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Abstract

Humans are able to successfully detect characteristics about others that serve to guide interaction, yet the source of this information is unclear. We hypothesized that biological motion specifies sex and race as these invariant categorical characteristics often guide interaction. Results indicated that movement kinematics are necessary but not sufficient for sex detection and that race is detectable when movement is produced by Caucasians but not African Americans, and only when kinematic information is embedded in body structure. These results imply that social psychological perspectives on person perception should be integrated with ecological psychological perspectives on affordances in order to understand social cognition.

Keywords: social cognition; kinematic specification of dynamics; person perception; biological motion

Introduction

Humans are perpetually embedded within social context. As such, we are all potential interaction partners. A smile in passing, a short conversation with a stranger while standing in line, playing a game with friends, a dance, a marriage proposal, a surgical team performing an emergency procedure—we interact with others in a myriad of different ways. While interactions vary with regard to familiarity, complexity, purpose, and duration, the tasks we perform together allow us to accomplish shared goals and maintain various types of relationships. It is also necessary that we accurately detect social information. This information allows us to distinguish among those we interact with and provides feedback on how interactions might unfold over time. We also use this information to coordinate with one another, such that tasks are accomplished effectively and appropriately. Yet, there is not one prototypical social interaction. This is not to say that social interactions are not random or non-deterministic. On the contrary, social interactions are functionally defined and guided by time-evolving and goal directed behavior (e.g. type of interaction, need for social belonging), that allows us to understand and organize the world in terms of others and their relationship to us. Traditional social psychology suggests that social cognition, defined as an implicit and highly automatic information processing activity, guides ongoing behavior with others (Greenwald & Banaji, 1995). This approach has been valuable since social psychological research has clearly demonstrated that categorical person knowledge (e.g. race, sex), behavioral knowledge (e.g. relationship history, exposure, prior behavior), and dispositional characteristics (e.g. personality, attitudes, self-esteem) interact to allow for adaptive behavior in the service of effective social exchange (Greenwald & Banaji, 1995; Macrae & Quadflieg, 2010; Kenny, 2004).

A criticism of this perspective is that we do not fully understand how perceptual processes influence social cognition because explanations have been limited to representational accounts—abstract representations and disembodied cognitive processes are assumed to underlie social perception (Macrae & Quadflieg, 2010). Moreover, this traditional approach does not sufficiently recognize the role of coordination and action in social cognition, even though movement and coordination directly impact outcomes of social interaction such as rapport, liking, and person perception (e.g. Hodges & Baron, 2007; Marsh, Richardson, & Schmidt, 2009; Richardson, Marsh, & Schmidt, 2010; Runeson & Fryholm, 1983). As such, research is needed that addresses how perceptual-motor processes, including the movement coordination between interacting individuals, reveal social information during ongoing and dynamic social interaction with others. By understanding how motor processes reveal information about others and about the interaction itself, we can better conceptualize social cognition as an emergent outcome of a coupled system of co-actors in which perception, action, and cognition are irreducible and dynamically intertwined. As such, social cognition could be conceptualized as emerging from the mutual constraints and functional couplings amongst these processes, agents and environment, and agents themselves.

Social Cognition

The traditional understanding of person perception is that we develop schemas for interaction by integrating isolated pieces of information about ourselves, others, and behavioral actions in order to predict future behavior and understand social interactions with others (Macrae &

Quadflieg, 2010). In support of this interaction-based approach Kenny (2004) has found that people utilize both categorical and behavioral information to make target judgments and to predict how someone will act given a specific context, and, that we integrate these information sources to form individualized schema. Here, categorical information refers to nonverbal behaviors, appearance characteristics, stereotypes based on group membership, or other immediately detectable cues that place individuals into general categories. Behavioral information is functionally defined in that there is meaning attached to an individual's actions. Because people are capable of detecting information about others at zero acquaintance (when they have never met a person before), it is reasonable to hypothesize that there is invariant information (e.g., sex; race) available that individuals are sensitive to and that this information initially informs our interactions with others.

