Can the early visual processing of others' actions be related to social power and dominance

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The authors have no relevant financial or non-financial interests to disclose. The present study involves human participants, and was approved by the Ethical committee of Lille University. Participants gave their informed consent before the beginning of the study.

Author contributions:

The experiment was conceptualized and designed by Jérémy Decroix, Nicolas Morgado and Solène Kalénine. Material preparation and data collection were performed by Jérémy Decroix. Data analyses were performed by Laurent Ott. The first draft of the manuscript was written by Jérémy Decroix and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Abstract:

Although goals often drive action understanding, this ability is also prone to important variability among individuals, which may have its origin in individual social characteristics. The present study aimed at evaluating the relationship between the tendency to prioritize goal information over grip information during early visual processing of action and several social dimensions. Visual processing of grip and goal information during action recognition was evaluated in sixty-four participants using the priming protocol developed by Decroix and Kalénine (2018). Object-directed action photographs were primed by photographs sharing the same goal and/or the same grip. The effects of goal and grip priming on action recognition were evaluated for different prime durations. The same participants further fulfilled questionnaires characterizing the way individuals deal with their social environment, namely their sense of social power, dominance, perspective taking, and construal level. At the group level, results confirmed greater goal than grip priming effects on action recognition for the shortest prime duration. Regression analyses between the pattern of response times in the action priming protocol and scores at the questionnaires further showed that the advantage of goal over grip priming was associated with higher sense of social power, and possibly to lower dominance. Overall, data confirm that observers tend to prioritize goal-related information when processing visual actions but further indicate that this tendency is sensitive to individual social characteristics. Results suggest that goal information may not always drive action understanding and point out the connection between low-level processing of observed actions and more general individual characteristics.

Keywords: action perception, action goal, social power, dominance, perspective taking

Introduction

Understanding others' actions is a core ability of human beings and is considered as an important basis of social cognition (Jacob & Jeannerod, 2005; Kilner, 2011). Yet actions are not mere movements performed without purpose. They are organized and goal-directed movements. When people reach for and grasp a glass of water (i.e., the motor act), they usually do it for drinking (i.e., the goal). Therefore, understanding an action implies recognizing both the movement kinematics (including static and dynamic aspects of the movement) and the functional goal of the action (Bach & Schenke, 2017; Csibra, 2008; Jacob & Jeannerod, 2005; Kilner, 2011; Ondobaka & Bekkering, 2013; Vallacher & Wegner, 2012; Zacks et al., 2001).

Goals are thought to be particularly important in action understanding (Bach et al., 2014; Csibra, 2008; Kilner, 2011; Rizzolatti & Fogassi, 2014), and more generally in social cognition (Moskowitz & Olcaysoy Okten, 2016; Olcaysoy Okten & Moskowitz, 2020). Empirical evidence has repeatedly shown that observers mostly understand others' actions in terms of goals (Baldwin et al., 2001; Buresh & Woodward, 2007; Hrkać et al., 2014; Novack et al., 2016; Novack & Goldin-Meadow, 2016; Vallacher & Wegner, 1987, 1989; Zacks et al., 2001; Zacks & Tversky, 2001) and tend to implicitly infer and adopt others' goals (Aarts et al., 2004; Hassin et al., 2005; Laurin, 2016; Moskowitz & Olcaysoy Okten, 2016; Olcaysoy Okten & Moskowitz, 2018). The importance of goals have been particularly endorsed by predictive approaches of action understanding (Donnarumma et al., 2017; Kilner, 2011; Kilner et al., 2007; Westra, 2019). According to these approaches, goals are not only important to understand others' actions overall, but directly lead the process. Consistent with predictive approaches, we recently demonstrated that observers first rely on goal-related information before relying on kinematic parameters when processing object-directed action photographs (Decroix, Roger, et al., 2020; Decroix & Kalénine, 2018, 2019). In particular, we found that action recognition was facilitated after being primed by actions sharing the same visual goal information but not after being

primed by actions sharing the same grip (the kinematic parameter of interest in this experiment) when the prime duration was very brief (Decroix & Kalénine, 2018). Overall, these results support the leading role of goals during action understanding. The present paper aims at evaluating the consistency of this general pattern.

As recently highlighted by Spaulding (2018), action understanding is not unequivocal. In daily life situations, it is common to find one person interpreting a behavior (e.g., holding a piece of fruit in hand while walking on the street) as being aggressive (e.g., intend to through it in the face) and another person interpreting the same behavior in the same situation as being harmless (e.g., intend to eat it). Yet most models of action understanding do not take into account such variability: two different observers should end up with the same interpretation of the action if the available pieces of information are the same. Several authors have started to consider that interindividual differences could have their roots within the personal knowledge and social characteristics of the observers (Bach & Schenke, 2017; Spaulding, 2018; Westra, 2019). In particular, the observers' personal way to deal with their social environment could influence the way they understand others' actions (Fiebich & Coltheart, 2015; Spaulding, 2018; Westra, 2019). This proposal has originally been developed in the literature on mental state attributions rather than action understanding per se. Nonetheless, some data now suggest that this is also the case for action understanding. For instance, knowing that an actor likes to play basketball affects the processing of his/her visual kinematics (Schenke et al., 2016). Similarly, Marsh et al. (2010) found that the brain activity recorded with *f*MRI when reading sentences describing actions is modulated by the valence of the actor (i.e., whether the actor is likable or not). The extent to which the observers' dispositions, and, in particular, the way they deal with their social environment, penetrate action understanding remains to determine.

To investigate this question, we followed-up on the work previously reported in Decroix and Kalénine (2018) and related effects in the action priming protocol to scores of

questionnaires evaluating individual social characteristics. In the action priming protocol, object-directed action photographs are briefly primed with action photographs sharing similar grip configuration and/or similar visual goal. We previously observed that at the earliest prime duration, target action photographs were faster to recognize when preceded by primes sharing a similar visual goal than when preceded by primes sharing a similar grip. These results suggested that in general, observers rely on goal information early in the visual processing of others' actions. In the present study, we evaluated action priming effects at the group level but also at the individual level in order to determine to what extent each individual relies on goals rather than grip when processing visual actions. As the individual dispositions of the observers are thought to penetrate and influence action understanding even during the first steps of visual processing (Bach & Schenke, 2017; Westra, 2019), we reasoned that the observers' social characteristics could influence the balance between goal and grip information. In this line, individual social characteristics has been proposed as an important source of inter-individual differences (Spaulding, 2018; Westra, 2019). The present study explored the influence of two important sources of individual social characteristics: social power and perspective taking abilities.

In the literature on social cognition, social status (i.e., the prestige, respect and esteem granted to someone by its surrounding; Blader & Chen, 2014) and social power (i.e., one's capacity to control resources or to influence others; Anderson et al., 2012) have often been considered as they provide a general overview of how individuals are dealing with their social environment (Berger, 2008; Blader & Chen, 2014; Witkower et al., 2020). In this direction, several pieces of evidence show that social power and social status affect the spontaneous tendency to infer and adopt others' goals (Chiu et al., 2017; Jia et al., 2018; Wessler & Hansen, 2016). Usually, higher social power and higher social status are associated with a lower tendency to infer and adopt others' goals. In the action understanding literature, perspective

taking is the most considered social characteristics of individuals. Perspective taking is indeed an important component of action understanding and social cognition, as being able to dissociate oneself from others is needed to successfully understand others' actions (Bird & Viding, 2014; Deschrijver & Palmer, 2020; Quesque & Brass, 2019). Perspective taking has been related to the amount of motor activation during action perception, and higher tendencies to take the perspective of others is usually found to be positively associated with the amount of motor activation (Borgomaneri et al., 2015; Y. Cheng et al., 2008; Gazzola et al., 2006; Pfeifer et al., 2008; but see DiGirolamo, Simon, Hubley, Kopulsky & Gutsell, 2019). These results are often used to justify the relationship between the motor system and the ability to understand others' action goals (Dapretto et al., 2006; Rizzolatti & Fogassi, 2014). Interestingly, perspective taking and social power have also been related to one another (Galinsky et al., 2006, 2016; Smith & Galinsky, 2010) and social power is even reflected in the motor behaviors of the power holders (Witkower et al., 2020). Social power is indeed thought to impair perspective taking, as taking and maintaining one's power require, to some extent, to ignore others (Galinsky et al., 2006; Jia et al., 2018). As such, higher sense of social power is associated with a lower tendency to take the perspective of others (Galinsky et al., 2006; Jia et al., 2018), although these effects could rather be due to the use of a dominant strategy rather than social power per se (Blader et al., 2016). Given the importance of social power and perspective taking in the literature on action understanding and social cognition, we decided to focus on these two constructs and evaluate whether individual variability on these social characteristics could modulate the priority of goal processing during action understanding.

