Predictive person models elicit motor biases: the face-inhibition effect revisited

SCHOLARONE™
Manuscripts

07/07/2020 12:28

Predictive person models elicit motor biases: the face-inhibition effect revisited

Kimberley C. Schenke[1], Natalie A. Wyer[2], Steven P. Tipper[3], Patric Bach[45]

[1] School of Natural and Social Sciences, University of Gloucestershire, Gloucestershire, UK

[2] Department of Psychology, East Anglia University, Norwich, UK

[3] Department of Psychology, University of York, Yorkshire, UK

[4] School of Psychology, University of Plymouth, Devon, UK

[5] School of Psychology, University of Aberdeen, Aberdeen, UK

* corresponding author kschenke1@glos.ac.uk

Tel: 01242 714559

School of Natural and Social Sciences

University of Gloucestershire

Cheltenham,

Gloucestershire,

GL50 4AZ

United Kingdom

Total word count: 8026 (excluding abstract, figure captions & references)

Key words: embodied cognition, motor priming, person memory, predictive processing, social perception

Disclosure of interest: The authors report no conflicts of interest

1

07/07/2020 12:28

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Abstract

Using an established paradigm (Bach & Tipper, 2007; Tipper & Bach, 2010), we tested

whether people derive motoric predictions about an actor's forthcoming actions from both

prior knowledge about them, and the context in which they are seen. In two experiments,

participants identified famous tennis and soccer players using either hand or foot responses.

Athletes were shown either carrying out or not carrying out their associated actions (swinging,

kicking), either in the context where these actions are typically seen (tennis court, soccer field)

or outside these contexts (beach, awards ceremony). Replicating prior work, identifying non-

acting athletes revealed the negative compatibility effects: viewing tennis players led to faster

responses with a foot than a hand, and vice versa for viewing soccer players. Consistent with

the idea that negative compatibility effects result from the absence of a predicted action, these

effects were eliminated (or reversed) when the athletes were seen carrying out actions

typically associated with them. Strikingly, however, these motoric biases were not limited to

In-Context trials but were, if anything, more robust in the Out-of-Context trials. This pattern

held even when attention was drawn specifically to the context (Experiment 2). These results

confirm that people hold motoric knowledge about the actions that others typically carry out

and that these actions are part of perceptual representations that are accessed when those

others are re-encountered, possibly in order to resolve uncertainty in person perception.

2

07/07/2020 12:28

Predictive person-models elicit motor biases: the face-inhibition effect revisited

Social interactions are highly dynamic and ambiguous. Yet, they require us to rapidly make sense of the internal mental states that drive others' behaviour and respond to them appropriately. Motoric accounts of social perception solve this problem by assuming that others' behaviour is directly mapped onto the observer's own motor system, so that the associated internal states can be accessed and the behaviour can be understood "from the inside" (e.g., Rizzolatti, Cattaneo, Fabbri-destro, & Rozzi, 2014; Giacomo Rizzolatti & Sinigaglia, 2010; Wilson & Knoblich, 2005). Mirror neurons – which fire both when we perform an action, and when we merely observe someone else perform that same action – are assumed to be a central mechanism in this mapping, directly matching incoming kinematic features to corresponding motor programs in the observer (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996).

The robust motoric activation present in behavioural and neuroimaging studies of human action observation (for reviews, see Cracco et al., 2018; Naish, Houston-Price, Bremner, & Holmes, 2014; Oosterhof, Tipper, & Downing, 2013) has been taken as support of this view. For example, simply seeing someone lift a finger facilitates the same finger lift by the observer (Brass, Bekkering, Wohlschlager, & Prinz, 2000; Stürmer, Aschersleben, & Prinz, 2000; for a review, see Cracco et al., 2018). Similarly, viewing someone act with their hand (e.g., typing on a keyboard) or foot (e.g., kicking a football) speeds up the participants' responses with the same body parts (e.g., Bach & Tipper, 2006; Bach, Peatfield, & Tipper, 2007; Gillmeister, Catmur, Liepelt, Brass & Heyes, 2008).

More recently, it has recently been argued that the ambiguity inherent in perceptual input cannot be resolved by such simple bottom-up mechanisms, even in low-level, non-social vision where the mapping is much simpler (e.g., Clark, 2013; Yuille & Kersten, 2006). The

3

07/07/2020 12:28

same social stimulus (e.g., a smile) can have different meanings in different situations (e.g., a polite, happy, or sad smile), and the same internal state can express itself through different behaviours (e.g., experiencing anger can result in either aggressive or avoidant behaviour). More recent approaches therefore cast social perception as a top-down process of hypothesis-testing and revision, in which prior action expectations – derived from various contextual cues, such as facial expressions, nearby objects, or verbal statements – are tested against others' actual behaviour (e.g., Bach, Nicholson & Hudson, 2014; Bach & Schenke, 2017; Hickok, 2009; Kilner, Friston, & Frith, 2007a; Liepelt et al., 2009). In such predictive processing accounts, the robust motor activation during action observation reflects not a bottom-up matching of observed behaviour to own motor representations, but instead an attempt to *predict* the other's most likely action and to test it against what was actually observed (e.g., Hickok, 2009; Kilner et al., 2007; Csibra, 2008; Bach, Nicholson & Hudson, 2014). Recent studies provide direct evidence for such predictions, showing, for example, that attributing goals to others induces predictive perceptual biases in action identification and perceptual judgments (Hudson et al., 2016[ab]; 2017, 2018; McDonough, Hudson, & Bach, 2019; Schenke et al., 2016; see Bach & Schenke, 2017, for a review). Moreover, consistent with motor prediction views, the well-documented motor activation during action observation can reflect actions that are expected but not (yet) observed (Avenanti, Annella, Candidi, Urgesi, & Aglioti, 2013), even on the level of single neurons (Maranesi, Livi, Fogassi, Rizzolatti, & Bonini, 2014; Urgesi et al., 2010). It is sensitive to the (inferred) goal of the action (Liepelt et al., 2009), and is strongest for actions compatible with goal achievement (e.g., Bach, Bayliss & Tipper, 2011).

So far, most research to date has investigated how action predictions are derived from overt cues: the objects surrounding the actor, their gaze, facial expressions or overt intention statements (e.g., Bach, Nicholson & Hudson, 2014; Adams, Ambady, Macrae, & Kleck,

4

07/07/2020 12:28

2006; Bach et al., 2011; Hudson, Nicholson, Ellis, & Bach, 2016; Hudson, Nicholson, Ellis, & Bach, 2015; Hunnius & Bekkering, 2010; Johnston, Miles, & Macrae, 2010; Pierno et al., 2006; Stapel, Hunnius, & Bekkering, 2012). Recently, we and others have argued that the *identity* of the actors themselves could make an important contribution as well (Bach & Schenke, 2017; Schenke, Wyer & Bach, 2016; Barresi & Moore, 1996; Newen, 2015). Humans form sophisticated internal models of how other people behave in different situations, such as which toy our child typically picks, or which wine our spouse prefers (e.g., Schenke et al., 2016; Barresi & Moore, 1996; Newen, 2015; Monroy, Meyer, Gerson & Hunnius, 2017; Buchsbaum, Gopnik, Griffiths, & Shafto, 2011). As soon as such models are established, they can support social interactions by providing information about which actions will be carried out by an individual when they are encountered again in the same situation. Consistent with this view, studies have shown, for example, that people's attention is automatically biased towards the object someone *usually* looks at rather than where they are actually looking (Joyce, Schenke, Bayliss, & Bach, 2015). Moreover, people are faster to identify an action that is typically carried out by one person in a given situation, compared to an action that is typically carried out by someone else (Schenke et al., 2016), and they unconsciously learn another player's idiosyncratic "tells" that predict their actions in gambling (Heerey & Velani, 2010).

Here, we examine whether the activation of internal person models can be tracked not only by perceptual measures, but by motoric activation as well. This hypothesis follows from the idea that people embody their action knowledge of the other person, using their own motor system to *predict* the other person's forthcoming actions (e.g., Csibra, 2008; Kilner et al., 2007ab; Bach et al., 2014; Schenke & Bach, 2017). Prior work from ourselves and others (Bach and Tipper , 2006; Tipper & Bach, 2011; Candidi, Vicario, Abreu, & Aglioti, 2010; Sinnett, Hodges, Chua, & Kingstone, 2011) provides suggestive evidence for just such an

5

effect. In these studies, participants were asked to identify famous soccer and tennis players from their faces with hand or foot responses. The results revealed a negative compatibility effect between the foot and hand responses required of the participant and the hand and foot-centric sports of the athletes. That is, participants responded more slowly with their own hand when identifying tennis players than soccer players and more slowly with their own foot when identifying a soccer than a tennis player. According to predictive processing views, these negative compatibility effects may index a prediction error: the activation of a predicted action that cannot be matched to the actual sensory input in the photographs that showed non-acting athletes. Indeed, the effects reversed (i.e., turned into positive compatibility effects), when, in a later study, the same athletes were shown carrying out the actions they are known for (hitting a tennis ball or kicking a football; Tipper & Bach, 2011).