The zero acquaintance or "thin slices" paradigm requires participants to view a short (less than 5 minute) visual sample of a target, and make judgments about the categorical and behavioral information that applies to them (Ambady, Bernieri, & Richeson, 2000). Thin slices successfully predict a wide variety of variant and invariant characteristics including: affect, personality traits, interaction motivation, social relationships between actors, bias, job performance, quality of relationship, gender, sexual orientation, and others (see Ambady, Bernieri & Richeson, 2000 for review). Interestingly, individuals who move more are more accurately and reliably judged than less expressive individuals (Ambady, Bernieri, & Richeson, 2000). Also, contrary to expectation, longer behavioral samples (4-5 minute) do not result in greater accuracy than shorter samples of 200-400 ms. Yet, it is well known that as interaction time increases the utilization of variant behavioral information compared to invariant categorical information also increases (Ambady, Bernieri & Richeson, 2000). Together, these findings suggest that brief movements supply information that is integral to accuracy and reliability of judgments when forming person perceptions, but additional information is gained from social interaction extended in time.

People may also bring individual variability into situations, including judgments others from thin slices. Hirschberg and Jennings (1980) have proposed that we attend to our interpersonal environment in ways that correspond to our self-perceptions (e.g. personality traits). They have demonstrated that our opinions about ourselves may impact how we judge others—that salient characteristics of our identity my impact those judgments (Hirschberg & Jennings, 1980). More recently, it has been shown that evaluator characteristics during clinical personality assessments demonstrate the same types of effects (Miller, Rufino, Boccaccini, Jackson, & Murrie, 2011). More generally, these effects are consistent across individual perceivers (Wood, Harms, & Vazire, 2010), lending credibility to the idea that individual differences may be considered a type of invariant characteristic in person perception.

While categorical information is often invariant, for example, individuals do not often change their race or sex, this information implies variant behavioral characteristics associated with belonging to these categories and used to form interaction schema. Yet, we know little about how these processes overlap or how these characteristics are specified. This begs the question, can we detect these characteristics, and if so, what information facilitates accurate detection?

Macrae and Quadflieg (2010) have argued that person knowledge is perceptual and we detect both of these types of information. To be clear, invariant person knowledge refers to stable cues that are not context specific, like sex, race, age, or other visual information and is analogous to categorical information described above. Variant person knowledge, like behavioral information, is a medium that propagates social information and includes dynamic cues like eye gaze direction and head-body orientation. Importantly, both invariant and variant person knowledge are integrated in order to maintain stable understandings of other conspecifics and interact effectively (Macrae & Quadflieg, 2010). Thus, it is possible that we may extend the thin slice literature by exploring what information might be available in human movement.

Biological Motion and Person Perception

One promising area of research that provides a methodology for testing informational specification of invariant categorical person knowledge is biological motion. First described by Johansson (1973), point light displays have been used to identify the type of detectable characteristics available in biological motion quite broadly. A point-light (PL) display is a dynamic video that reduces whole body movement to bright markers placed on major joints. Point light displays retain kinematic information while eliminating all other sources of person knowledge (Johansson, 1973). Because movement is determined by kinematics (mechanics of motion) and motion is explained by dynamics (properties of objects that are causally involved in the course of movement), individuals perceive causality by detecting dynamic properties that specify what can be done with a moving object, including other individuals (Runeson & Frykholm, 1983). This implies that a portion of person knowledge may be derived from human motion because what we can do with another human is often closely associated with socially relevant information that helps to guide interaction (e.g. sex or race).

Indeed, prior research has shown that socially relevant information can be detected from movement, specifically from gait dynamics. Kozlowski and Cutting (1977) demonstrated that the sex of a walker could be detected from a dynamic point light display. Cutting and Kozlowski (1977) found that information in gait using PL displays allowed subjects to categorize strangers and friends accurately. Gait dynamics also impact trait impressions of power, happiness, and youthfulness, masculinity, easygoingness and approachability (Montepare & Zebrowitz-McArthur, 1988). Yet, research that examines how other types of social behaviors (e.g. dancing, playing sports, etc.) specify categorical or behavioral characteristics (e.g. race, personality, liking etc.) is needed in order to make a stronger claim that person characteristics are perceptual in nature. As such, we argue that movement guides accurate person perception and we are able to detect both variant and invariant information from biological motion.

Current Study

Overall, the previous research suggests that movement produces information that may guide initial interaction by specifying target characteristics. However, it is unclear how biological motion is used to make accurate predictions about targets in terms of person knowledge, and what target characteristics are detectible from movement kinematics in more ecologically valid tasks beyond gait. Furthermore, while various types of target characteristics can be detected from biological motion, to date, no studies have addressed whether race is specified by kinematics. Moreover, individuals do not only encounter the movements of joints on a screen—we come across a set of embodied joints that have a characteristic shape and outline in addition to kinematics. As such, research that addresses whether a moving body devoid of facial features and skin complexion allows for successful detection of invariant person characteristics adds to our understanding of how movement makes person knowledge discoverable. In the current study we will address these issues by employing two types of movement displays. First, a point light display that is height normalized and shows the movements of the major joints as dots on a screen, and second, a grey scale depth display using the Xbox Kinect, which displays body structure and outline, but no other identifying characteristics like facial structure, skin complexion or hair. All movement displays will show movement from individuals between 5'9" and 6' tall actors.

