Behavioral signatures of social signal detection

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Abstract:

Recent work suggests that social perception begins as early as primary sensory (e.g., visual) processing. However, the underlying shared and individual mechanisms that make visual information social (or not), and/or determine the nature of that information, are not clear. Drawing inspiration from psychophysics, we systematically varied motion parameters in Heider-Simmel-esque animations of geometric shapes and studied how these parameters influence whether and how social interactions are perceived. Our results show that at the group level, simple motion parameters can influence percepts of the presence and nature of social interactions. Additionally, we observed robust individual differences in sensitivity to these parameters that may be associated with social skills and positive affect traits. In sum, our work highlights the potential of (1) simple motion parameters to influence how we perceive complex social interactions, and (2) parametric designs to study idiosyncrasies in visuo-social perception.

Keywords: social perception; parametric designs; individual differences.

Introduction

Recent work suggests that our basic sensory systems are tuned to social input (McMahon & Isik, 2023; Pitcher & Ungerleider, 2021), which may explain why we are primed to perceive social information even in very stripped-down stimuli with minimal visual detail such as animated geometric shapes (Heider & Simmel, 1944). Further, percepts of the same information can vary substantially across people even within neurotypical populations (e.g., Varrier & Finn, 2022). This poses the question of what could be driving both shared and subjective social perception.

We hypothesize that there are at least two factors driving social perception: (1) group-level mechanisms shared by most humans (explaining the high agreement in perceiving social gestures), and (2) idiosyncratic mechanisms shaped by each person's genetics and environment. We sought to study these two factors by parametrically varying simple motion parameters in animations (Gao et al., 2009) and deriving group- and individual-level social "tuning" curves. We studied both social interaction (1) detection (i.e., determining *if* an interaction is present) and (2) discrimination (i.e., determining the nature—positive or negative—of an interaction) by varying single motion parameters in two types of social behaviors (Figure 1). Our main questions were: (1) can simple visual properties explain shared and unique aspects of social perception?, and (2) how trait-like/stable are the individual differences?

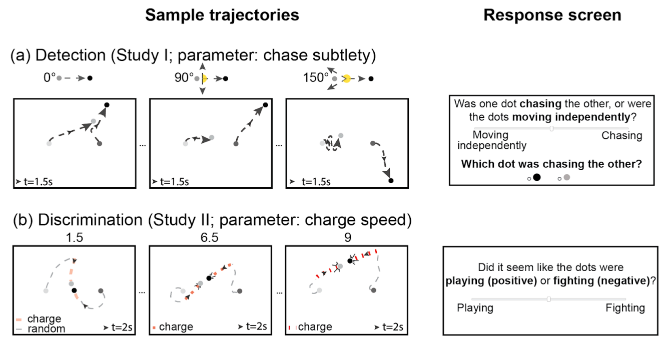

Figure 1: Parametrizing social information in simple animations. (a) In a social detection task, a predator chased a prey at 6 levels of chase subtlety (directness of chase). (b) In a social discrimination task, the two agents charged at each other at 7 levels of charge speeds.

Methods

We generated two sets of animations for the detection (Study I) and discrimination (Study II) studies using a Javascript-based application *psyanim* (in development). Each animation was made up of two circular agents (1 black, 1 gray). In Study I, one agent chased the other at varying degrees of *chase subtlety* (lower chase subtlety: more direct chases; Fig. 1a, left). In Study II, the agents alternated between "charge" (approach the other agent at the *charge speed*) and "wander" states (Fig. 1b, left). Higher charge speeds were expected to be perceived as more aggressive. All other parameters were kept constant across all animations within a study. Study I also included non-social controls for overall motion contingencies (*invisible chase*: predator chases an invisible prey while a second agent mimics the true prey with a 180-degree reflection; Gao et al., 2009) and baseline social perception (agents "wandering" with no motion contingency). Each animation lasted 6 sec in Study I and 8 sec in Study II. We used a cover story that the animations represented anonymized videos of children in a park to minimize ambiguity about what the agents represented (e.g., animals, balls), thereby isolating socialness above and beyond animacy. After each animation, participants made judgments about its content (Fig. 1, right).

To explore if and how variability in social perception relates to individual characteristics, we additionally had participants complete the Autism Quotient (AQ; Baron-Cohen et al., 2001) and Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) trait questionnaires.