Here, we test whether this actor-specific modulation of motor output reflects the activation of person-specific internal models for action prediction. One key signature of such person models is that they should not just generally capture the actions that others' typically carry out, but also the situations in which these actions are typically seen in (Bach & Schenke, 2017; Barresi & Moore, 1996). In our case, for example, participants should not only predict that Ronaldo generally kicks a ball, but that he would do so specifically when he is seen on the soccer pitch (but not, say, on the beach). Similarly, a famous tennis player should only be predicted to use the racket on, but not off, the tennis court. Thus, if positive and negative compatibility effects reflect successful and unsuccessful motoric predictions from such situation-specific person models, they should be observed primarily when the athletes are seen in their sporty contexts but less so in neutral contexts where these actions are not expected. This hypothesis has not yet been directly tested in any of the previous studies. For example, while Tipper and Bach (2010) showed acting or not-acting athletes, they did not manipulate whether they were seen within or outside their sports contexts. In contrast, Bach

6

07/07/2020 12:28

& Tipper (2006) did manipulate context, but mostly to increase variability of the stimuli, and only showed not-acting athletes. Moreover, as the stimuli showed mostly the athletes' faces, the sporty and neutral contexts were not salient and no differential compatibility effects were observed.

Here, we report two experiments that adapted the original design to directly test the predictions outlined above. As before, we presented participants with various images of four famous athletes – two tennis players and two soccer players – either carrying out their usual sporting actions (kicking a football, hitting a tennis ball with a racket) or showing them in a neutral pose not related to these behaviours. In a fully factorial design, we varied independently whether these athletes were seen within their typical contexts (e.g., on the tennis court or soccer pitch) or outside those contexts (e.g., at an awards ceremony or at the beach). Participants again identified these athletes using either a finger or foot key press, such that for each participant, one tennis and one soccer player had to be identified with the foot, and the other two athletes with the hand.

This design enables us to confirm, first, whether the athletes' typical behaviour is an embodied component of the observer's person knowledge that is matched against the behaviour that is observed. If so, then, just as in prior research, identifying the famous athletes should induce compatibility effects in opposite directions depending on whether the athletes are seen acting or not-acting: Athletes that are carrying out their usual behaviour should elicit *positive* compatibility effects; they should be identified more quickly with a body part that matches these typical behaviours (e.g., faster foot responses to identify a footballer that a tennis player, and vice versa for hand responses, Bach et al., 2007; Bach & Tipper, 2006; Gillmeister et al., 2008). In contrast, athletes that are seen not-acting should elicit *negative* compatibility effects. They should be identified *more slowly* with the body part

7

that matches their usual motor behaviour, indexing the unexpected absence of these actions (Bach & Tipper, 2006; Tipper & Bach, 2010).

Second, and more importantly, this design allows us to test the novel hypothesis, derived from predictive person model accounts, that these motoric predictions reflect the actions that actors are expected to carry out in a specific situation. If so, then the motoric modulation should be sensitive to the context in which the athletes are observed: both positive and negative compatibility effects should be stronger when the actors are seen in their typical sporty contexts – the soccer field and tennis court – where these behaviours are expected, but less so in more neutral contexts in which they are not.

The current findings will help test predictive person model accounts against competing theories. For example, in associative accounts (Heyes, 2010; Keysers & Perrett, 2004; Hommel, Müsseler, Aschersleben & Prinz, 2001; Hommel, 2019), motor activation during action observation reflects domain-general learning processes that have associated one's motor behaviours to the perceptual effects that reliably go along with them, rather than attempts to test predictions against the perceptual input. Such associative learning mechanisms readily account for the positive compatibility effects elicited by the different athletes, and potentially also by their tennis- and soccer-contexts, as these could simply be linked to the initial motor-action representations via spreading activation. However, they have a hard time accounting for the negative compatibility effects that emerge when the athletes are seen not-acting: if athletes have been associated with different motor behaviours, then these behaviours should be activated – but not inhibited – when the athletes are seen again, even when the actions themselves are not part of the stimulus display.

Another possibility is that actor-related motor activations do not reflect predictions of a specific action in a given situation, but instead reflect more general predictive person

8

07/07/2020 12:28

knowledge that is not linked to a particular context. For example, from watching the athletes play, we might have formed rather general links between them and their typical behaviour: that Rooney and Ronaldo typically kick soccer balls and that Federer and Murray typically hit tennis balls with their rackets, irrespective of whether they are in or out of their sporty contexts. Later on, when re-encountering the athlete, we might rely on these general action expectations to confirm that it is really them that we are seeing. If this were the case, then the positive and negative compatibility effects should be insensitive to the current situation and be observed both when the athletes are seen in their sporting contexts and outside of it. In fact, it could even be the case that such motoric knowledge is recruited particularly when people are seen *outside* their usual context. Encountering someone out of their usual context (e.g., running into one of your students at the supermarket) produces surprise and uncertainty. This uncertainty may, in turn, draw attention and lead to the recruitment of additional processing – including activating the actions the individuals typically carry out – to make sense of the novel situation (e.g., Bar, 2003; Fenske, Aminoff, Gronau, & Bar, 2006; Reichardt, Polner, & Simor, 2020). Context should then have the opposite effects than those assumed by predictive person models: positive and negative compatibility effects should be stronger, not weaker, whenever the athletes are seen outside their usual contexts.

Experiment 1

Experiment 1 tested whether participants' motor systems represent the merely predicted (but not observed) actions of other people, based on our prior knowledge of them. Participants were presented with photographs of famous soccer (Wayne Rooney, Cristiano Ronaldo) and tennis (Andy Murray, Roger Federer) players either acting, or not acting, in a neutral context

9

or in their usual sports context, in a fully counterbalanced factorial design. Participants had to identify these athletes with hand and foot responses, such that one tennis player (e.g., Andy Murray) and one footballer (e.g., Wayne Rooney) had to be identified with a foot response, and the others (e.g., Roger Federer and Cristiano Ronaldo) with a hand response.

The goal of Experiment 1 was, first, to replicate the finding that identifying famous athletes interferes with participants' ability to use the body part used in their sport when they are seen not acting (i.e., the face inhibition effect, Bach & Tipper, 2006), but facilitates similar motor output when they are seen carrying out the expected actions (Tipper & Bach, 2011). Second, and more importantly, it tested whether these effects reflect underlying person models that predict others' behaviour in different situations. If so, then these effects should be context-specific: both the negative and positive compatibility effects should be stronger when the athlete is in their sporty situation (e.g., on a soccer pitch), where such an action is expected, but not in a neutral situation (e.g., at the beach), where these actions are less likely to be seen.

Method

Participants

43 participants (34 female, mean age = 20.86 years, SD= 4.49; 38 right-handed) took part in exchange for course credit. They were recruited based on their self-reported ability to recognise the four athletes. All participants provided written consent. The experiment was approved by the Faculty of Health and Human Sciences Research Ethics Committee at the University of Plymouth prior to data collection [reference number: 14/15-320]. We report all measures, manipulations and exclusions for both experiments. Sample size matched prior studies on this effect (Bach & Tipper, 2006; Tipper & Bach, 2011; Sinnett et al., 2011). Four

10

07/07/2020 12:28

participants had technical difficulties with the foot pedal and were excluded from the analysis. The final sample size provides 80% power to detect medium effect sizes in the predicted direction with $d > .405$, and in either direction with $d > .460$, as determined with a sensitivity analysis using G-Power (Erdfelder, Faul, Lang, & Buchner, 2007). The smallest effect sizes of interest (SESOI; Lakens, Scheel, & Isager, 2018) given the sample size and test are $d = 0.324$ (two-sided) and $d = 0.270$ (one-sided).

Materials and apparatus

The experiment was administered with E-prime 2.0 (Psychology Software Tools, Pittsburgh, PA), running on an Intel i3 CPU, 4GB Memory, 500GB HDD, Windows 10 Professional with a Philips Brilliance 221P monitor set to a resolution of 1024 by 768.

The stimulus set consisted of 32 photographs of four athletes: two well-known soccer players (Wayne Rooney, Cristiano Ronaldo) and two well-known tennis players (Andy Murray, Roger Federer). Each of the four athletes were shown in two photographs for each of the four conditions that resulted from the factorial combination of In-Context and Out-of-Context scenes and acting or not-acting athletes (see Figure 1 for examples). The photographs were sourced from a Google image search and selected such that they showed the athletes' full body with the face easily identifiable. The In-Context photos showed soccer players on the soccer field and tennis players on the tennis court, wearing their usual sports attire. The Out-of-Context images showed the four athletes in any situation other than a tennis court or soccer field, such as at an awards ceremony, a photo shoot, or on the beach. The images were of varying sizes (between 328 and 522 pixels vertically and 169 to 483 pixels horizontally). To prevent laterality effects (Simon, 1969), all images were presented centred in the middle of the screen and each photograph was cropped so that the athlete filled the whole photograph

11

07/07/2020 12:28

from left to right, with the identification-relevant features of body and face centred as much

as possible (see Supplementary Materials for the full stimulus set).

--- Insert Figure 1 about here ---

As in Bach and Tipper (2006), a post-experiment questionnaire asked how often participants

had seen each athlete playing tennis/football, how skilled they thought the athlete was

compared to other professionals within their sport, how talented they thought the athlete

would be at the other sport (e.g., for Andy Murray, participants were asked how talented they

thought he would be at football), and finally how much participants liked each athlete. Each

question was answered on an 8-point Likert scale from -4 to +4 with no zero point.

The social intelligence scale (Silvera, Martinussen, & Dahl, 2001) was administered to test

correlations between self-report measures of social intelligence and response time effects.

However, as there were no statistically reliable correlations for either the negative or positive

compatibility effects, this will not be discussed further.