The current study tested the hypothesis that movement underlies social cognition because movement produces kinematic information that specifies invariant person knowledge. Additionally, we sought to identify whether variables important for person perception (sex and race) were detectable at zero acquaintance, and what type of information was required to do so (i.e. kinematics alone vs. body structure in addition to kinematic information). We hypothesized that sex and race would be detectable at zero acquaintance from kinematic information alone and kinematic information plus body structure, but that accuracy would be greater with additional information about body structure. We also predicted that individual difference variables would be related to detection accuracy (e.g. mood, personality, sociability, status).

Method

The current project implemented a within subjects design with stimulus type (point light and depth array) as the primary independent variable. Sex and race detection sensitivity served as the primary dependent variables. Participants were asked to judge avatars being designed for use in a virtual reality game in order to disguise the actual purpose of the experiment and minimize bias. All experimental procedures and materials were approved by the University of Cincinnati Institutional Review Board.

Participants

Subjects ($N = 27$) participated in exchange for partial course credit. Subjects were all right handed and free from any known neurological or musculoskeletal disorder and had normal or corrected to normal vision. The majority of participants were white (89.7%), female (72.4%), and ranged in age from 17 to 44 years old ($M = 19.4$).

Procedure

Participants completed a questionnaire assessing demographic variables and individual differences and practiced making avatar judgments upon entering the lab and after providing informed consent. Subsequently, participants viewed a total of 48 pre-recorded movements produced by eight actors and recorded by the Xbox Kinect displayed on a 50" computer monitor. Each video stimulus was 15 seconds in duration and displayed one of three movements (walking in place, jumping jacks or side-to-side shuffle steps) produced by each actor. Each actor (2 black men, 2 black women, 2 white men, and 2 white women) had his or her movements recorded at an earlier date to create each stimulus. Point light displays and depth array displays were matched such that the same movement data produced by the actor for each movement created both types of stimuli. Participants viewed 24 point light stimuli and 24 depth array stimuli in blocks. Video type was counterbalanced and no order effects were observed. Immediately following each video, participants filled out a questionnaire on an iPad to indicate their judgments of the target (i.e., sex, race).

Results

We employed several data analysis techniques in order to determine participants' sensitivity and ability to accurately detect sex and race. We used signal detection theory and calculated d-prime (d'), a signal-to-noise sensitivity measure, for each participant as a function of sex, race, and stimulus type. We tested these values against zero to determine if participants were able to successfully predict target characteristics above chance levels. We used a one-way repeated measures ANOVA to determine if stimulus type was related to accuracy. Finally, we correlated sensitivity measures with individual difference variables in order to determine if participants' sensitivity was related to dispositional characteristics.

Sex Detection

We hypothesized that participants would be able to accurately detect sex from both types of stimuli, but would be more accurate when viewing the depth array. Results partially supported this hypothesis. Results from an one sample *t*-test (against a *d*' value of 0) indicated that participants were able to accurately detect sex above chance levels from point light displays if the movement was produced by a female, $t(24) = 2.584$, $p = .016$, but not if the movement was produced by a male ($p > .05$). When viewing the depth array, participants were able to successfully detect both male, $t(25) = 18.173$, $p < .001$, and female, $t(25) = 19.739$, $p < .001$ above chance levels. Furthermore, results of a paired samples *t*-test indicated that there was a significant difference in detection accuracy between stimulus type when detecting males, $t(23) = -11.798$, $p < .001$, and females, $t(23) = -14.212$, $p < .001$, such that participants were more accurate in detecting sex from the depth array in both cases. Figure 2 summarizes these patterns.

We also tested the effects of stimulus type on sex detection using a one-way repeated measures ANOVA. All results were non-significant (all *p's* > .21). This indicates the type of movement the participants viewed did not impact detection sensitivity to sex. Together, these results indicate that it is not a specific movement type driving sex detection in the current study.