Data was collected online through Prolific (www.prolific.com; Study I: *N* = *336* subjects, 2 sessions, 84 trials/session; Study II: *N* = *316*, 1 session, 70 trials). We used linear mixed effects analysis to model the relationship between parameter level and behavioral ratings in both studies, and intra-class correlation (ICC) to study test-retest reliability in Study I. We also fitted a sigmoid curve over participant-level curves (Fig. 3a) using the equation:

$$S(x) = \gamma + (1 - \gamma - \lambda)\frac{1}{1-e^{-\frac{(x-\alpha)}{\beta}}}$$

where x = the parameter level (chase subtlety/charge speed); γ and λ = the lower/upper asymptote of the curve; α, β = center/slope of participants' ratings. We calculated several key metrics from the fitted curve:

Biases: $bias_{xmin}$ and $bias_{xmax}$ (lower and upper intercepts) reflect biases at the lowest and highest stimulus levels.

Midpoints: Objective ($x_{obj} = f^{-1}(S(x) = 0.5)$) and subjective (α) midpoints indicate the subtlety/charge speed value at which perception transitions from non-social/playing to social/fighting, as per the objective scale (50%) or subjective scale (participants' own mid-point), respectively.

Sigma (σ): Inverse slope ($\frac{1}{\beta}$) influences the steepness of the sigmoid curve (smaller sigma → quicker transition from one end of the spectrum to the other).

Results

As expected, at the group level (Fig. 2a-b), the detection of social interactions decreased with chase subtlety in Study I in the chase animations (est. = −0.67, $p < .001$), but not in the control animations (est. = 0.14, $p < .001$). In Study II, percepts of fight-like interactions increased with charge speed (est. = 6.85, $p < .001$). The individual response curves reflected these general trends, yet with replicable individual differences (Fig. 2 c-d).

The curve fit parameters for biases and x_{obj} showed moderate retest reliability (ICC > 0.52), while that of α and σ were weaker (ICC > 0.1) Multiple regressions (trait ~ f($bias_{xmin}$,$bias_{xmax}$,x_{obj},σ); Fig. 3c) revealed that people with higher social skill deficits are less confident when switching from non-social to social (higher σ) whereas people with higher positive affect showed a higher bias towards playful interactions (lower $bias_{xmin}$).

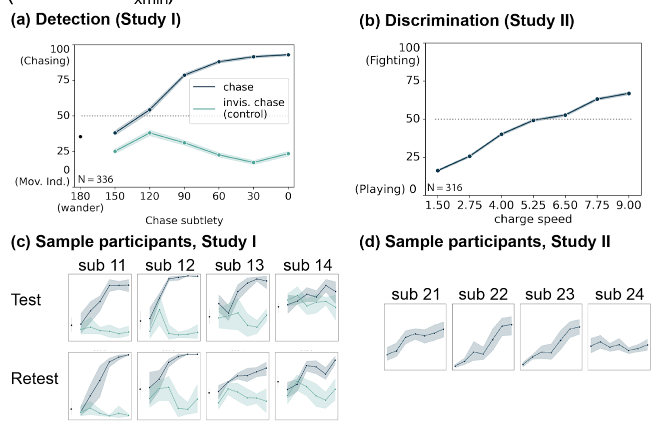

Figure 2: Socialness and aggressiveness ratings showing group-level similarities (a-b) and individual differences (c-d; 2 sessions for Study I).

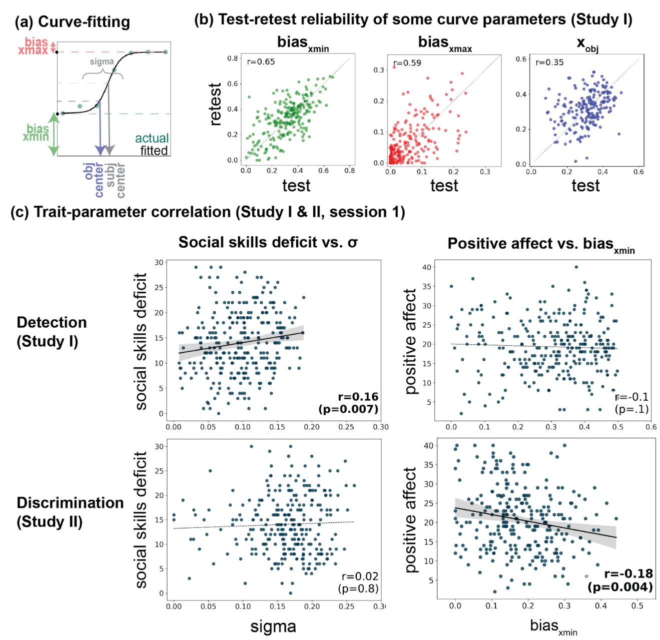

Figure 3: Individual differences in social tuning curve parameters (a) show moderate test-retest reliability (b) and some correlations with trait characteristics (c).

Conclusion

By creating fully parameterized versions of well-known social perception stimuli, here we showed that simple visual features can not only influence global perception, but also help identify subject-level social tuning curves that exist atop this shared foundation. Together, they are a powerful way to quantify social perception.

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