Procedure

Each trial started with a fixation point in the centre of the screen for between 800 and 1000

ms (randomly chosen) followed by the photograph of one of the athletes in one of the

conditions. This image disappeared as soon as a response was given, up to a maximum

interval of 2000 ms. Participants were instructed to identify the athletes as quickly and as

accurately as possible. One soccer player and one tennis player had to be identified by

12

07/07/2020 12:28

pressing the foot pedal, and the second soccer player and tennis player had to be identified by pressing a key on the keyboard, with the response assignment counterbalanced across four groups of participants. If participants responded correctly, they were shown a blank screen for 300 ms. If not, or if they responded too late, they were given a reminder of which response to use for each athlete for 3000 ms.

As in the prior studies (Bach & Tipper, 2006; Tipper & Bach, 2011) participants were asked to respond with the right hand and the right foot to press centralized response devices. Such a response setup should further safeguard against (Simon-like) laterality effects affecting the results, as such effects are only observed when there is differential lateralization in *both* stimuli and response alternatives (Dolk et al., 2014; Hommel, 1996; Sebanz, Knoblich & Prinz, 2003). In contrast, here, participants responded to centrally presented images (see Stimuli) with two responses that were equally right-lateralized and therefore only differed in whether they involved a foot or hand movement; they should therefore not induce lateralized response effects.

Participants completed 384 trials in total – 12 blocks of the 32 photographs presented in random order. After six blocks, participants were given the opportunity for a break. After the experiment was completed, participants filled out the exit questionnaire and the social intelligence scale and were debriefed and thanked for their participation.

13

Results

Response times

Trials were excluded if they had RTs greater than the trial duration, and if they had RTs greater than three SDs from their condition mean (1.65%). For the analysis of RTs, error trials were additionally excluded (4.79%). The remaining data were averaged by condition for each participant and analysed with a repeated measures ANOVA with the within-subjects factors Context (In-Context, Out-of-Context), Action (Action, Non-Action) and Effector Congruency (congruent with the athlete's typical effector, incongruent with the athlete's typical effector). Group (Rooney/Murray hand and Ronaldo/Federer foot, Rooney/Murray foot and Ronaldo/Federer hand, Ronaldo/Murray hand and Rooney/Federer foot, Ronaldo/Murray foot Rooney/Federer hand), was added as a between subjects factor of no interest to account for variability due to one of the four counterbalancing conditions (which of the tennis/soccer players were identified with the hand and which with the foot).

We predicted that the ANOVA would replicate the two-way interaction of Action and Effector Congruency observed in prior research (Bach & Tipper, 2006; Tipper & Bach, 2011), reflecting that seen and merely predicted actions bias observers' motor systems in the opposite direction, inducing positive and negative compatibility effects, respectively. In addition, we expected compatibility effects to be larger when the athletes are seen in their usual contexts, reflected in a three-way interaction of Context, Action and Effector Congruency. These predicted results will be evaluated against the usual alpha of $p < .05$ (two tailed). Due to alpha-inflation linked to multiple testing in an ANOVA (Cramer et al., 2016), the five other possible main effects and interactions should be evaluated with caution unless they meet a Bonferroni-corrected alpha threshold of $p < .01$ (see Supplementary Materials for a table of the full output).

14

07/07/2020 12:28

As in the original studies (Bach & Tipper, 2006; Tipper & Bach, 2011), the analysis of the

response time data revealed the predicted interaction of Action and Effector Congruency,

$F[1,35] = 5.580$, $p = .024$, $\eta\rho^2 = .138$. Planned comparisons for the Action and Non-Action

trials separately (with Group as a factor of no interest) revealed that this difference mainly

reflected that, in the Non-Action trials, responses were slower for Congruent than

Incongruent trials, $F[1,35] = 5.410$, $p = .026$, $\eta\rho^2 = .134$, replicating the face-inhibition effect.

However, while the Action trials numerically showed the predicted positive compatibility

effect, the difference between Congruent and Incongruent responses was not robust, $F[1,35]$

$=1.251$, $p =.306$. The predicted three-way interaction of Context, Action and Effector

Congruency was not significant, $F[1,35] = .048$, $p = .827$, $\eta\rho^2 = .001$. Indeed, when In-

Context and Out-of-Context trials were analysed separately in planned comparisons, the

crucial interaction of Action and Effector Congruency was, if anything, more robust in the

Out-of-Context trials, $F[1,35] = 3.834$, $p = .058$, $\eta\rho^2 = .099$, than the In-Context trials,

$F[1,35] = 1.241$, $p = .273$, $\eta\rho^2 = .034$, contrary to our predictions.

Aside from these confirmatory hypothesis tests, the ANOVA only revealed a theoretically

uninteresting main effect of Context, $F[1,35] = 80.740$, $p < .001$, $\eta\rho^2 = .698$, with faster

response times for identification of athletes Out-of-Context than In-Context, as well as a main

effect of Action, $F[1,35] = 9.278$, $p = .004$, $\eta\rho^2 = .210$, with faster responses when athletes

were seen performing their action compared to when they were not acting. As in the original

study, these differences probably reflect low-level differences in the stimuli in these

conditions but are independent of our main results. There was no main effect of Effector

Congruency, $F[1,35] = 1.111$, $p = .299$, $\eta\rho^2 = .031$.

--- Insert Figure 2 about here ---

15

07/07/2020 12:28

Error rates

An analogous ANOVA as for the response time was carried out on the error rates (see Table 1) but revealed no theoretically relevant effects.

--- Insert Table 1 about here ---

Correlations with subjective ratings

In the study of Tipper and Bach (2011), the positive compatibility effects when the athletes were seen acting, but not the negative compatibility effects when the athletes were seen not carrying out these actions, correlated with participants' familiarity with the athletes and their evaluation of their skills, with positive compatibility effects being larger for participants that were very familiar with the athletes and judged their skills highly. No correlations were observed with assessments of the athletes' respective other sport (e.g., tennis for Ronaldo), nor for how much the athletes were generally liked. Exactly this pattern was observed here (see Supplementary Materials for a table of the full results). The positive, but not the negative, compatibility effects correlated with the familiarity of the athletes (r=.331, $p =$ .040) and assessments of their skill (r= .381, p = .017), but not with the other measures (r < .180).

Discussion

Experiment 1 tested whether seeing a famous athlete elicits a motoric expectation that they would carry out their sporting actions, and whether these expectations depend upon whether the athlete is seen within or outside his usual sporting contexts. The results replicated

16

07/07/2020 12:28

previous findings that viewing famous athletes influences the observer's motor systems

(Bach & Tipper, 2006; Tipper & Bach, 2011) in a completely new stimulus set. As before,

identifying the athletes when they were not-acting elicited negative compatibility effects.

Participants responded more slowly when identifying the tennis player Andy Murray with a

hand compared to a foot response, for example, and vice versa for the soccer player Cristiano

Ronaldo. Moreover, as in Tipper and Bach (2011), these negative compatibility effects were

eliminated – and turned numerically into positive compatibility effects – when participants

identified the athletes performing their typical actions, in line with the idea that the negative

compatibility effects index a prediction failure: the surprising absence of an action that the

athlete would have been expected to carry out.

Contrary to the predictions of situation-specific internal person models, Experiment 1 did not

provide evidence that these positive and negative compatibility effects would be stronger

when the athletes were seen in their usual sporty context, where they would be most likely to

execute these expected actions. If anything, while this was not supported by a robust

statistical difference, effects were larger and more reliable when the athletes were seen

outside their usual sporting contexts, potentially in line with the idea that seeing the athletes

in unexpected environments draws attention and recruits additional action knowledge about

them.

One reason for the absence of a reliable difference might be that the context manipulation

was not strong enough to induce detectable effects within the current paradigm. The relevant

context may not have been salient enough, and may be activated too late, to influence

responses. Therefore, in Experiment 2, each athlete image was preceded with a short preview

of the context they would be presented with in the next critical image.

17

07/07/2020 12:28

Experiment 2

Experiment 2 sought to enhance the availability of context information in order to more clearly delineate the conditions most likely to produce positive and negative compatibility effects. It therefore provided photographs of the contexts in which the athlete would later be seen (a tennis court, soccer pitch, or one of two beach scenes) for 500 ms. prior to the critical athlete photograph. As before, the following photograph then showed one of the four athletes either carrying out their specific action (kicking or playing tennis) or not carrying out this action in an unusual situation or in their usual sporty context. Participants identified the athletes with a foot or hand response which was either congruent or incongruent with the expected or observed action of the athlete.

As before, we hypothesized that any motoric expectancy effects should be stronger when the athlete is seen in their typical situation (e.g., on a soccer pitch), where they would be expected to perform these actions, compared to a situation, where such an action would be less expected (e.g., at the beach). Thus, the In-Context trials should show that identifying famous athletes interferes with participants' ability to use the body part primarily used in their sport when they are seen not acting, but facilitates similar motor output when they are seen carrying out the expected actions (Bach & Tipper, 2006; Tipper & Bach, 2011). These effects should be absent or reduced when the athletes are seen outside their usual sporty contexts.

Method

Participants

56 participants (35 female, mean age = 21.29 years, SD = 5.28; 49 right-handed) took part in the study in exchange for course credit. All other aspects of the participant selection were

18

07/07/2020 12:28

identical to Experiment 1. Sample size was increased relative to Experiment 1 to be able to

detect potentially smaller effects. This sample size provides 80% power to detect medium

effect sizes in the predicted direction with $d > .336$, and in either direction with $d > .381$, as

determined with a sensitivity analysis using G-Power (Erdfelder et al., 2007), in line with the

effect size of the Action by Effector Congruency interaction observed in Experiment 1 ($d = $

.358). The smallest effect sizes of interest (SESOI; Lakens, Scheel, & Isager, 2018) given the

sample size are $d = 0.268$ (two-sided) and $d = 0.224$ (one-sided).