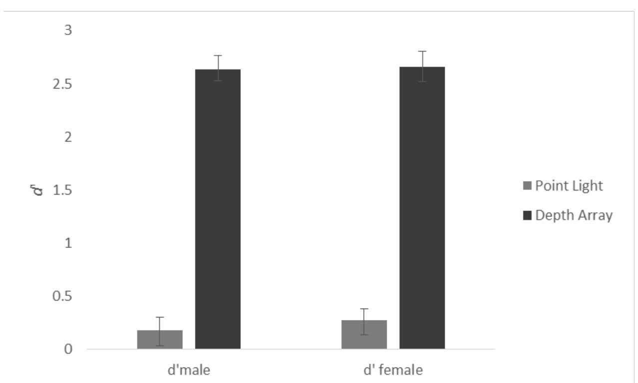

Figure 2. Sensitivity to sex as a function of stimulus type.

Race Detection

We also expected that participants might be able to successfully detect race from both point light and depth array stimuli, but that they would be more sensitive in the depth array condition. Overall, however, the result did not support this hypothesis. Participants were unable to detect either race (Caucasian or African American) from the point light displays (all *p*'s > .05). For the depth array, participants were able to accurately detect race above a chance level if the stimulus depicted the movements of someone Caucasian, $t(23) = 2.097$, $p = .047$, but not if the movements were produced by an African American individual ($p > .05$). Results are summarized in Figure 3 below. In light of the sex detection results and because race does not seem to be detectable from these movements we did not test for the effects of movement type on *d*'.

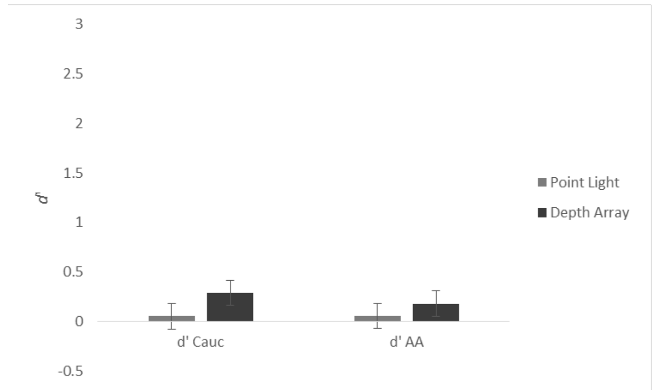

Figure 2. Sensitivity to race as a function of stimulus type.

Individual Differences

We also hypothesized that participants' dispositional characteristics would be related to their ability accurately detect sex and race. We calculated bivariate correlations between *d*' values and individual difference scores to determine if any dispositional characteristics (e.g. personality traits or sociality) were associated with detection sensitivity. We found that several dispositional characteristics were significantly associated with *d*' values, which are summarized below (Table 1). In general, participants' mood at the time of the experiment and self-reported friendliness impacted race detection, while personality (openness to experience) and self-perceived status impacted sex detection from kinematic information.

Table 1: Correlations between sensitivity and individual difference variables (**p* < .05, ***p* < .001)

	Openness	High Status	Friendliness	Good Mood
d' female (PL)	.523*			
d' male (PL)		-.451*		
d' male (DA)				
d' Cauc (PL)			-.525*	-.424*
d' Afr. Am. (PL)			-.525*	-.424*
d' Afr. Am. (DA)				.534**

Discussion

Individuals are embedded within a rich social context. Other people provide a potentially infinite number of possible interactions, yet there is structure to the way we understand others and how we interact with them. We accomplish shared goals and form complex and unique relationships with others. Interaction is guided by both invariant categorical and variant behavioral information that function to differentiate individuals from one another and guide interaction norms. We need to belong, and, as such, we often parse the world in terms of the social relationships we have with others.

A long history in social psychology has understood social cognition as an information processing activity that is rather implicit, yet integrates variant and invariant person knowledge and organizes this information in order to effectively interact with others. On the other hand, a long history in ecological psychology posits that we interact with others in terms of what we can do with or what others afford us (Gibson, 1979). This perspective argues that what we do with others is a function of information detection, rather than processing, in which information is detectable from energetic invariants (e.g. biological motion) that specify particular possibilities for interaction.