Although evaluating the relationship between general social characteristics and low-level visual processing of action dimensions is rather exploratory, hypotheses on the direction of this relationship, if present, can easily be derived from the above considerations. Sense of social power (Anderson et al., 2012) is usually negatively associated with goal inference, and

should thus be negatively associated with goal priority. Some authors have argued that the effects related to social power are better accounted for by the actual use of dominant strategy than by the sense of social power itself (Blader et al., 2016). Therefore, we added a measure of dominance (J. T. Cheng et al., 2010) as a possible alternative candidate, but with similar predictions. Regarding perspective taking (Davis, 1983; Gilet et al., 2013), it has been positively associated with better goal recognition, and should thus be positively associated with goal priority. Finally, we also added a measure of the level of construal in action understanding (Vallacher & Wegner, 1989). The level of construal refers, roughly, to the level of abstraction at which observers represent others' actions. The level of abstraction of action representation is thought to be more generally related to the level of psychological distance (Trope & Liberman, 2010; Wessler & Hansen, 2016), namely the tendency to move farther away from here and now. As taking the perspective of others also requires to move farther away from here and now, the level of construal might capture perspective taking abilities more generally and should be positively associated with goal priority.

Methodology

Participants

Sixty-four healthy participants took part in the study (M_{age} = 21, from 18 to 39; 32 females). We conducted an a priori power analysis based on the plot_power function from the 0.1.1. version of the "Superpower" package (Lakens & Caldwell, 2021) to determine a reasonable sample size to increase the chance to detect the difference between grip and goal priming effects. The analysis indicated that 62 participants ensured sufficient statistical power (.80) to detect at the bilateral alpha threshold .05 the Grip similarity x Goal similarity interaction (partial-eta squared 0.14) reported in Decroix & Kalénine (2018). We subsequently performed an a priori power sensitivity analyses on correlations to identify the effect size we should be

able to detect using the pwr.r.test function from the 1.3-0 version of the "pwr" package (Champely, 2020). The analysis indicated that 60 participants would allow the detection of moderate correlations (r ~ .35) with power at .80 and a bilateral alpha threshold at .05. All participants were right-handed ($M_{\text{Edinbrugh Handedness Inventory}}$ = 86 % , from 40 % to 100 %; Oldfield, 1971) and reported normal or corrected-to-normal vision. We discarded the data of one participant because of missing responses for the questionnaires. The participants provided written informed consent and received 10 € for their participation. The protocol was approved by the Ethical Committee of the University of Lille (reference number 2018-268-S58) and was in accordance with the declaration of Helsinki (1964, revised in 2013). Materials and data for the study are available at doi.org/10.17605/osf.io/ythra.

Apparatus and Procedure

The present study was divided in two main phases. First, participants performed a similar priming paradigm as the one used by Decroix and Kalénine (2018). Second, they completed a series of questionnaires. The questionnaires were ordered from the most implicit to the least implicit. We first assessed the level of construal of the participants using the Behavioral Identification Form (BIF; Vallacher & Wegner, 1989) followed by their perspective taking abilities using the Interpersonal Reactivity Index (IRI; Davis, 1983). Right after these two first questionnaires, we assessed their sense of power using the personal sense of power scale (Anderson et al., 2012) and their dominant social strategy using the dominance questionnaire (J. T. Cheng et al., 2010) in a counterbalanced order between participants. The overall experiment lasted about one hour and a half. All materials can be found at doi.org/10.17605/osf.io/ythra.

Action priming paradigm:

Stimuli: Twenty reference objects were selected. For each reference object, four 1024 x 683-pixel photographs presented hand-on-object actions and were designed by crossing the typicality of the grip configuration and the typicality of the visual goal of the action as in Decroix and Kalénine (2018). The only difference with the previous study was that the hand and the object were the only visible elements on the photograph and the upper body of the actress was not displayed. The grip configuration could be consistent with the typical manipulation of the object or not. The visual goal could be consistent with the typical functional goal associated with the object or not. Importantly, the typical goal could still be achieved even when the grip was atypical and vice-versa. Thus, an upside-down pencil can still be handled with a precision grip (typical grip), though it is not possible to use it to write (atypical goal). Inversely, an upright pencil can still be used to write (typical goal) even when handled with a power grasp (atypical grip). Overall, there were four types of photographs: "typical grip/typical goal"; "atypical grip/typical goal"; "typical grip/atypical goal"; "atypical grip/ atypical goal". Stimuli are presented in Figure 1.

For each action photograph, nine participants who were not considered in the final sample were asked to determine whether the action was correct or not according to the typical use of the object. We chose the word "use" ("utilisation" in French) as it refers to both the visual kinematic component of the action (i.e., "how to use the object") and the goal component of the action (i.e., "what the object is used for"). The pre-test confirmed that participants considered both the grip typicality and the goal typicality in their judgment when determining the overall correctness of the action, as they successfully classified actions with either one or both atypical dimensions as being incorrect. A Chi-square test for independence indicated that performance was equally distributed between conditions, $\chi^2(3) = 0.55$, $p = .907$.

Priming procedure: The photographs were implemented in a priming protocol in which a target was preceded by a prime. The four types of photographs could be used as primes. Only the fully typical actions (typical grip/typical goal; correct action) or the fully atypical actions (atypical grip/atypical goal; incorrect action) were presented as targets. Therefore, for each reference object there were four prime-target relations: "grip similar/goal similar"; "grip similar/goal dissimilar"; "grip dissimilar/goal dissimilar"; "grip dissimilar/goal dissimilar". The object was always kept the same across the four types of prime-target relations so that the identity of the object was kept constant across conditions. Participants had to judge whether the target action was correct ("yes" response) or incorrect ("no" response) according to the typical use of the object. In addition to the prime-target relations, we also varied the duration of the prime. Primes could last either 66 ms or 220 ms following Decroix and Kalénine (2018). The shortest prime duration was of primary interest as it allowed us to evaluate the relative priority given to grip and goal dimensions during the first processing steps of observed actions.

Overall, there was a total of 320 trials by crossing two grip similarities (grip-similar; grip-dissimilar), two goal similarities (goal-similar; goal-dissimilar), two target correctness (yes = "correct target"; no = "incorrect target"), two prime durations (66 or 220), and 20 objects. The 320 trials were randomly divided into four blocks.

Control measure of perceptual similarity: To assess potential differences in terms of low-level visual features between prime-target pairs in the different conditions, an objective index of perceptual similarity was computed between each prime-target pair (Zhang et al., 2011). For correct and incorrect target, prime-target pairs sharing the same grip were perceptually more similar than prime-target pairs not sharing the same grip (correct target: mean difference = 0.051, 95% CI [0.045 – 0.061], $t(19) = 13.173$, $p < .001$; incorrect target: mean difference = 0.037, 95% CI [0.028 – 0.047], $t(19) = 8.117$, $p < .001$). Similarly, prime-target pairs sharing the same goal were more perceptually similar than prime-target pairs not sharing

the same goal (correct target: mean difference = 0.039, 95% CI [0.030 – 0.049], $t(19) = 8.667$, $p < .001$; incorrect target: mean difference = 0.055, 95% CI [0.046 – 0.064], $t(19) = 12.787$, $p < .001$). It might not be surprising that prime-target pairs sharing the same dimensions are more perceptually similar than prime-target pairs that do not. Importantly, however, the perceptual similarity advantage is highly similar for both grip and goal similar conditions. Therefore, this situation may facilitate the emergence of grip and goal priming effects but unlikely explain any differences between the two priming effects. Nonetheless for a strict control of perceptual similarity variations, these scores will be taken into account in the analysis of the action recognition priming task.