Materials, apparatus and procedure

The experiment was identical to Experiment 1 except that an additional 'priming' photograph

of either a beach scene or a tennis/soccer scene was now presented for 500 ms prior to the

critical photograph, 509 and 512 pixels wide and 396 and 384 pixels tall. There were four

priming photographs altogether, two showing non-sports environments (two different beach

scenes) for priming the Out-of-Context images, and two showing the two (tennis and soccer)

sports environments for priming the In-Context images. To ensure that the Out-of-Context

scenes were as predictive of the subsequent athlete type as the In-Context scenes, one of the

beach scenes always preceded tennis players and one always preceded soccer players. In

addition, all Out-of-Context photographs now showed the actors on the beach.

--- Insert Figure 3 about here ---

19

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Results

Response times

Trials were excluded as before (5.29% for error trials, 1.83% for scores greater than 3 SD from the mean). The remaining data for each participant were averaged by condition and analysed with a repeated measures ANOVA with the factors Context (In-Context, Out-of-Context), Action (Action, Non-Action) and Effector Congruency (congruent with the athlete's typical effector, incongruent with the athlete's typical effector) with Group (Rooney/Murray hand and Ronaldo/Federer foot identification, Rooney/Murray foot and Ronaldo/Federer hand identification, Ronaldo/Murray hand and Rooney/Federer foot identification, Ronaldo/Murray foot Rooney/Federer hand identification) included as a between subjects factor of no interest.

As in Experiment 1, we predicted a two-way interaction of Action and Effector Congruency (Bach & Tipper, 2006; Tipper & Bach, 2011) and/or a three-way interaction of Context, Action and Effector Congruency. Due to alpha-inflation linked to multiple testing in an ANOVA (Cramer, 2016), the five other possible main effects and interactions should be evaluated with caution unless they meet a Bonferroni-corrected alpha threshold of $p < .01$ (see Supplementary Materials for a table of the full output).

Replicating Experiment 1, and previous experiments (Bach & Tipper, 2006; Tipper & Bach, 2011), the analysis of response times revealed the predicted interaction between Action and Effector Congruency, $F[1,52] = 6.531$, $p = .014$, $\eta\rho^2 = .112$. Planned comparisons revealed faster response times when acting athletes were identified with the Congruent compared to Incongruent effector, $F[1,52] = 4.148$, $p = .047$, $\eta\rho^2 = .074$, showing positive compatibility effects. The negative compatibility effect for identifying non-acting athletes seen in Experiment 1, and previous research (Bach & Tipper, 2006; Tipper & Bach, 2011), were

20

07/07/2020 12:28

present numerically but failed to reach significance, $F[1,52]=2.744$, $p = .104$, $\eta\rho^2 = .050$. The predicted three-way interaction was, again, not significant, $F[1,52] = 1.579$, $p = .215$, $\eta\rho^2 = .029$. As before, and contrary to the predictions of situation-specific person models, when Out-of-Context and In-Context trials were analysed separately in planned comparisons, the crucial interaction of Action and Effector Congruency was statistically robust in the Out-of-Context trials, $F[1,52] = 6.748$, $p = .012$, $\eta\rho^2 = .115$, but not in the In-Context trials, $F[1,52] = 1.434$, $p = .237$, $\eta\rho^2 = .027$.

Beyond these confirmatory hypotheses, the analysis only revealed a theoretically uninteresting main effect of Context, $F[1,52] =14.524$, $p < .001$, $\eta\rho^2 = .218$, but no interaction of Action and Context, $F[1,52] = 5.021$, $p = .029$, $\eta\rho^2 = .088$ and no overall main effects of Effector Congruency, $F[1,52] =.016$, $p = .901$, $\eta\rho^2 < .001$ nor of Action, $F[1,52] = .244$, $p = .624$, $\eta\rho^2 = .005$.

--- Insert Figure 4 about here ---

Error rates

The same ANOVA was conducted on the error data but revealed no theoretically relevant effects (see Supplementary Materials and Table 2).

--- Insert Table 2 about here ---

Correlations with subjective judgments

We again tested whether we would replicate the relationships between the positive compatibility effects and participants' subjective judgments seen in prior research (Bach &

21

07/07/2020 12:28

Tipper, 2006) and Experiment 1 (see Supplementary Materials for a table of the full results). Accordingly, we predicted that the positive compatibility effects when the athletes were seen acting, but not the negative compatibility effects when they were seen not acting, would correlate positively with participants' familiarity with the athletes and their evaluation of their skills. However, this pattern was not replicated in Experiment 2 ($r < .187$, for all), which differed in methodology in the use of the priming context images to Experiment 1 and the prior studies.

Discussion

Experiment 2 showed – as in Experiment 1 and previous studies (Bach & Tipper, 2006; Tipper & Bach, 2011) – that viewing famous athletes did influence the observer's motor systems. As before, seeing the athletes act or not-act, produced compatibility effects in opposite directions. Whilst positive compatibility effects were found when the athletes were seen carrying out their sporty activities, they turned (numerically) into negative compatibility effects when the athletes were seen not carrying out these actions. These findings are in line with the idea that people predict the athletes' forthcoming actions, and that these prediction successes and failures are indexed by positive and negative compatibility effects, respectively. However, we could not confirm that these effects were stronger when the athletes were seen in their usual sporty context, where they would be most likely to execute these expected actions. If anything, effects were more reliable when the athletes were seen in neutral contexts. To estimate the evidence for the presence or absence of the relevant effects, a post-hoc exploratory analysis including Bayesian statistics was conducted on the pooled data from both experiments.

22

Across-experiment analysis

Both experiments provided evidence that identifying famous athletes modulates the

observer's motor system in opposite directions, depending on whether the athletes are seen

acting or not acting. However, neither experiment supported the prediction that the resulting

positive and negative compatibility effects were larger when the athletes were presented in

their usual contexts (e.g., tennis court, soccer field). If anything, the effects were more robust

when the athletes were seen *outside* these contexts (e.g., at the beach). In order to estimate the

extent to which the combined data provide evidence for – or against – a difference between

the two contexts, we conducted an exploratory analysis using both Frequentist and Bayesian

analysis methods that combines the data from both experiments for additional power. This

combination of both experiments (n=95) provides us with 80% power to detect d=.256 (one-

sided) and d=.290 (two-sided), with a smallest effect size of interest of d=.203 (two-sided)

and d=.170 (one-sided).

This analysis also allows us to estimate the robustness of the positive and negative

compatibility effects. While the overall modulation of motor output when seeing acting or

not-acting athletes was robust and present in both experiments, it is not clear whether this

mainly reflects (1) positive compatibility effects when the athletes were seen acting, (2)

negative compatibility effects when they were seen not acting, or (3) both. While the negative

compatibility effects elicited by not-acting athletes were statistically robust in Experiment 1,

they were only present numerically in Experiment 2. Conversely, the positive compatibility

effects for acting athletes were statistically robust in Experiment 2, but only present

numerically in Experiment 1. Combining the data from both experiments will therefore reveal

to what extent the data provide evidence for either effect.

07/07/2020 12:28

We used the same ANOVA model as in Experiments 1 and 2 and applied it to the pooled

data, including the factors Context (In-Context, Out-of-Context), Action (Action, Non-

Action) and Effector Congruency (congruent with athlete's typical effector, incongruent with

athlete's typical effector) with counterbalancing Group and Experiment added as between-

subjects factors of no interest. This ANOVA was run both in Frequentist and Bayesian

versions (using JASP, JASP Team, 2018) to robustly estimate evidence for each effect, and

then further investigated with step-down analyses.

The omnibus ANOVA confirmed the interaction of Action and Effector Congruency that was

present in both experiments, providing considerable evidence that viewing acting or not-

acting athletes induces congruency effects in opposite directions, $F[1,87] = 10.66$, $p = .002$,

$\eta\rho^2 = .109$, $BF_{10} = 3.954$. Step-down analyses showed that this interaction was mainly driven

by the negative compatibility effects when identifying not-acting athletes, $F[1,87] = 8.014$, p

$= .006$, $\eta\rho^2 = .084$, $BF_{10} = 2.604$, but not the positive compatibility effects when seeing them

act, $F[1,87] = 0.485$, $p = .488$, $\eta\rho^2 = .006$, $BF_{10} = 0.220$.

Most importantly, as in the single experiments, the predicted interaction of this effect with

Context was not present, $F[1,87] = 1.33$, $p = .252$, $\eta\rho^2 = .015$, with the Bayesian analysis

providing considerable evidence *against* such a three-way interaction, $BF_{10} = .251$. Indeed,

planned step-down analyses in each context condition separately revealed considerable to

strong evidence for the presence of an interaction of Action and Effector Congruency in the

Out-of-Context trials, $F[1,87] = 10.435$, $p = .002$, $\eta\rho^2 = .107$, $BF_{10} = 9.260$, but anecdotal to

considerable evidence for its *absence* in the In-Context trials, $F[1,87] = 2.448$, $p = .121$, $\eta\rho^2 =$

$.001$, $BF_{10} = 0.367$.

