements onto one's own motor system can play a pivotal role in attributing emotional states to others. It is thus possible that because our participants had human bodies, mappings may have differed in such a way that led them to perceive the human movements as genuinely experiencing anger and having a body that is capable of physical threat. However, that we demonstrated an effect of body form on emotion perception stands in contrast to the study conducted by McDonnell et al. (2009), which used some of the same body forms and movements that were used in the current work. One critical difference between our work and their work is that our participants had to make judgments under time-pressure rather than after extensive viewing. This suggests that embodied processes in body and emotion perception particularly impact judgment calls that are made under time-pressure and that more processing time can improve these processes.

The current work carries implications for theories concerned with how humans perceive real life versus mediated life. For example, it adds to the media equation's hypothesis that perceivers will not treat emotional body movements performed by human bodies and non-human virtual bodies differently. Our pilot data revealed no difference in identifying emotions conveyed by the two types of beings, when there was no time-pressure for action, which is consistent with the media equation. However, our data also revealed that dissimilarities could be found in identifying the exact same emotions, when there was time-pressure for action.

One may wonder to what extent our work is limited, given that each experiment used only two stimuli, as well as, a between-subjects design where participants were given a single trial. A drawback to this approach is that the absence of multiple stimuli could have potentially led to a significant effect that was not controlled for. For example, the happy human might have one subtle difference other than being human that was unconsciously processed, thereby contributing to the emotion being misidentified as angry. This is a common problem among researchers using virtual characters and it is often dealt with by using multiple

methods to examine how results converge. Recent work using a different time-sensitive paradigm corroborates our findings by demonstrating angry body movements are more recognizable in a real human than a virtual human, but that happy body movements are more recognizable in a virtual human than a real human (McHugh, MacDonnell, Chan, & Newell, 2008). Nonetheless, even if a single feature of our stimuli did tip the scale in emotion perception, this would reveal important information concerning how people perceive emotions under time pressure. In particular, it would suggest that such scenarios can result in emotion judgments being tainted by nonessential features. This idea is consistent with past research revealing that the same facial configuration can convey diverse emotions depending upon the context (Aviezer, et al. 2008). Future research should examine whether our findings generalize to other portrayals of the emotions examined in our study, as well as, across different human actors and virtual characters.

Another short-coming of our method is that it could have rendered the reaction time analyses unreliable, due to the fact that reaction time data often varies greatly and requires collecting numerous responses to achieve stability. Aside from being hindered by difficulties in obtaining a sizeable stimulus set, there was a concern that practice effects might emerge from using multiple trials, which could have reduced the chance of findings a potential false alarm effect. We conducted Levene's Test of Equality of Variances on reaction times for correct responses, using the same design (Emotion x Arm Movement) used in each experiment, which revealed no significant differences in between-subject variability in reaction times. Further evidence for the interpretations of our reaction time data can be found by noting how pulling responses to an angry human were quicker than pulling responses to an angry virtual character.

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