Task and trials procedure: Participants were seated at 100 cm from the screen so that the action in the photograph would appear within 5° of visual angle. They had to judge as quickly and accurately as possible whether the target action photograph was correct or not according to the typical use of the object (forced choice). Instructions were displayed on the screen and carefully explained by the experimenter to ensure that participants understood the correct/incorrect distinction. Twelve representative practice trials with feedback were provided with three objects that were not included in the actual experiment. The experimental session was the same as the practice session but without feedback. The priming procedure was conducted with E-Prime V3.0 software (Psychology Software Tools, Pittsburgh, PA) and lasted about 30 min. Short breaks were proposed between blocks.

A trial was composed of a fixation cross (2500 ms), then the prime (66 or 220 ms) followed by a black and pixelated mask (66 ms), and the target until participants' response. Participants answered "yes" (correct) or "no" (incorrect) using their left and right hands on left and right extreme keys of the response box. Response mapping (yes/no, left/right) was counterbalanced between participants. Response times (RT) and correct responses (accuracy) were recorded.

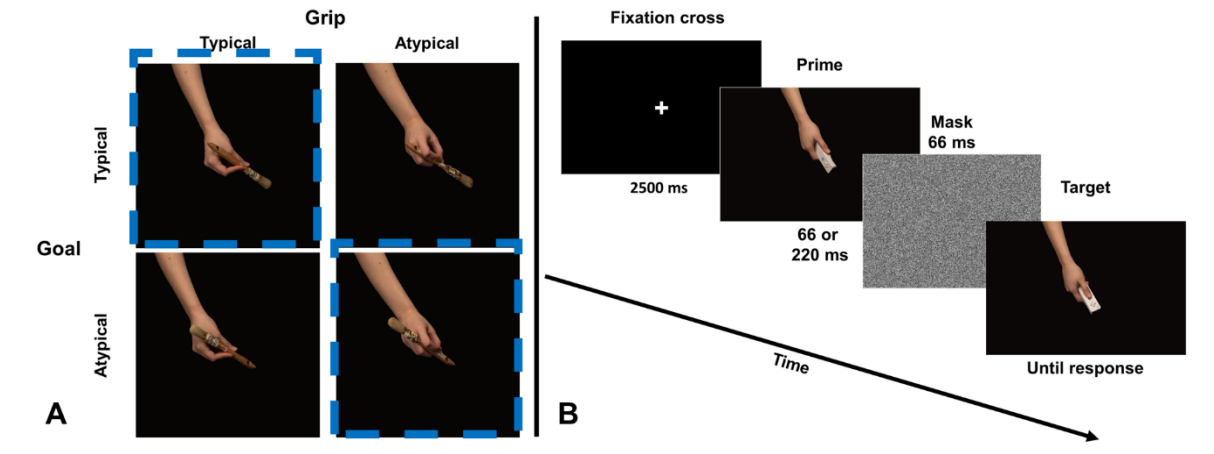

Figure 1. A. Example of stimuli in the different conditions. B. Trial procedure. Targets could be either fully typical or fully atypical (dashed line square in A.) and primes could be any of the photographs presented in A. Participants were required to determine whether the target action was correct or incorrect according to the typical use of the object.

Construal-level of action representation using the Behavioral Identification Form (BIF)

The BIF was developed by Vallacher and Wegner (1989). We obtained the French version by asking two French speakers, experts in Psychology who were fluent in English, to translate the English version into French. The obtained version was then back-translated from French to English by bilingual individuals to ensure that the translated items remained consistent with the original ones. Each of the 25 items presented an action (e.g., "Attending class"). For each item, two alternatives were proposed (e.g., "sitting in a chair" or "increasing one's knowledge") and participants had to select the one they preferred. Among the two alternatives, one was always more abstract than the other (e.g., "increasing one's knowledge"). Cronbach's alpha in our study (Cronbach's α = .75, 95% CI [.66, .84]) was comparable to the one previously reported (Cronbach's α = .82, 95% CI [.74, .88] in Kozak et al., 2006; Cronbach's α = .84, 95% CI [.82, .87] in Vallacher & Wegner, 1989). Scores were obtained by adding one point each time the "most abstract" alternative was selected. The higher the score, the higher the tendency of the participants to represent actions in an abstract manner.

Perspective taking using the Interpersonal Reactivity Index (IRI)

The IRI was developed by Davis (1983). This questionnaire provides four sub-scores representing four dimensions of empathy. We used the French version of the IRI developed by Gilet, Mella, Studer, Grühn, and Labouvie-Vief (2013). The IRI was composed of 28 items. Participants had to select from a 5-point Likert scale whether each item fitted with their personality. The scale goes from "I completely disagree" (0; "Fortement en désaccord") to "I completely agree" (4; "Fortement d'accord"). We only focused on the sub-score generally reported in previous studies on action recognition: The perspective taking (PT) sub-score. Cronbach's alpha in our study (Cronbach's α = .61, 95% CI [.47, .75]) was comparable to the one previously reported (Cronbach's α = .71, 95% CI [.65, .75] in Gilet et al., 2013). Scores were obtained by adding the individual score of each item. The higher the score the better the self-reported perspective-taking ability of the participants.

Personal sense of social power

The personal sense of social power scale was developed by Anderson, John, and Keltner (2012). The English version was first translated into French by French speakers, experts in Psychology who were fluent in English and then back-translated from French to English by bilingual individuals to ensure that the translated items remained similar to the original ones (Morgado, François, & Palluel-Germain, personal communication). The personal sense of social power scale is composed of eight items. Participants had to select from a 7-point Likert scale whether each item fitted with their personality. The scale goes from "I completely disagree" (1; "Fortement en désaccord") to "I completely agree" (7; "Fortement d'accord"). Cronbach's alpha in our study (Cronbach's α = .81, 95% CI [.74, .88]) was comparable to the one previously reported (Cronbach's α = .85, 95% CI [.81, .88] in Anderson et al., 2012). Scores

were obtained by averaging the individual scores of the different items. The higher the score, the more participants felt a high sense of social power.

Subjective ratings of dominance

The questionnaire of subjective ratings of dominance was developed by Cheng, Tracy, and Henrich (2010). The French version was developed for the purpose of the present study. There were seven items in the questionnaire. Participants had to select from a 5-point Likert scale whether each item fits with their personality. The scale goes from "Not at all" (1; "Pas du tout") to "Totally" (5; "Totalement"). Cronbach's α in our study (Cronbach's α = .58, 95% CI [.41, .74]) was lower, though not significantly different based on the overlapping CI, than the one previously reported (Cronbach's α = .77, 95% CI [.71, .82] in J. T. Cheng et al., 2010). Note that removing one of the seven items did not improve the Cronbach's α, so all of them were kept. Scores were obtained by adding the individual score of each item. The higher the score, the more participants consider themselves as adopting a dominant behavior.

Data Analyses

As a general strategy to analyze our data, we opted for the Bayesian statistical analysis framework (for an introduction, see McElreath, 2020). Compared to null hypothesis significance testing, Bayesian analyses do not rely on p-values and statistical significance (Benjamin et al., 2018; Lima Portugal et al., 2020; McShane et al., 2019), but report P(θ | data), the probability distribution of the model's parameters (or quantities of interest derived from them) that are consistent with the model, observed data and prior information. Here, we summarize the uncertainty in our inference results by reporting the 95% credible intervals (95% CrI; 2.5%-97.5% quantiles) of the quantities of interest as well as the probability (P+ or P-) of the quantities of interest θ being greater or lower than 0, P+ = P(θ > 0 | data) or P- = P(θ < 0 |

data). The closer the probability P+ (or P-) to one the stronger the weight accorded to positivity (or negativity) of the effect. Statistical analyses were all carried out with R version 3.6.1 (R Core Team, 2020).

With this approach, we first analyzed the action priming paradigm: we expected goal priming effects but no grip priming effects at 66 ms, whereas both should be observed at 220 ms. In other words, grip and goal similarity should be moderated by prime duration. As we previously reported an effect of target correctness (Decroix, Borgomaneri, et al., 2020; Decroix & Kalénine, 2018), this interaction might further be moderated by target correctness. From this analysis, we extracted individual estimates of goal priority and evaluated how they relate to individual social characteristics.