As the pattern is, if anything, opposite to the hypothesis of situation-specific person models

for action prediction we directly compared the contrast values for the critical Action by

24

07/07/2020 12:28

Effector Congruency interaction in the In-Context and Out-of-Context trials against each

other with Bayesian t-tests. This allows one to separately evaluate evidence for the directed

hypotheses that the motoric modulation is either stronger or weaker in the In-Context

compared to the Out-Of-Context trials. This analysis provided strong evidence *against* the

hypothesis that the motoric modulation is situation-specific and larger in the In-Context than

the Out-of-Context trials, BF_{10}=.06, but may leave some (limited) scope that it may

potentially be smaller, BF_{10}=.312.

Together, therefore, this analysis of the pooled data provides evidence for a robust

modulation of the observer's motor system when seeing famous athletes not acting, which is

– against our predictions – not larger when the athletes are seen in their usual contexts. In

fact, the results are mostly driven by seeing these athletes *not* act in Out-of-Context

situations.

General discussion

We tested whether person identification involves activating – *predicting* – the actions that an

individual typically carries out, and whether these predictions rely on the observer's motor

system. In two experiments, participants viewed well-known soccer and tennis players in

their typical contexts (soccer field, tennis court) or outside their typical contexts (e.g., on the

beach), either carrying out their typical actions or in a neutral posture. Participants identified

these individuals by making either foot or hand responses, allowing us to test whether merely

identifying these athletes biases the observer's motor system towards the effector typically

used in their sport, even if this action is not currently observed.

25

07/07/2020 12:28

Both experiments confirmed that identifying famous athletes modulates the observers' motor

systems in opposite directions depending on whether the athletes were seen acting or not-

acting (Bach & Tipper, 2006; Tipper & Bach, 2011; Candidi et al., 2010; Sinnett et al., 2011).

When the athletes were seen *not carrying out their expected actions* we found the expected

negative compatibility effects, such that participants were impaired in using the effector that

was primarily used in the seen athlete's sport, as reported previously (Tipper and Bach; 2011;

Bach & Tipper, 2006; Candidi et al., 2010). Thus, participants were slower to identify a

tennis player (e.g., Andy Murray) with a hand than a foot response, and vice versa for a

famous soccer player (e.g., Cristiano Ronaldo). We also replicated – at least in Experiment 2

– the usual automatic imitation ("mirror") responses when the athletes were seen carrying out

their usual actions, such that participants more quickly identified a soccer player with a foot

response and a tennis player with a hand response (Bach et al., 2007; Gillmeister, Catmur,

Liepelt, Brass, & Heyes, 2008; Tipper & Bach, 2011). Note though that this difference was

not robust in the pooled data across experiments, consistent with the view that these effects

are rarely observed in static displays where no motion draws attention to the observed actions

(e.g., Bach et al., 2006).

The observed modulation of the observer's motor system is consistent with our proposal that

person identification draws not only upon information about the individual's visual features

(e.g., face shape, complexion, etc.) or known traits (Macrae, Quinn, Mason, & Quadflieg,

2005; Quinn, Mason, & Macrae, 2009; Quinn, Mason, & Macrae, 2010), but also information

about their expected behaviours (Schenke et al., 2016; Joyce et al, 2015; for theoretical

arguments, see Bach & Schenke, 2017; Barresi & Moore, 1996). It implies that these action

expectations are represented in an (at least partially) embodied format and are matched

against the behaviour that is actually observed, such that seeing the athletes either carry out or

not-carry out their expected actions facilitates or impairs the use of the relevant body part in

26

07/07/2020 12:28

the observer. Such a reversal is not consistent with the idea that the compatibility effects

reflect mere associations of athletes to motor behaviours, which would have been

independent from the athletes' actual behaviour. Instead, it implies that the positive and

negative compatibility effects reflect either successful or unsuccessful attempts to match

these prior action expectations to the behaviour that was indeed observed.

Strikingly, this opposite modulation of the motor system was not larger when these athletes

were seen in their usual contexts. We had hypothesized that any action expectation should be

strongest when the athletes are seen in situations in which these actions are most likely to

occur – on the soccer field or the tennis court – and weaker outside these contexts. However,

neither of the experiments provided evidence for such a context-based modulation, and the

Bayesian analysis of both experiments together revealed decisive evidence *against* it. If

anything, both the single experiments and the Bayesian across-experiment analysis pointed to

the opposite pattern: there was strong evidence for the signature pattern of positive and

negative compatibility effects only when the athletes were presented *outside* their usual

context (e.g., at the beach), but there was no such evidence when the athletes were seen

within the contexts in which they usually carried out these behaviours (the tennis court, the

soccer field). This counterintuitive pattern was even present in the original study on which

the current work was based (Bach & Tipper, 2006), where the negative compatibility effects

were numerically stronger for athletes' faces identified outside their usual contexts.

Together, while larger samples and/or stronger manipulations are required to establish

whether the motoric modulation is indeed stronger for athletes outside their usual action

contexts, the current data – and Bayesian analyses – provide clear evidence that it is *not*

stronger when athletes are seen within their typical contexts. This result challenges the

hypothesis that the compatibility effects emerge from sophisticated person-models which

27

07/07/2020 12:28

predict the actions an individual is most likely to carry out in a situation (e.g., Barresi & Moore, 1996; Bach & Schenke, 2017; Schenke, Wyer & Bach, 2017). Instead, the effects seem to reflect the re-activation of more stereotypical, not situation-specific action knowledge about the athletes that ultimately serves person identification rather than action prediction or social interaction. In such views, a kick is not predicted because it is the action we expect to see Ronaldo carry out on the soccer field, but simply because it has been a typical feature of this athlete in our prior perceptual experience with him, and can therefore help to confirm that it is really him that we are seeing.

The finding that such cross-checking occurs primarily when these athletes need to be identified outside their usual context fits well to such a view. It is well-established that other people – and objects in general – can be identified from minimal information when we see them in their typical situations that provide converging evidence for person identification (e.g., Davenport & Potter, 2004; Ganis & Kutas, 2003; Young, Hay, & Ellis, 1985). However, seeing them outside these contexts attracts attention and recruits more extensive knowledge about the stimulus to compensate for the increased uncertainty (e.g., Bar, 2003; Fenske, Aminoff, Gronau, & Bar, 2006; Reichardt, Polner, & Simor, 2020). If confirmed by further research, this would suggest that the observed 'mapping' of others' actions onto one's own motor system may not be a default process during social perception, but part of these compensatory activations of person knowledge, which is then actively projected onto the unusual stimulus to confirm – or reject – initial hypotheses about its identity. Note though that this would either require a stronger context manipulation and/or much larger sample sizes ($n > 600$ at the current effect size) to convincingly demonstrate such a stronger motoric modulation in the unusual Out-of-Context trials.

07/07/2020 12:28

Such an account would integrate the compatibility effects during person recognition with the

larger field of person-knowledge, as noted above, but is also consistent with several other

literatures that have argued that the activation of "embodied" knowledge reflects a process of

confirmatory hypothesis testing. For example, Csibra (2007, see also Kilner, Friston & Frith,

2007[ab], Bach, Nicholson & Hudson, 2014) argued that the well-known motor activation

during action observation does not reflect a bottom-up process of identifying the motoric

components of the action, but a top-down verification about whether the observed action fits

the goals we attribute to them. Consistent with such a proposal, these motor activations

depend on observing a goal-directed action (e.g., Liepelt, Von Cramon, & Brass, 2008;

Longo & Bertenthal, 2009; see Bach, Nicholson, & Hudson, 2014 for a review), and increase

the less clear these goals are, consistent with such a secondary verification process (e.g.,

Nicholson, Roser, & Bach, 2017). Even more fundamental visuospatial perspective taking

processes seem to be stronger with unusual contextual information, for example, when

conflict between another's gaze and action need to be resolved (Furlanetto, Cavallo, Manera,

Tversky, & Becchio, 2013) or the other person shows an unusual fearful facial expression, for

which the referent in the real world is unclear (e.g., Zwickel and Müller, 2010). Butterfill and

Apperly (2013) therefore argued for a two-stage approach to theory of mind, in which people

can either be initially 'registered' but not fully represented (e.g., in terms of attitudes, beliefs,

etc.), but which is expanded to more elaborate processing for more complicated or uncertain

situations. The embodiment of the actions that others' typically carry out might therefore be

part of such a secondary recruitment of knowledge that is engaged when the visual input is

uncertain (e.g., when people need to be identified in unusual contexts).

07/07/2020 12:28

Conclusion

We tested whether effector-specific positive and negative compatibility effects when

identifying well-known athletes emerge from person-models that predict this athlete's most

likely forthcoming actions (kicking a soccer ball, hitting a tennis ball). We generally replicate

these effects, showing that the typical actions of others are activated when they are seen, even

when completely irrelevant to the participants' task. We cannot confirm, however, that these

action expectations emerge from an integration of person and situation cues (e.g., Barresi &

Moore, 1996; Bach & Schenke, 2017). Instead, our data suggests that person-specific motor

knowledge is activated because it is a frequently encountered feature when watching these

athletes. We argue that when these individuals are later re-encountered, such as in our task

here, this information is used to confirm – in a perceptual hypothesis-testing process – one's

initial hypotheses about the actor's identity, specifically in uncertain stimulus situations when

the person is not encountered in their typical context.