Yet, these two traditions are not mutually exclusive or contradictory. Here, we attempted to illustrate how these two perspectives can reinforce one another by examining if movement provides the energetic information that specifies particular invariant categorical characteristics important for social cognition—sex and race. Additionally, we attempted to tease apart what information is available in kinematics alone (by displaying joint movements devoid of all other bodily cues to sex and race) from what can be detected from movement in the absence of other socially relevant invariant information (e.g. facial structure, hair, skin tone) by displaying kinematics embedded in body structure. We hypothesized that, in general, social cognition likely emerges from the mutual constraints and functional couplings between co-actors embedded in a social environment (Marsh, Richardson & Schmidt, 2009) and that it was likely that rather than an actor simply detecting behavioral possibilities from a static object via their own movement (Gibson, 1979) social information is specified by the movement of others and modulated by individual differences in detection ability. We found that the relationship between biological motion and invariant categorical information about targets is not clear-cut.

For sex, kinematics alone seems to provide information for accurately detecting females, as prior work has demonstrated. Yet, in support of our hypotheses, providing some body structure drastically improves detection accuracy for both males and females. This provides initial evidence that kinematics are necessary, but not sufficient for successful recognition of sex, although it could be an issue of statistical power as to why we were unable to fully replicate Kozlowski and Cutting (1977). Additionally, we found that movement type was not related to the sensitivity to sex. This seems to indicate that there may be information in movement that specifies sex more broadly. Although some work exists that implicates hip to waist ratio and gait patterns like hip sway and shoulder swagger as specifying characteristics for sex detection (Johnson & Tassinary, 2005), determining additional biological constraints that might specify sex (e.g. center of mass or specific joint movement) would be useful. Our work is also novel in light of prior research that has demonstrated a bias toward male sex recognition from biological motion both temporally and in frequency of categorization (Johnson, Iida, & Tassinary, 2012). Additionally, it would be valuable to explore how movements associated with stereotypical female activities (e.g. loading a washing machine vs. fixing a car) are linked to detection sensitivity.

These results imply that neither traditional social psychological research suggesting representation of categorical knowledge, nor ecological suggestions that posit all information is contained in movement are correct in and of themselves. As such, future research on how sex is perceived and used during social interaction *must* address and integrate both of these perspectives. Additionally, future research should address perceiver characteristics that might influence sex detection such as sexual orientation. As many of our participants were female, it also would be appropriate to determine if group status (same sex vs. different sex) impacts the degree to which participants are sensitive to target sex or if gender identification maps onto movement in a similar manner to biological sex.

As for race detection, the results are even less clear. Our results suggest that race is only detectable with body structure, and perhaps only when produced by Caucasian individuals. Prior research has yet to As race is an invariant categorical characteristic that is socially constructed and irreducible to skin complexion, these results are not insignificant. Participants predicted that targets were Caucasian more frequently than they predicted that targets were African American. The demographic composition at the university or geographically is likely to impact both familiarity with and perceived representation of non-white individuals, thus researchers should take this into account when generalizing as to whether or not race is detectable from movement. Furthermore, because the majority of our participants were white, it could be the case that individuals are more sensitive to their racial in-group, although we were underpowered and could not test this assumption statistically. Finally, it could be the case that because race is less biologically constrained than sex (e.g. men and women have a different center of mass due to skeletal and body proportion differences) and it may be the case that race perception has more to do with how people *think* people of different racial categories are likely to move. This suggests that implicit biases or stereotypical racial associations should be examined in future studies.

Finally, we attempted to address the question of what people bring to the situation; what individual differences are likely to affect sex or race detection? While some correlations exist between sensitivity to race and sex, we are reluctant to make any strong conclusions from these relationships. The presence of moderately strong associations precludes us from dismissing them entirely, but for now we only suggest that individuals' dispositional characteristics are a likely influence on the ability to detect sex and race from human movement. It could also be the case that methodological characteristics of the study (e.g. order of the questions in the survey) made these characteristics salient. Future research should address additional individual difference variables on sex and race detection to determine which, if any, moderate or mediate sensitivity scores.

Conclusion

The research described here suggests the following. First, that sex is detectable from biological motion and that body structure plays a significant role, above and beyond joint kinematics. This is the case for multiple types of movements, indicating that gait is not the only specifying action for sex. Second, that race may be detectable for members of one's in-group or more easily with familiarity and experience, but is likely not a result of biological constraints on movement or kinematics. Third, that individual differences seem to be related to detecting both sex and race, thus identifying the pertinent factors that impact sensitivity is needed. Overall, we have provided initial evidence that both the social and ecological perspectives on social cognition can contribute to our understanding of how we perceive and identify the characteristics of others that impact our interactions with them.

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