Results

Group level action priming results

Errors (4.19%) and extreme RTs (i.e., RT < 200-ms or above 3 SD from the mean of each individual; 1.74%) were excluded from the RT analyses. Prior to RT analyses, we checked with a chi-square test for independence that errors were equally distributed between conditions, $\chi2(4) = .031$, $p > .99$, to ensure that there was no speed-accuracy trade-off in our data. Finally, we evaluated the internal consistency of RTs in each condition using a permutation-based split-half approach (Parsons et al., 2019) using the *splithalf* function of the 0.7.2 splithalf package (Parsons, 2021) with 5000 random splits. All conditions showed a very good level of internal consistency ($r_{\text{Spearman-Brown}} > .81$). The Spearman-Brown corrected split-half coefficients, means, and standard deviations of each condition are reported in Table 1.

Table 1. Mean reaction, standard deviation and split-half reliability as a function of target correctness (yes, no), prime duration (66, 220-ms), grip and goal similarities.

Target correctness	Prime duration	Grip similarity	Goal similarity	M_{RT} (in ms)	*SD* (in ms)	Spearman-Brown split-half index
Yes	66	Grip-similar	Goal-similar	516	173	0.86
Yes	66	Grip-similar	Goal-dissimilar	570	148	0.88
Yes	66	Grip-dissimilar	Goal-similar	538	165	0.88
Yes	66	Grip-dissimilar	Goal-dissimilar	579	153	0.88
Yes	220	Grip-similar	Goal-similar	454	158	0.83
Yes	220	Grip-similar	Goal-dissimilar	542	163	0.88
Yes	220	Grip-dissimilar	Goal-similar	528	169	0.87
Yes	220	Grip-dissimilar	Goal-dissimilar	551	165	0.89
No	66	Grip-similar	Goal-similar	561	167	0.83
No	66	Grip-similar	Goal-dissimilar	592	150	0.85
No	66	Grip-dissimilar	Goal-similar	599	165	0.87
No	66	Grip-dissimilar	Goal-dissimilar	590	148	0.88
No	220	Grip-similar	Goal-similar	512	169	0.81
No	220	Grip-similar	Goal-dissimilar	573	156	0.88
No	220	Grip-dissimilar	Goal-similar	586	168	0.85
No	220	Grip-dissimilar	Goal-dissimilar	553	149	0.91

RTs were analyzed using Bayesian generalized linear multilevel models using the 2.15.0 version of the "brms" package together with the Stan MCMC sampler version 2.26.1 (Bürkner, 2017; Carpenter et al., 2017). RT were modeled with an ex-gaussian distribution of RT together with a log link function that better capture the typical characteristics of RT distribution, i.e., skewness and non-decision time period (Luce, 1986; Whelan, 2008). Importantly, as the difference of two log values may be expressed as a log ratio (log(A)-log(B)= log(A/B)), estimates of the model correspond to log ratios. Log ratios of RTs can easily be translated in percentage of RT change between conditions. Therefore, action priming effects are expressed as the log ratio of RT in the action (grip or goal) dissimilar condition on the RT in the action

(grip or goal) similar condition. A log ratio of 0.05 thus corresponds to an increase of 5% RT in the condition of dissimilar grip/goal when compared to the condition of similar grip/goal.

The model for RT included grip similarity between prime and target (grip-similar/grip-dissimilar), goal similarity between prime and target (goal-similar/goal-dissimilar), prime duration (66 ms, 220 ms), target correctness (yes, no), gender (female, male), and their related first-, second-, third-, and fourth-order interactions as fixed effects. The perceptual similarity index was added as a fixed effect to control for the impact of the perceptual distance between primes and targets. The random structure was kept maximal (Barr et al., 2013) and included random intercepts for both participants and objects, as well as random slopes for grip similarity, goal similarity, prime duration, target correctness, gender, and their related interactions for both participants and objects. Results are presented in Figure 2.

The analysis showed poor evidence for a 4-way interaction, estimate = -0.004, 95% CrI [-0.050; 0.044], P+ = 0.45, though there was strong evidence for both a Grip Similarity x Goal Similarity x Prime Duration interaction, estimate = -0.102, 95% CrI [-0.126; -0.078], P- = 1, and a Grip Similarity x Goal Similarity x Target Correctness interaction, estimate = -0.04, 95% CrI [-0.065; 0.015], P- = 0.99.

The Grip Similarity x Goal Similarity x Prime Duration interaction was explained by evidence for higher goal than grip similarity priming effects at 66 ms, estimate = 0.029, 95% CrI [0.008; 0.049], P+ = 0.998, whereas there was no such evidence for a difference at 220 ms of prime duration, estimate = 0.002, 95% CrI [-0.021; 0.024], P+ = 0.55. At 220 ms of prime duration, both primed actions with similar grips and goals speeded up target action judgements by about 5% compared to prime actions with dissimilar grips and actions with dissimilar goals (grip-similarity priming effect at 220 ms: estimate = 0.054, 95% CrI [0.038; 0.071], P+ = 1; goal-similarity priming effect at 220 ms: estimate = 0.056, 95% CrI [0.036; 0.076], P+ = 1). At 66 ms of prime duration, prime actions with similar goals speeded up target action judgements by about 5% compared to prime actions with dissimilar goals (estimate = 0.047, 95% CrI

[0.028; 0.065], P+ = 1). Although to a lower extent, prime actions with similar grips also speeded up target action judgements by about 2% compared to prime actions with dissimilar grips (estimate = 0.018, 95% CrI [0.003; 0.033], P+ = 0.99).

The Grip Similarity x Goal Similarity x Target Correctness interaction was explained by evidence for higher goal than grip similarity priming effects for yes-response, estimate = 0.048, 95% CrI [0.027; 0.070], P+ = 1, but no similar evidence was found for such a difference for no-response, estimate = -0.018, 95% CrI [-0.040; 0.004], P- = 0.95, independently of the prime duration.

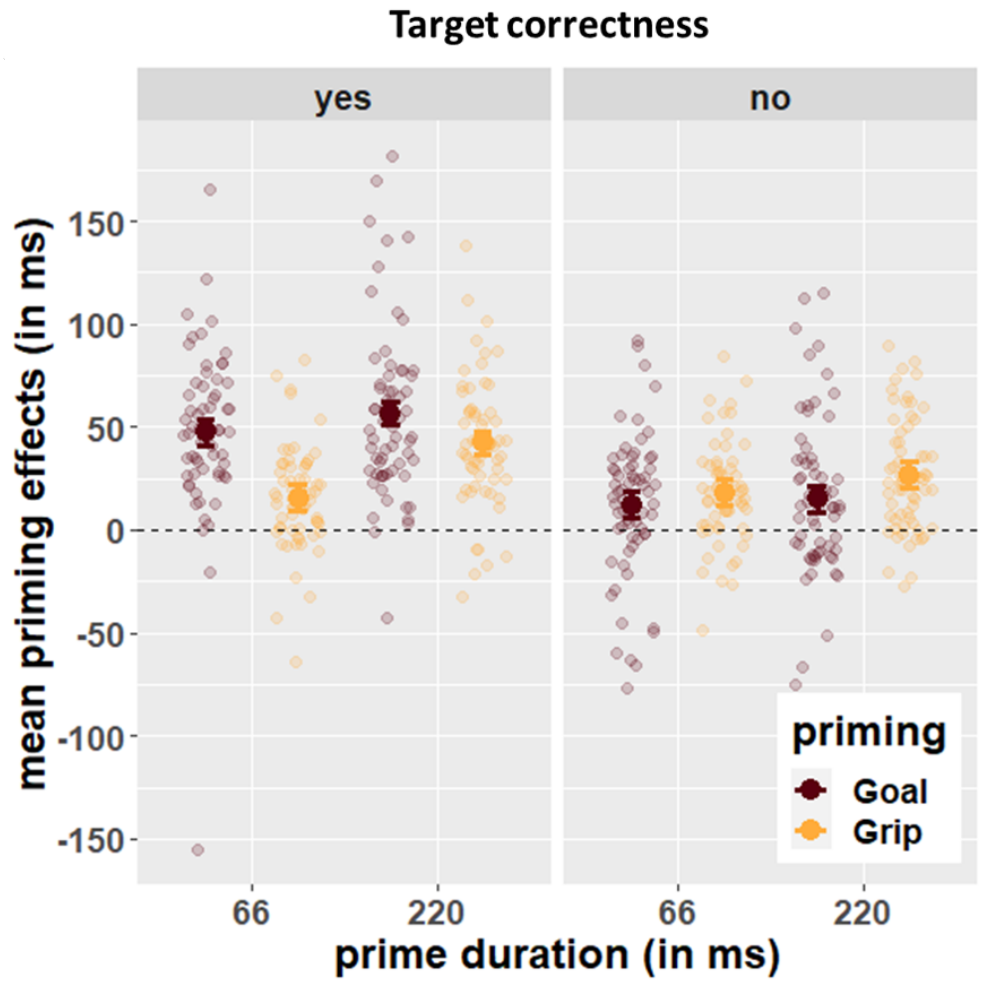

Figure 2: Grip and goal mean priming effects (in ms) as a function of prime duration (66-ms, 220-ms) and target correctness (yes = target correct; no = target incorrect). Bold dots represent the group mean. Error bars represent pairwise standard errors.