Supplementary Material

The Supplementary Material is available at: qjep.sagepub.com

30

07/07/2020 12:28

References

Adams, R. B., Ambady, N., Macrae, C. N., & Kleck, R. E. (2006). Emotional expressions
forecast approach-avoidance behavior. *Motivation and Emotion*, *30*(2), 177–186.
https://doi.org/10.1007/s11031-006-9020-2

Avenanti, A., Annella, L., Candidi, M., Urgesi, C., & Aglioti, S. M. (2013). Compensatory
Plasticity in the Action Observation Network: Virtual Lesions of STS Enhance
Anticipatory Simulation of Seen Actions. *Cerebral Cortex (New York, N.Y. : 1991)*,
23(3), 570–580. https://doi.org/10.1093/cercor/bhs040

Bach, P., & Tipper, S. P. (2006). Bend it like Beckham: Embodying the motor skills of
famous athletes. *The Quarterly Journal of Experimental Psychology*, *59*(12), 2033–
2039.

Bach, Patric, Bayliss, A. P., & Tipper, S. P. (2011). The predictive mirror: interactions of
mirror and affordance processes during action observation. *Psychonomic Bulletin &
Review*, *18*(1), 171–176. https://doi.org/10.3758/s13423-010-0029-x

Bach, Patric, Nicholson, T., & Hudson, M. (2014). The affordance-matching hypothesis: how
objects guide action understanding and prediction. *Frontiers in Human Neuroscience*,
8(May), 254. https://doi.org/10.3389/fnhum.2014.00254

Bach, Patric, Peatfield, N. A., & Tipper, S. P. (2007). Focusing on body sites: The role of
spatial attention in action perception. *Experimental Brain Research*, *178*(4), 509–517.
https://doi.org/10.1007/s00221-006-0756-4

Bach, Patric, & Schenke, K. C. (2017). Predictive social perception: Towards a unifying
framework from action observation to person knowledge. *Social and Personality*

31

07/07/2020 12:28

Psychology Compass, *11*(7), e12312. https://doi.org/10.1111/spc3.12312

Bar, M. (2003). A cortical mechanism for triggering top-down facilitation in visual object

recognition. *Journal of Cognitive Neuroscience*, *15*(4), 600–609.

https://doi.org/10.1162/089892903321662976

Barresi, J., & Moore, C. (1996). Intentional relations and social understanding. *Behavioral*

and Brain Sciences, *19*, 107–154. Retrieved from

http://journals.cambridge.org/production/action/cjoGetFulltext?fulltextid=6761980

Brass, M., Bekkering, H., Wohlschlager, A., & Prinz, W. (2000). Compatability between

observed and executed finger movements: comparing symbolic, spatial, and imitative

cues. *Brain and Cognition*, *44*, 124–143.

Buchsbaum, D., Gopnik, A., Griffiths, T. L., & Shafto, P. (2011). Children's imitation of

causal action sequences is influenced by statistical and pedagogical evidence. *Cognition*,

120(3), 331–340. https://doi.org/10.1016/j.cognition.2010.12.001

Butterfill, S. A., & Apperly, I. A. (2013). How to construct a minimal theory of mind. *Mind*

and Language, *28*(5), 606–637. https://doi.org/10.1111/mila.12036

Candidi, M., Vicario, C. M., Abreu, A. M., & Aglioti, S. M. (2010). Competing mechanisms

for mapping action-related categorical knowledge and observed actions. *Cerebral*

Cortex, *20*(12), 2832–2841. https://doi.org/10.1093/cercor/bhq033

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of

cognitive science. *Behavioral and Brain Sciences*, *36*(03), 181–204.

https://doi.org/10.1017/S0140525X12000477

Cracco, E., Bardi, L., Desmet, C., Genschow, O., Rigoni, D., De Coster, L., … Brass, M.

32

07/07/2020 12:28

(2018). Automatic Imitation: A Meta-Analysis. *Psychological Bulletin*, *144*(5), 453–500. Retrieved from 10.1037/bul0000143

Cramer, A. O. J., van Ravenzwaaij, D., Matzke, D., Steingroever, H., Wetzels, R., Grasman, R. P. P. P., … Wagenmakers, E. J. (2016). Hidden multiplicity in exploratory multiway ANOVA: Prevalence and remedies. *Psychonomic Bulletin and Review*, *23*(2), 640–647. https://doi.org/10.3758/s13423-015-0913-5

Davenport, J. L., & Potter, M. C. (2004). Scene consistency in object and background perception. *Psychological Science*, *15*(8), 559–564. https://doi.org/10.1111/j.0956-7976.2004.00719.x

di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., & Rizzolatti, G. (1992). Understanding motor events: a neurophysiological study. *Experimental Brain Research*, *91*, 176–180.

Dolk, T., Hommel, B., Colzato, L. S., Schütz-Bosbach, S., Prinz, W., & Liepelt, R. (2014). The joint Simon effect: a review and theoretical integration. *Frontiers in Psychology*, 5, 974.

Erdfelder, E., Faul, F., Lang, A.-G., & Buchner, A. (2007). GPOWER:A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/BF03193146

Fenske, M. J., Aminoff, E., Gronau, N., & Bar, M. (2006). Top-down facilitation of visual object recognition: object-based and context-based contributions. *Progress in Brain Research*, *155 B*, 3–21. https://doi.org/10.1016/S0079-6123(06)55001-0

Furlanetto, T., Cavallo, A., Manera, V., Tversky, B., & Becchio, C. (2013). Through your eyes: incongruence of gaze and action increases spontaneous perspective taking.

33

07/07/2020 12:28

Frontiers in Human Neuroscience, *7*(August), 1–5.

https://doi.org/10.3389/fnhum.2013.00455

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the

premotor cortex. *Brain : A Journal of Neurology*, *119 (Pt 2*, 593–609. Retrieved from

http://www.ncbi.nlm.nih.gov/pubmed/8800951

Ganis, G., & Kutas, M. (2003). An electrophysiological study of scene effects on object

identification. *Cognitive Brain Research*, *16*(2), 123–144.

https://doi.org/10.1016/S0926-6410(02)00244-6

Gillmeister, H., Catmur, C., Liepelt, R., Brass, M., & Heyes, C. (2008). Experience-based

priming of body parts: a study of action imitation. *Brain Research*, *1217*, 157–170.

https://doi.org/10.1016/j.brainres.2007.12.076

Heerey, E. a., & Velani, H. (2010). Implicit learning of social predictions. *Journal of

Experimental Social Psychology*, *46*(3), 577–581.

https://doi.org/10.1016/j.jesp.2010.01.003

Hickok, G. (2009). Eight problems for the mirror neuron theory of action understanding in

monkeys and humans. *Journal of Cognitive Neuroscience*, *21*(7), 1229–1243.

https://doi.org/10.1162/jocn.2009.21189

Hommel, B. (1996). S-R compatibility effects without response uncertainty. *Q. J. Exp*.

Psychol. 49A, 546–571. doi: 10.1080/713755643

Hommel, B. (2019). Theory of Event Coding (TEC) V2. 0: Representing and controlling

perception and action. *Attention, Perception, & Psychophysics*, 81(7), 2139-2154.

Hudson, M., Nicholson, T., Ellis, R., & Bach, P. (2016). I see what you say: Prior knowledge

34

07/07/2020 12:28

of other's goals automatically biases the perception of their actions. *Cognition*, *146*,
245–250. https://doi.org/10.1016/j.cognition.2015.09.021

Hudson, M., Nicholson, T., W.A., S., Ellis, R., & Bach, P. (2015). One step ahead: the
perceived kinematics of others' actions are biased towards expected goals. *Journal of Experimental Psychology. General*, *145*(1), 1–7.
https://doi.org/10.1017/CBO9781107415324.004

Hunnius, S., & Bekkering, H. (2010). The early development of object knowledge: a study of
infants' visual anticipations during action observation. *Developmental Psychology*,
46(2), 446–454. https://doi.org/10.1037/a0016543

Johnston, L., Miles, L., & Macrae, C. N. (2010). Why are you smiling at me? Social
functions of enjoyment and non-enjoyment smiles. *British Journal of Social Psychology*,
49(1), 107–127. https://doi.org/10.1348/014466609X412476

Joyce, K., Schenke, K., Bayliss, A., & Bach, P. (2015). Looking ahead: Anticipatory cueing
of attention to objects others will look at. *Cognitive Neuroscience*, (July), 1–8.
https://doi.org/10.1080/17588928.2015.1053443

Kilner, J. M., Friston, K. J., & Frith, C. D. (2007). Predictive coding: an account of the mirror
neuron system. *Cognitive Processing*, *8*(3), 159–166. https://doi.org/10.1007/s10339-007-0170-2

Lakens, D., Scheel, A. M., & Isager, P. M. (2018). Equivalence Testing for Psychological
Research : A Tutorial. https://doi.org/10.1177/2515245918770963

Liepelt, R, Ullsperger, M., Obst, K., Spengler, S., von Cramon, D. Y., & Brass, M. (2009).
Contextual movement constraints of others modulate motor preparation in the observer.

35

07/07/2020 12:28

Neuropsychologia, *47*, 268–275.

Liepelt, Roman, Von Cramon, D. Y., & Brass, M. (2008). How do we infer others' goals

from non-stereotypic actions? The outcome of context-sensitive inferential processing in

right inferior parietal and posterior temporal cortex. *NeuroImage*, *43*(4), 784–792.

https://doi.org/10.1016/j.neuroimage.2008.08.007

Longo, M.R., & Bertenthal, B. I. (2009). Attention modulates the specificity of automatic

imitation to human actors. *Experimental Brain Research*, *192*(4), 739–744.