Summary and computation of individual goal priority

Overall, the same pattern as reported in Decroix and Kalénine (2018) has been found: goal-similarity priming effects were more important than grip-similarity priming effects at 66-ms. Grip- and goal-similarity priming effects were not different from one another at 220 ms. In addition, the goal-priming effect was different from the grip-similarity priming effect for yes-response, but not for the no-response. Thus, at the group level the largest difference between goal and grip priming effects was observed when action primes were presented for 66 ms in the yes-response condition. Previous results using a similar protocol also reported modulations of the effect of grip and goal similarity on response times and neuroanatomical substrates of action processing (Decroix & Kalénine, 2018; Decroix, Borgomaneri, Kalénine, & Avenanti, 2020), consistent with a probable temporal delay in the processing of incorrect target actions. In order to reduce the overall intra-individual variability of response times and maximize the chance to detect individual differences in goal vs. grip priming, goal priority was evaluated from responses times to correct target actions. For each participant, the individual goal priority effect was computed by subtracting the estimated goal-similarity priming effect from the Bayesian model (i.e., the log ratio of different goal and similar goal) from the estimated grip-similarity priming effect (i.e., the log ratio of different grip and similar grip), at 66 ms and for yes-response. The split-half reliability of this particular effect was $r_{\text{Spearman-Brown}} = .26$[1], which sets up an upper limit to the strength of the relation we can expect between this effect and the measures we obtained from the questionnaires.

Individual-level action priming analyses

The same Bayesian framework was used to analyze the relationship between individual goal priority in the action priming protocol and individual scores to the social questionnaires.

[1] In contrast to Bayesian multilevel analyses, the computation of the split-half reliability index does not accommodate missing data points and was based on 48 participants out of 64.

To ease the comparisons between the different questionnaires, the scores were standardized (i.e., centered and reduced). Individual goal priority effect was analyzed as a function of the score means of each different scale:

Goal priority effect ~ Sense of Power + Dominance + Perspective Taking + Construal Level

To make sure that the results were not driven by outliers, we used the the '*check_outliers*' function from the 0.7.0 *performance* package (Lüdecke et al., 2021) which apply multiple outliers detections algorithms and classify participants as outliers if they are classified as such by at least half of the methods used. One participant was removed based on this procedure. Results provided evidence for an association between social power and goal priority: higher social power was associated with higher goal priority, estimate = 0.006, 95% CrI [0.001; 0.010], P+ = .994. Interestingly, despite lacking sufficient supporting evidence, the association between dominance and goal priority seemed to go in the opposite direction: higher dominance would tend to be associated with lower goal priority, estimate = - 0.004, 95% CrI [-0.009; 0.001], P- = .957. Moreover, the association between goal priority and perspective taking, estimate = 0.002, 95% CI [-0.002; 0.007], P+ = .87, or between goal priority and the construal level, estimate = - 0.002, 95% CI [-0.006; 0.002], P- = .80, was not supported. Results are presented in Figure 3.

A general overview of the paired correlations between the different scores is also provided on Figure 4. Interestingly, a moderate positive correlation is observed between social power and dominance scores (r =.35, 95% CrI [0.12; 0.55], P+ = 1), despite their relations in the opposite direction with goal priority.

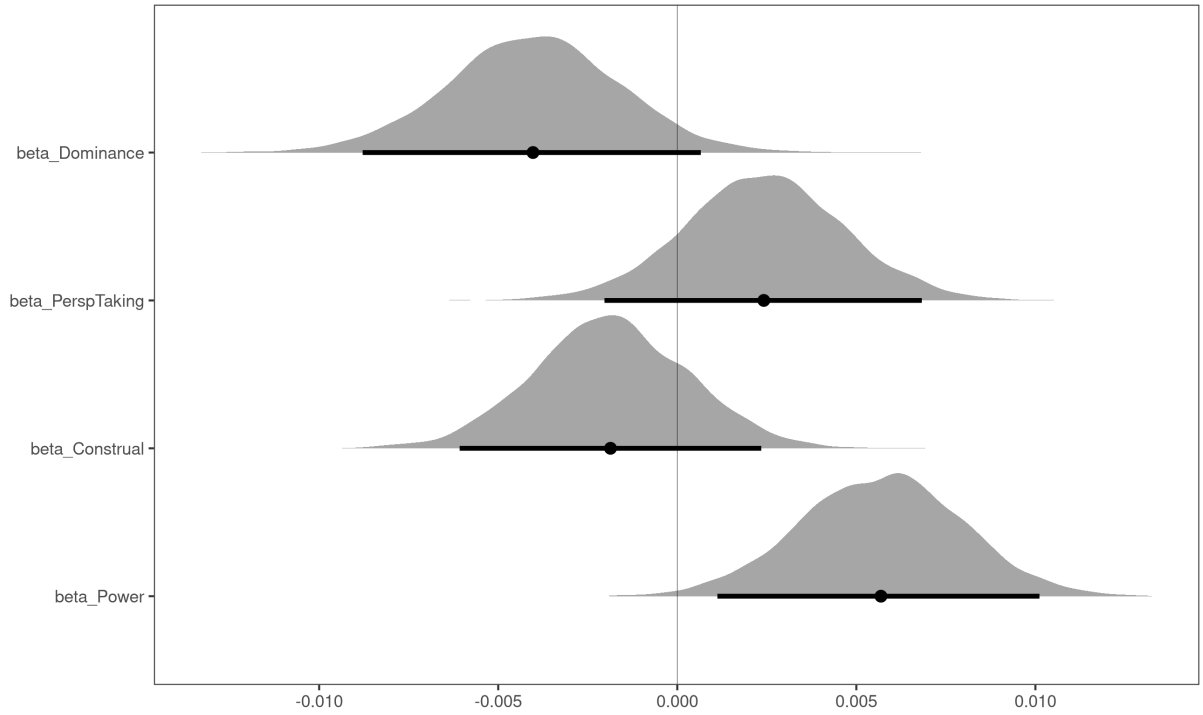

Figure 3. Estimates of the regression model of the individual goal priority effect with scores at the social questionnaires as predictors. Dots represent the estimate, error bar represent 95% CrI, and the density distribution is displayed in grey.

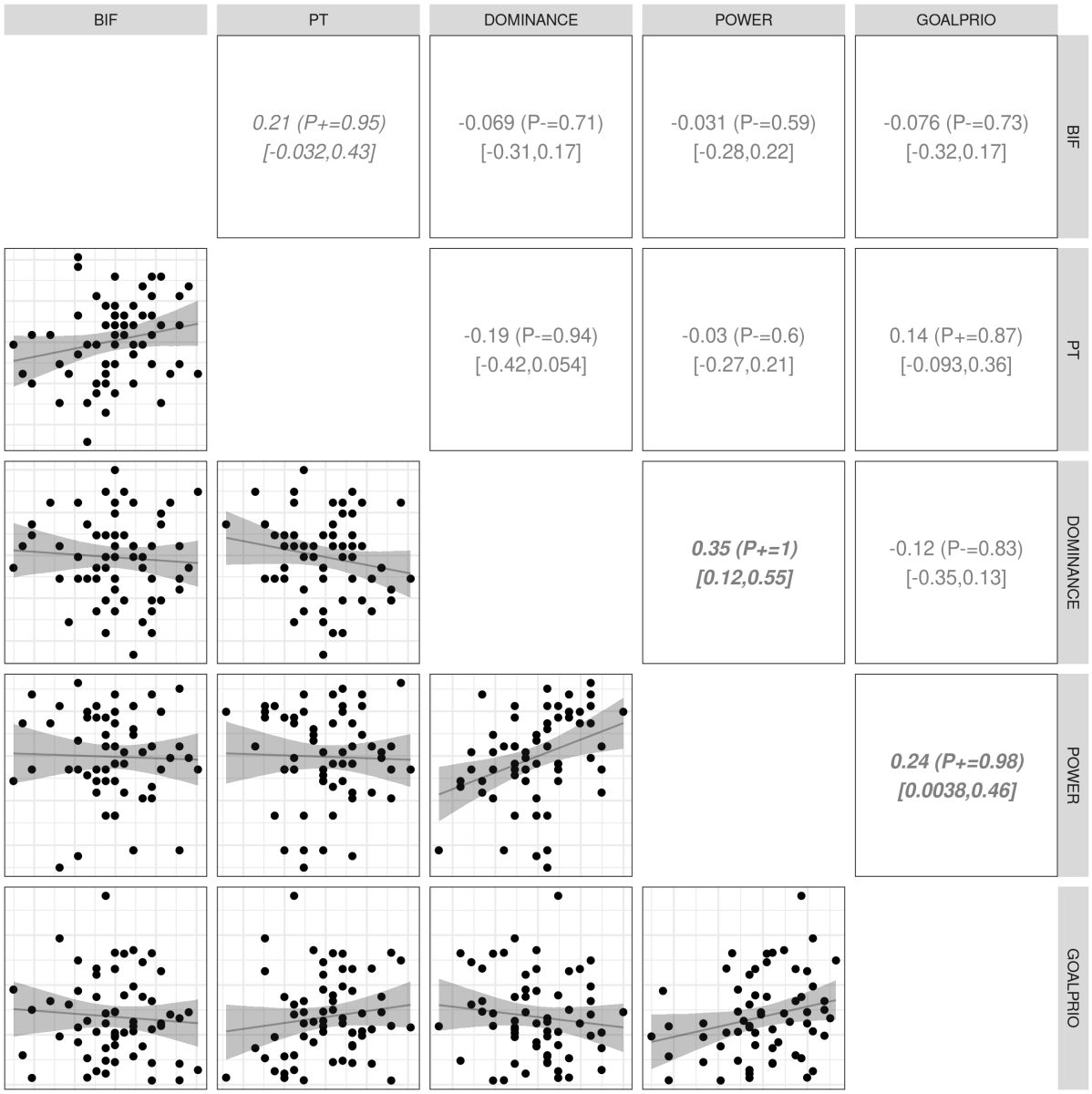

Figure 4. Paired correlations between the different factors. The correlation, the P+/- and the 95% CrI are provided. Correlations where the 95% CrI did not cross zero are represented in bold.

4. Discussion

In an environment that is inherently social, understanding others and their actions is crucial. While the importance of movement kinematics, goals, or various contextual factors on action understanding have been reported, little attention has been paid to the characteristics of the observer (Bach & Schenke, 2017; Spaulding, 2018). Yet, observers' characteristics may

have an important role in explaining the important interindividual variability found in action understanding (Spaulding, 2018). The present study was designed on the basis of previous work (Decroix & Kalénine, 2018) showing that, at the group level, goal-related information was prioritized over grip-related information during action understanding. The current aim was to evaluate whether this tendency to prioritize goal-related information could be related to the social characteristics of the observer. Sense of social power, dominance, perspective taking, and level of construal were considered as candidates to predict the individual tendency to prioritize goal over kinematic parameters: social power and dominance because they provide a general overview of individual social characteristics, which is thought to be an important source of individual variability in action understanding (Spaulding, 2018); perspective taking because it has already been related to neurophysiological indicators of action understanding (Borgomaneri et al., 2015; Y. Cheng et al., 2008; Gazzola et al., 2006; Pfeifer et al., 2008); the level of construal because it might be generally related to psychological perspective taking abilities. As expected, social power and dominance predicted goal priority in the action priming protocol. Interestingly, the direction of these associations was different for the two social factors. Whereas, as expected, dominance was negatively associated with goal priority, higher scores of social power predicted higher (and not lower) goal priority. Importantly, these results stand even though the visual similarity was taken into account by the model, thus ruling out the possibility that our priming effects were explained by the visual similarity.

The present study confirms previous findings reported in Decroix and Kalénine (2018). Despite a different set of stimuli, the same pattern of results was found at the group level: observers prioritized goal-related information over grip-related information during the first steps of action processing. This early advantage for goal over grip may be underpinned by early perceptual processes (Decroix, Roger, et al., 2020), but is *not* driven by perceptual differences in the stimuli. Indeed, perceptual similarity between primes and targets was equivalent for both

grips and goals, and differences in priming effects stand even though perceptual similarity was accounted for in the analyses. The task demands may have biased action processing towards goals instead of grips, but the advantage for goals over grips is found even when tasks emphasized the processing of grips (van Elk et al., 2008, 2014). One last possibility is that the prioritization of goals over grips might be limited to object-directed actions (Hommel, 2014), and recent theoretical positions have started to emphasize the importance of considering different categories of action when studying action understanding (Bach et al., 2014; Bach & Schenke, 2017; Novack & Goldin-Meadow, 2016; Pomiechowska & Csibra, 2017; Uithol & Maranesi, 2014). Regardless, the demonstration that the priority given to goals arises early during action visual processing is a notable advance for these models.

Beyond the general tendency to prioritize goals over grips during action understanding, we found that social power and dominance could predict the relative magnitude of this priority for the different observers. Social power usually refers to the influence one has on others and the ability of this person to control and maintain this influence (Anderson et al., 2012; Berger, 2008; Blader & Chen, 2014; Galinsky et al., 2006), whereas dominance refers to the actual behavioral strategies to acquire and control this power (Berger, 2008; Blader & Chen, 2014; Witkower et al., 2020). Although some studies have previously reported negative effect of social power on goal processing (Jia et al., 2018), some authors have argued that this effect could rather be due to the use of dominant strategy rather than to social power itself (Blader et al., 2016; Witkower et al., 2020). Therefore, we propose that it is not social power (i.e., the acquired control and influence on others) that has a negative influence on goal processing, but rather the use of strategy based on fear and aggressiveness to obtain it. Consequently, when social power is acquired through strategies based on empathy and benevolence, social power could even have a positive effect on goal processing (J. T. Cheng et al., 2010). Although the existence of a negative relation between dominance and goal priority requires additional

empirical support, we believe that our data suggest to look more closely at the strategies used by individuals in their social relations to obtain power in addition to their overall sense of social power. If the dominance score captures the negative influence of social power on goal processing, an evaluation of the use of benevolent strategies should capture its positive influence.

Our results are not conclusive regarding the negative relation between goal priority and dominance, nor they convincingly support the existence of a relationship between goal priority and perspective taking or the level of construal. It is important to mention that our study was powered to detect medium effect sizes ($r \sim 0.35$). We also note that although our raw behavioral measures were quite reliable (split-half reliability ~ .88), the goal priority index taken from these measures was much less reliable (split-half reliability ~ .26). This is very common in behavioral experiments (Parsons et al., 2019), but implies that identifying more reliable indicators would greatly strengthen the exploration of the relations between behavioral measures and questionnaires. Therefore, it might be hasty to conclude to the inexistence of these relations, and it is rather wise to conclude that these relations, if they exist, might be small in terms of effect sizes. Although previous studies have reported a strong relationship between perspective taking and the activity of the motor system (e.g., Gazzola et al., 2006; Pfeifer et al., 2008), it may be trickier to evaluate how individual social characteristics show through the temporal dynamics of behavioral responses than to measure their impact on a general level of brain activity.