Longo, Matthew R, Kosobud, A., & Bertenthal, B. I. (2008). Automatic Imitation of

Biomechanically Possible and Impossible Actions : Effects of Priming Movements

Versus Goals, *34*(2), 489–501. https://doi.org/10.1037/0096-1523.34.2.489

Macrae, C. N., Quinn, K. A., Mason, M. F., & Quadflieg, S. (2005). Understanding Others :

The Face and Person Construal, *89*(5), 686–695. https://doi.org/10.1037/0022-

3514.89.5.686

Maranesi, M., Livi, A., Fogassi, L., Rizzolatti, G., & Bonini, L. (2014). Mirror Neuron

Activation Prior to Action Observation in a Predictable Context. *Journal of*

Neuroscience, *34*(45), 14827–14832. https://doi.org/10.1523/JNEUROSCI.2705-

14.2014

Naish, K. R., Houston-Price, C., Bremner, A. J., & Holmes, N. P. (2014). Effects of action

observation on corticospinal excitability: Muscle specificity, direction, and timing of the

mirror response. *Neuropsychologia*, *64*, 331–348.

https://doi.org/10.1016/j.neuropsychologia.2014.09.034

Newen, A. (2015). Understanding Others. *Open MIND*, *26*, 1–28.

36

07/07/2020 12:28

https://doi.org/10.15502/9783958570320

Nicholson, T., Roser, M., & Bach, P. (2017). Understanding the Goals of Everyday
Instrumental Actions Is Primarily Linked to Object, Not Motor-Kinematic, Information:
Evidence from fMRI. *Plos One*, *12*(1), e0169700.
https://doi.org/10.1371/journal.pone.0169700

Oosterhof, N. N., Tipper, S. P., & Downing, P. E. (2013). Crossmodal and action-specific:
Neuroimaging the human mirror neuron system. *Trends in Cognitive Sciences*, *17*(7),
311–318. https://doi.org/10.1016/j.tics.2013.04.012

Pierno, A. C., Becchio, C., Wall, M. B., Smith, A. T., Turella, L., & Castiello, U. (2006).
When gaze turns into grasp. *Journal of Cognitive Neuroscience*, *18*(12), 2130–2137.
https://doi.org/10.1162/jocn.2006.18.12.2130

Quinn, K. a., Mason, M. F., & Macrae, C. N. (2009). Familiarity and person construal:
individuating knowledge moderates the automaticicty of category activation. *European
Journal of Social Psychology*, *39*, 852–861. https://doi.org/10.1002/ejsp.596

Quinn, K. A., Mason, M. F., & Macrae, C. N. (2010). When Arnold is '" The Terminator "',
We No Longer See Him as a Man The Temporal Determinants of Person Perception,
57(1), 27–35. https://doi.org/10.1027/1618-3169/a000004

Reichardt, R., Polner, B., & Simor, P. (2020). Novelty Manipulations , Memory Performance
, and Predictive Coding : the Role of Unexpectedness, *14*(April), 1–11.
https://doi.org/10.3389/fnhum.2020.00152

Rizzolatti, G, Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the
recognition of motor actions. *Brain Research. Cognitive Brain Research*, *3*(2), 131–141.

37

07/07/2020 12:28

Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8713554

Rizzolatti, Giacomo, Cattaneo, L., Fabbri-destro, M., & Rozzi, S. (2014). Cortical

mechanisms underlying the organization of goal-directed actions and understanding C.

Physiol Rev, *94*, 655–706. https://doi.org/10.1152/physrev.00009.2013

Rizzolatti, Giacomo, & Craighero, L. (2004). The mirror-neuron system. *Annual Review of*

Neuroscience, *27*, 169–192. https://doi.org/10.1146/annurev.neuro.27.070203.144230

Rizzolatti, Giacomo, & Sinigaglia, C. (2010). The functional role of the parieto-frontal mirror

circuit : interpretations and misinterpretations, *9*(March), 1–11.

https://doi.org/10.1038/nrn2805

Schenke, K. C., Wyer, N. A., & Bach, P. (2016). The Things You Do: Internal Models of

Others' Expected Behaviour Guide Action Observation. *Plos One*, *11*(7), e0158910.

https://doi.org/10.1371/journal.pone.0158910

Sebanz, N., Knoblich, G., & Prinz, W. (2003). Representing others' actions: just like one's

own?. *Cognition*, 88(3), B11-B21.

Silvera, D. H., Martinussen, M., & Dahl, T. I. (2001). The Tromso Social Intelligence Scale,

a self-report measure of social intelligence. *Scandanavian Journal of Psychology*, *42*,

313–319.

Simon, J. R. (1969). Reactions toward the source of stimulation. *Journal of Experimental*

Psychology, 81(1), 174.

Sinnett, S., Hodges, N. J., Chua, R., & Kingstone, A. (2011). Embodiment of motor skills

when observing expert and novice athletes. *Quarterly Journal of Experimental*

Psychology (2006), *64*(4), 657–668. https://doi.org/10.1080/17470218.2010.513736

38

07/07/2020 12:28

Sparenberg, P., Springer, A., & Prinz, W. (2012). Predicting others' actions: Evidence for a

constant time delay in action simulation. *Psychological Research*, *76*(1), 41–49.

https://doi.org/10.1007/s00426-011-0321-z

Stapel, J. C., Hunnius, S., & Bekkering, H. (2012). Online prediction of others' actions: The

contribution of the target object, action context and movement kinematics.

Psychological Research, *76*(4), 434–445. https://doi.org/10.1007/s00426-012-0423-2

Stürmer, B., Aschersleben, G., & Prinz, W. (2000). Correspondence effects with manual

gestures and postures: a study of imitation. *Journal of Experimental Psychology. Human

Perception and Performance*, *26*(6), 1746–1759. https://doi.org/10.1037/0096-

1523.26.6.1746

Tipper, S. P., & Bach, P. (2011). The face inhibition effect: social contrast or motor

competition? *Journal of Cognitive Psychology*, *23*(1).

Urgesi, C., Maieron, M., Avenanti, A., Tidoni, E., Fabbro, F., & Aglioti, S. M. (2010).

Simulating the Future of Actions in the Human Corticospinal System. *Cerebral Cortex*,

20, 2511–2521.

Wilson, M., & Knoblich, G. (2005). The Case for Motor Involvement in Perceiving

Conspecifics. *Psychological Bulletin*, *131*(2), 460–473.

Young, A. W., Hay, D. C., & Ellis, A. W. (1985). The faces that launched a thousand slips:

Everyday difficulties and errors in recognizing people. *British Journal of Psychology*,

76, 495–523.

Yuille, A., & Kersten, D. (2006). Vision as Bayesian inference: analysis by synthesis? *Trends

in Cognitive Sciences*, *10*(7), 301–308. https://doi.org/10.1016/j.tics.2006.05.002

07/07/2020 12:28

Zwickel, J., & Müller, H. J. (2010). Observing fearful faces leads to visuo-spatial perspective

taking. *Cognition*, *117*(1), 101–105. https://doi.org/10.1016/j.cognition.2010.07.004

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

40

07/07/2020 12:28

Figure Captions

Figure 1. Examples of the athlete stimuli, showing well-known tennis and soccer players either carrying out their typical actions (left two columns) or not carrying out these actions (right two columns), in either their usual contexts (top row) or outside these contexts (bottom row). Note that the stimulus images shown here are vectorized schematics but were presented as high-resolution photographs in the experiments.

Figure 2. Average response times for Experiment 1. The top panel shows average response times in the In-Context conditions, and the bottom panel shows average response times in the Out-of-Context condition. In each panel, the left bars reflect identification times of athletes carrying out their typical actions, and the right bars represent them not carrying out these actions. The black bars show identification with a congruent effector, and the white bars show identification with an incongruent effector. Error bars show the between-subjects standard error of the mean.

Figure 3. Trial sequence. A fixation point was presented for 800-100ms (randomly chosen), this was followed by a context priming image (either a beach scene or a tennis court/soccer pitch) presented for 500 ms. Finally, the image of the athlete was shown (either performing their typical action or not and either in their usual sporty context or not). Note that the stimulus images shown here are schematics but were presented as high-resolution photographs in the experiments.

Figure 4. Average response times for Experiment 2. The top panel shows average response times in the In-Context conditions, and the bottom panel shows average response times in the Out-of-Context condition. In each panel, the left bars reflect identification times of athletes carrying out their typical actions, and the right bars represent them not carrying out these actions. The black bars show identification with a Congruent effector, and the white bars show identification with an Incongruent effector. Error bars show the between-subjects standard error of the mean.
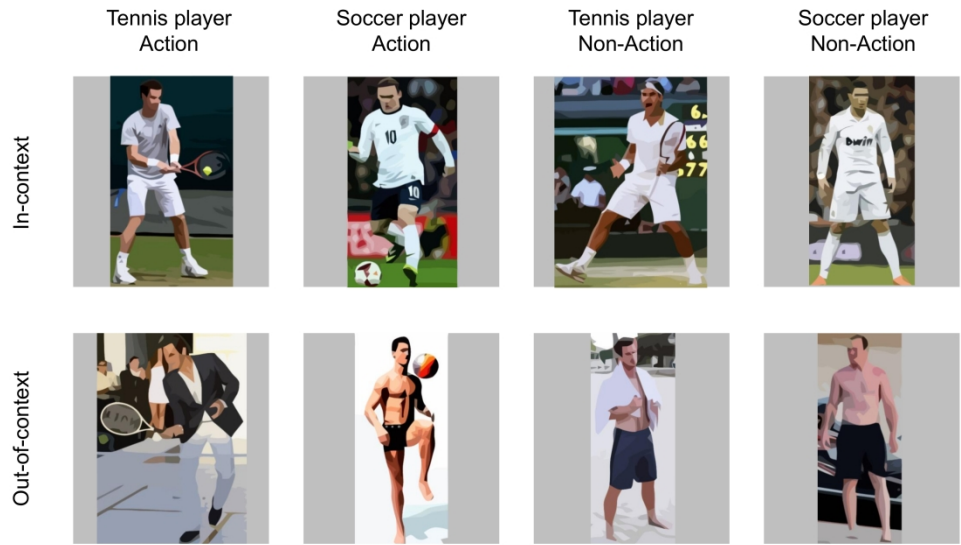
41

Figure 1. Examples of the athlete stimuli, showing well-known tennis and soccer players either carrying out their typical actions (left two columns) or not carrying out these actions (right two columns), in either their usual contexts (top row) or outside these contexts (bottom row). Note that that the stimulus images shown here are vectorized schematics but were presented as high-resolution photographs in the experiments.