Predictive approaches of action understanding have initially been introduced to challenge the classical idea that movement kinematics parameters were the primary sources of information guiding action understanding (Csibra, 2008; Kilner et al., 2007). Our previous studies fitted well with these approaches as they demonstrated that, at the group level, goal-related information was the primary and first source of information (Decroix, Roger, et al.,

2020; Decroix & Kalénine, 2018, 2019). Yet some studies found that under certain circumstances, movement kinematic parameters may be favored, especially in the absence of reliable sources of goal-related information (Koul et al., 2019; Nicholson et al., 2017; Pobric & Hamilton, 2006; Thioux & Keysers, 2015; Tidoni et al., 2013). The present study further extends these possibilities by showing that individual characteristics can also bias the reliance towards or away from goal-related information. In line with the rising pluralist views of action understanding, different strategies may be used depending on the situation and the preferences of individuals in the recognition of others' actions (Bach et al., 2014; Fiebich & Coltheart, 2015; Spaulding, 2018; Uithol & Paulus, 2014). Following this direction, it may be possible that the social characteristics of the observers and the usual ways they deal with their social environment might be at play in the strategy they use to recognize others' actions (Smith & Galinsky, 2010). The present results support this view by suggesting that subtle temporal differences in the early visual processing of observed actions can already be associated with much more general social characteristics such as social power and dominance.

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Figure 1

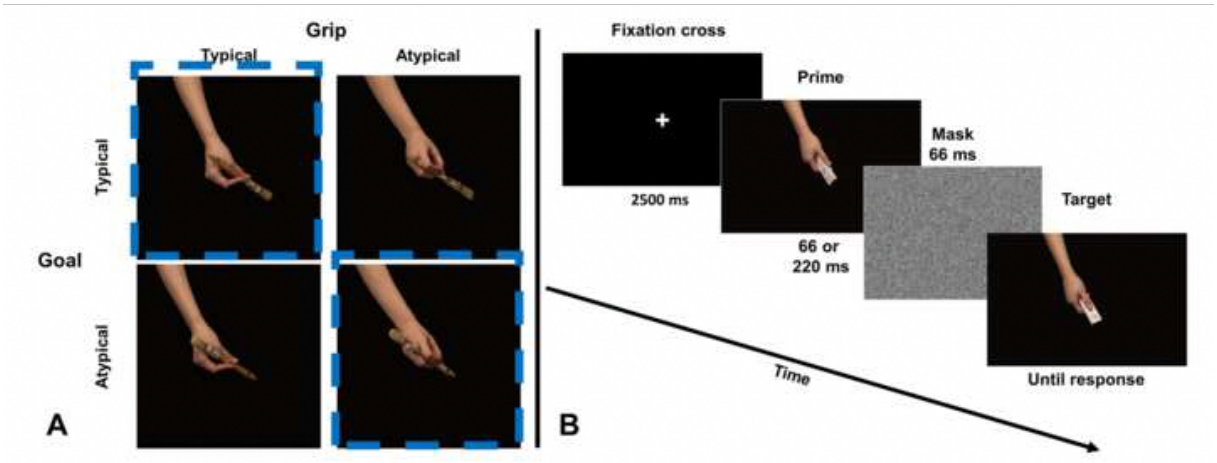
Grip
Typical
Atypical
Goal
Typical
Atypical
A
Fixation cross
Prime
Mask
66 ms
2500 ms
Target
66 or
220 ms
Time
Until response
B

Figure 2

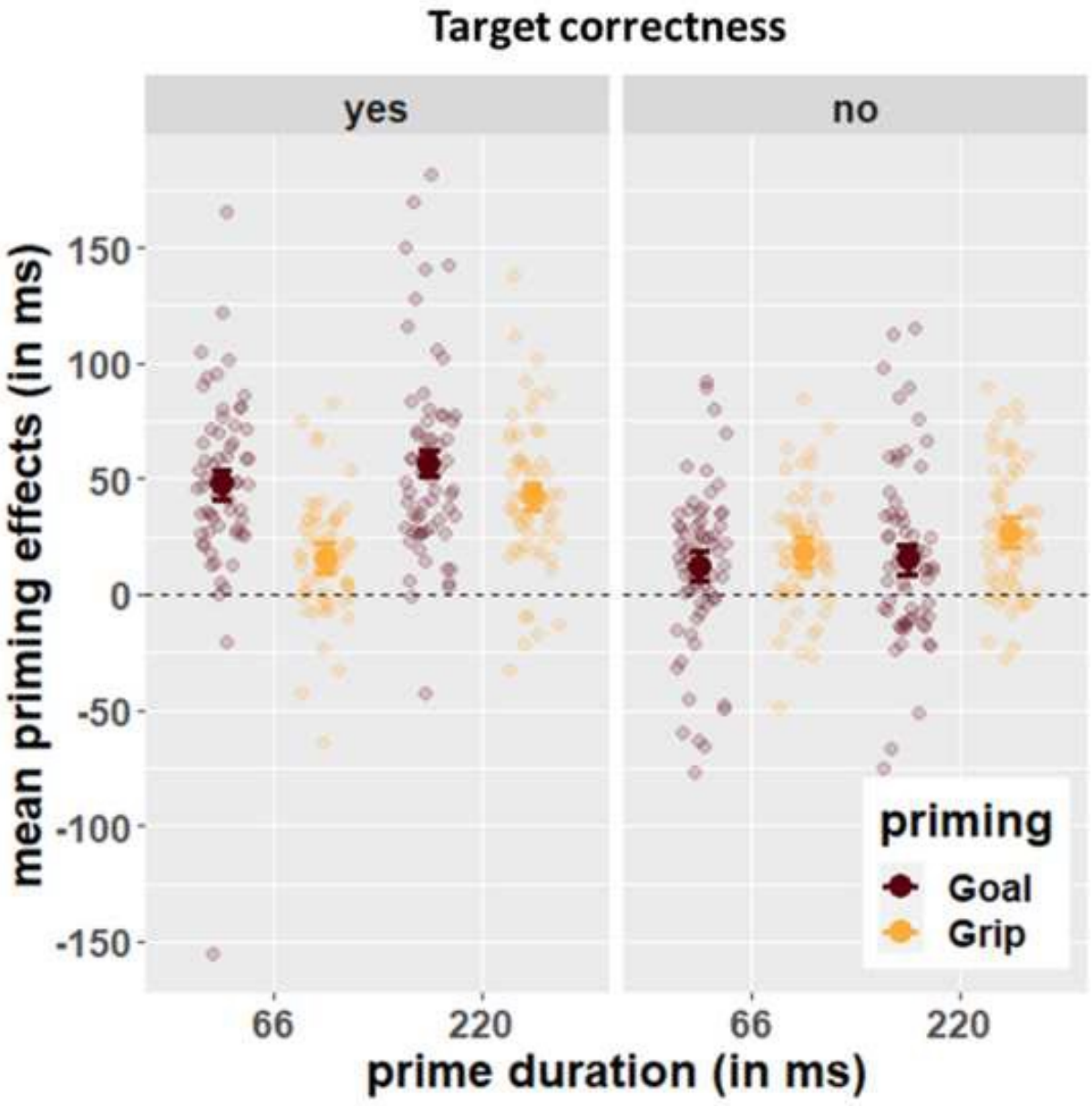
Target correctness
yes
no
mean priming effects (in ms)
150
100
50
0
-50
-100
-150
66
220
66
220
prime duration (in ms)
priming
Goal
Grip

Figure 3

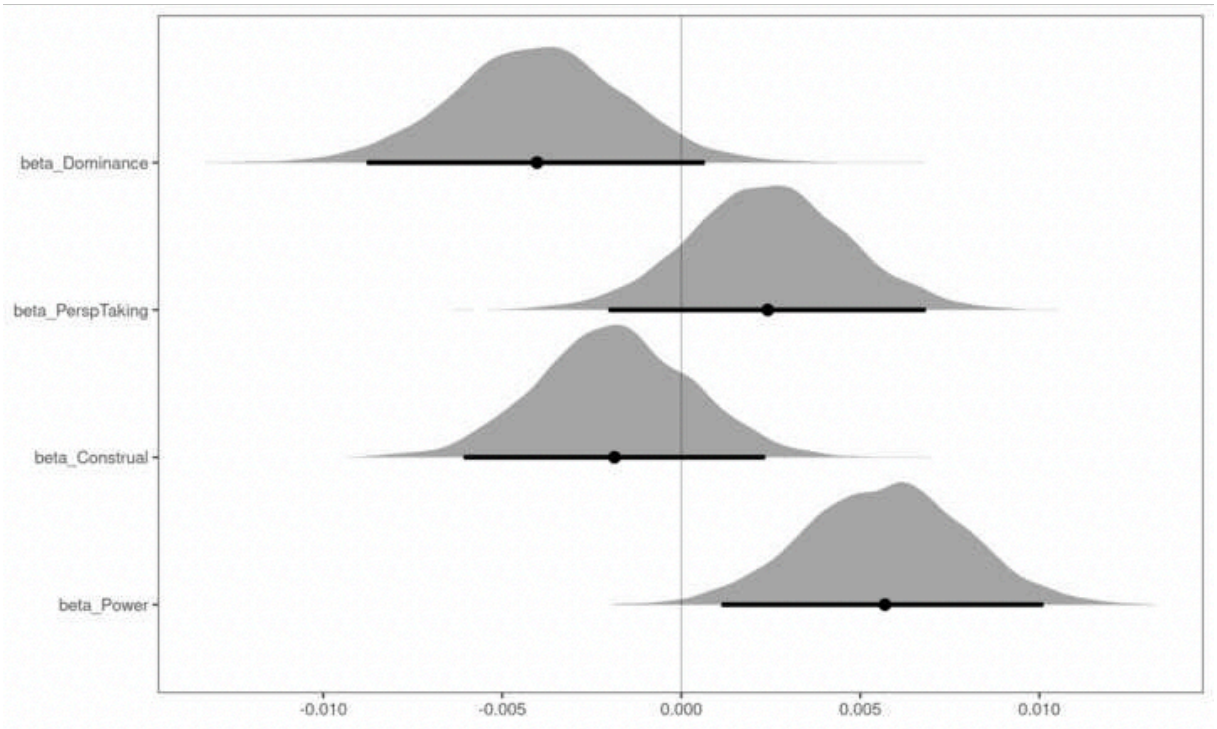
beta_Dominance
beta_PerspTaking
beta_Construal
beta_Power
-0.010
-0.005
0.000
0.005
0.010

Figure 4

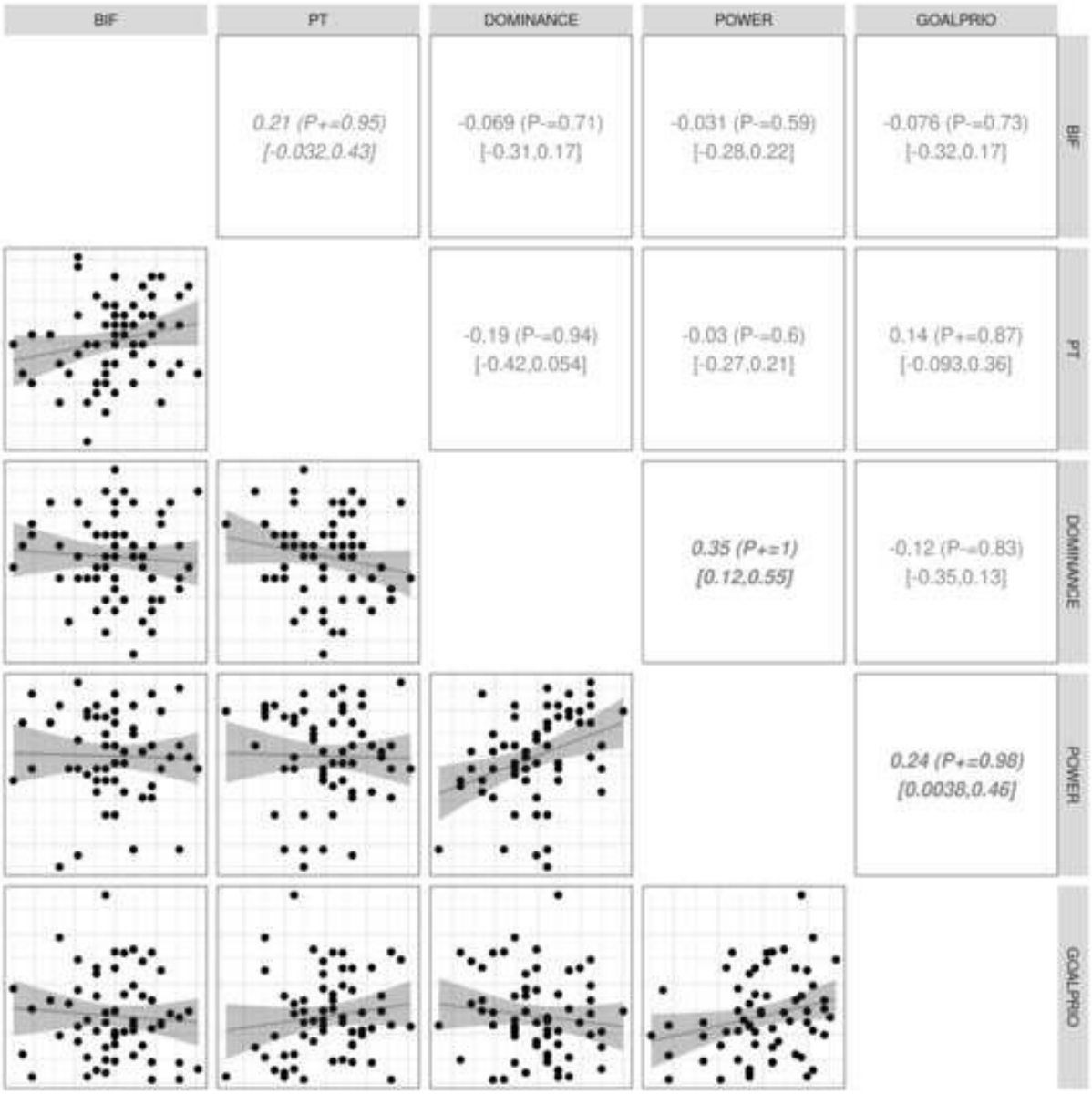
BIF
PT
DOMINANCE
POWER
GOALPRIO
0.21 (P+=0.95)
[-0.032,0.43]
-0.069 (P-=0.71)
[-0.31,0.17]
-0.031 (P-=0.59)
[-0.28,0.22]
-0.076 (P-=0.73)
[-0.32,0.17]
-0.19 (P-=0.94)
[-0.42,0.054]
-0.03 (P-=0.6)
[-0.27,0.21]
0.14 (P+=0.87)
[-0.093,0.36]
0.35 (P+=1)
[0.12,0.55]
-0.12 (P-=0.83)
[-0.35,0.13]
0.24 (P+=0.98)
[0.0038,0.46]

Table 1. Mean reaction, standard deviation and split-half reliability as a function of response type (yes, no), prime duration (66, 220-ms), grip and goal similarities.

Response type	**Prime duration**	**Grip similarity**	**Goal similarity**	M_{RT} **(in ms)**	***SD*** **(in ms)**	**Spearman-Brown split-half index**
Yes	66	Grip-similar	Goal-similar	516	173	0.86
Yes	66	Grip-similar	Goal-dissimilar	570	148	0.88
Yes	66	Grip-dissimilar	Goal-similar	538	165	0.88
Yes	66	Grip-dissimilar	Goal-dissimilar	579	153	0.88
Yes	220	Grip-similar	Goal-similar	454	158	0.83
Yes	220	Grip-similar	Goal-dissimilar	542	163	0.88
Yes	220	Grip-dissimilar	Goal-similar	528	169	0.87
Yes	220	Grip-dissimilar	Goal-dissimilar	551	165	0.89
No	66	Grip-similar	Goal-similar	561	167	0.83
No	66	Grip-similar	Goal-dissimilar	592	150	0.85
No	66	Grip-dissimilar	Goal-similar	599	165	0.87
No	66	Grip-dissimilar	Goal-dissimilar	590	148	0.88
No	220	Grip-similar	Goal-similar	512	169	0.81
No	220	Grip-similar	Goal-dissimilar	573	156	0.88
No	220	Grip-dissimilar	Goal-similar	586	168	0.85
No	220	Grip-dissimilar	Goal-dissimilar	553	149	0.91