297x177mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
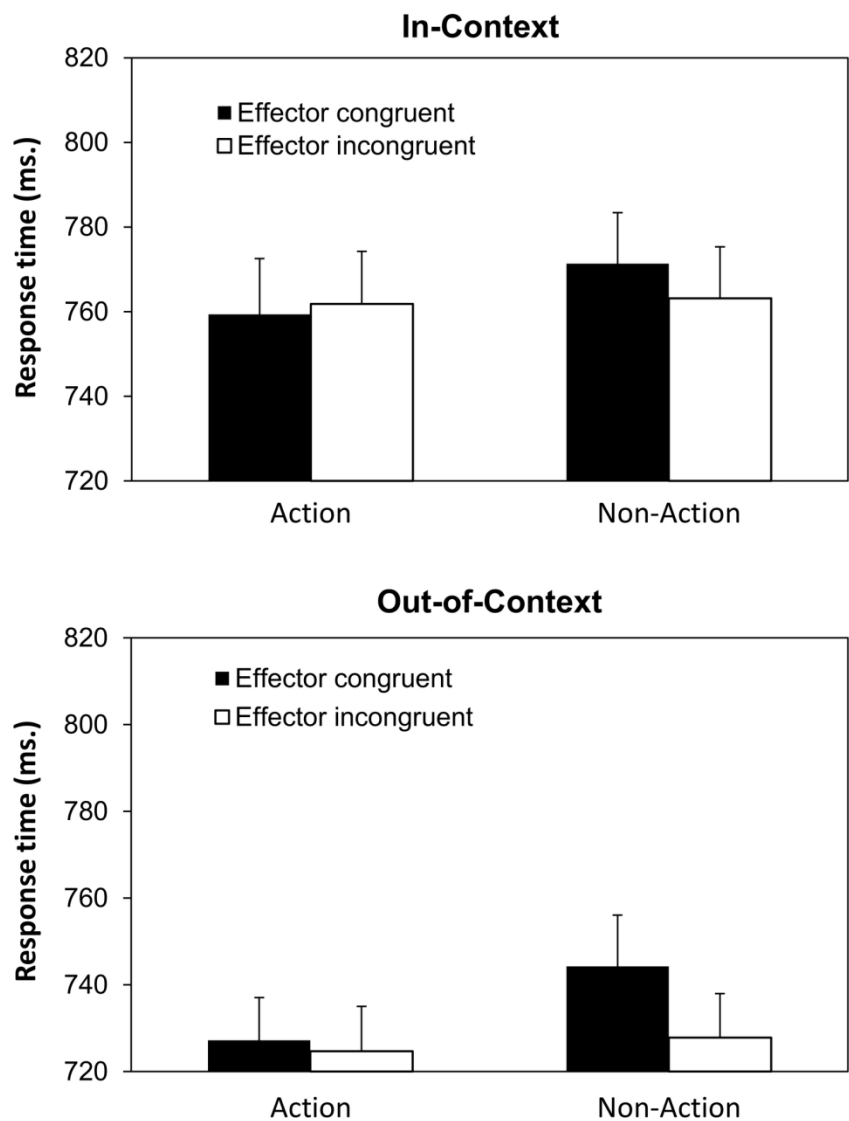51
52
53
54
55
56
57
58
59
60

Figure 2. Average response times for Experiment 1. The top panel shows average response times in the In-Context conditions, and the bottom panel shows average response times in the Out-of-Context condition. In each panel, the left bars reflect identification times of athletes carrying out their typical actions, and the right bars represent them not carrying out these actions. The black bars show identification with a congruent effector, and the white bars show identification with an incongruent effector. Error bars show the between-subjects standard error of the mean.

148x190mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

800 ms – 1000 ms
(randomly chosen)

500 ms

Up to 2000 ms

Figure 3. Trial sequence. A fixation point was presented for 800-100ms (randomly chosen), this was followed by a context priming image (either a beach scene or a tennis court/soccer pitch) presented for 500 ms. Finally, the image of the athlete was shown (either performing their typical action or not and either in their usual sporty context or not). Note that the stimulus images shown here are schematics but were presented as high-resolution photographs in the experiments.

284x154mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
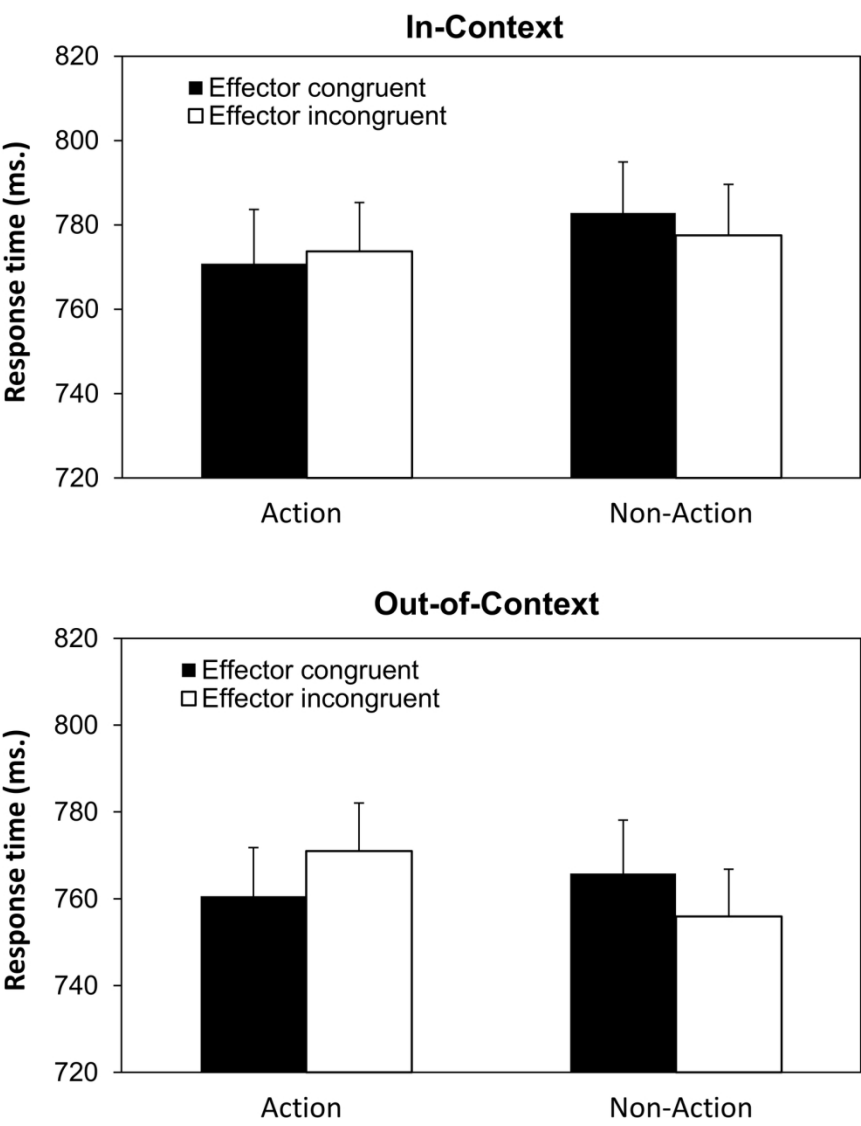51
52
53
54
55
56
57
58
59
60

Figure 4. Average response times for Experiment 2. The top panel shows average response times in the In-Context conditions, and the bottom panel shows average response times in the Out-of-Context condition. In each panel, the left bars reflect identification times of athletes carrying out their typical actions, and the right bars represent them not carrying out these actions. The black bars show identification with a Congruent effector, and the white bars show identification with an Incongruent effector. Error bars show the between-subjects standard error of the mean.

152x190mm (300 x 300 DPI)

Table 1. *Mean proportion of errors in Experiment 1. Values in brackets show standard deviations.*

	Action		Non-action	
	Effector Congruent	Effector Incongruent	Effector Congruent	Effector Incongruent
In-Context	.053 (.037)	.060 (.035)	.046 (.040)	.057 (.046)
Out-of-Context	.040 (.034)	.040 (.033)	.040 (.037)	.041 (.031)

Table 2. *The mean proportion of errors in Experiment 2. Values in brackets show standard deviations.*

	Action		Non-action	
	Effector congruent	Effector incongruent	Effector congruent	Effector incongruent
In-Context	.046 (.036)	.047 (.032)	.038 (.035)	.038 (.035)
Out-of-Context	.034 (.030)	.034 (.031)	.030 (.028)	.040 (.035)