2019

The Role of Cues and Kinematics on Social Event Perception

Estefania Berrios

University of Central Florida

THE ROLE OF CUES AND KINEMATICS ON SOCIAL EVENT PERCEPTION

by

ESTEFANIA BERRIOS

A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Psychology
in the College of Sciences
and in The Burnett Honors College
at the University of Central Florida
Orlando, Florida

Spring Term, 2019

Thesis Chair: Daniel McConnell, Ph.D.

ABSTRACT

The belief that intentions are hidden away in the minds of individuals has been circulating for many years. Theories of indirect perception, such as the Theory of Mind, have since been developed to help explain this phenomenon. Conversely, research in the field of human kinematics and event perception have also given rise to theories of direct perception. The purpose of the study was to determine if intentionality can be directly perceived rather than requiring inferential processes. Prior research regarding kinematics of cooperative and competitive movements have pointed toward direct perception, demonstrating participants can accurately judge a movement as cooperative or competitive by simply observing point-light displays of the isolated arm movements. Considering competitive movements are often performed faster than cooperative movements, speed was perturbed for the purpose of this study to determine if participants are relying on cues or if they can indeed perceive a unique kinematic pattern that corresponds to intentionality. Judging the clips correctly despite perturbation would suggest perception is direct. Additionally, we hypothesized judgments accuracy would be higher in the presence of two actors pointing to the use of interpersonal affordances. Twenty-eight participants from the University of Central Florida were asked to judge 40 clips presented in random order including: normal or perturbed competitive actions with one or two actors; normal or perturbed cooperative actions with one or two actors. Percent correct and reaction time data were analyzed on SPSS using a repeated measures ANOVA. Results rejected the hypothesis that social perception is direct and supported indirect perception, indicating participants relied on cues to make judgments, and provided potential support for the interpersonal affordance hypothesis.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank Dr. Daniel McConnell for his encouragement and support throughout this journey. I owe a great deal of my newly acquired knowledge and experience to Dr. McConnell's mentorship and expertise. I would also like to thank Dr. Mark Neider for contributing his knowledge and forming part of my committee. I thank my family and loved ones who believed in me and encouraged me to reach beyond the stars. Finally, I thank God for bestowing in me the confidence to pursue and successfully complete this project.

"I can do all things through Christ who strengthens me."

Phillipians 4:13

DEDICATION

To my parents Eduardo Berrios and Enid Quiñones, my sister Nelvis Berrios, and my aunt Brendaly Quiñones. This project would not have been possible without your unconditional love and support.

TABLE OF CONTENTS

CHAPTER ONE: INTRODUCTION

Problems and Theories in Social Perception

A common belief is that intentions and mental states are hidden away in the mind of each individual; in philosophy of mind, this is known as *the problem of other minds*. How do we know what other people are thinking, or even whether they have a mind at all? Humans are said to develop a *Theory of Mind* (ToM) at a young age to understand the mental states of others. Theory of Mind is the notion that humans can ascribe mental states to other individuals without any direct access to their actual mental states. Humans may either formulate inferences regarding the mental states of others (*Theory-Theory* or *TT*) or make attributions of mental states based on the individual's own mental states and experiences (*Simulation-Theory* or *ST*) (Gallagher, 2008). The problem of other minds arises as a product of these inferential processes (i.e. TT and ST) because, as is generally believed, one's own mind is the only mind that can be known to exist and one's own mental states are the only ones that can be directly experienced. This suggests that intentions are hidden away in the minds of the acting agents in the world and can, therefore, not be known by other perceiving agents. Understanding the mechanisms underlying social perception has the potential to shed light on the problem of other minds and improve our understanding of the nature of ToM.

While these theories describe different approaches, the common theme is that social perception is a form of cognition and reasoning (Wiltshire et al., 2015). These traditional accounts of ToM have been studied for many years. While research in the field provides evidence to support this account, it is important to further evaluate these studies. Research on

ToM often consists of making observational judgments based on pictures and videos, thus creating a “third person” perspective on the situation (Di Paolo & De Jaegher, 2012; Przyrembel et al., 2012). While this form of stimulus can depict real life situations, it does not provide realistic engagement. Realistically, an opportunity for social perception would truly be present during actual social interaction. Interaction is an important component to social perception. Interaction Theory (IT) focuses on the “interaction” aspect of social perception. This theory proposes that the perception of others’ mental states is direct and requires no inferential processes, such as those proposed by TT and ST (Gallagher, 2008; Gallagher & Varga, 2013).

Research by Tylen and colleagues (2012) shows that social observation and social interaction activate different brain regions. During their study, participants observed a person manipulating an object individually and a person showing an object to a partner. While observing individual manipulation, prefrontal cortex, right inferior gyrus, and right inferior parietal lobule areas were activated. During the interactive condition, there was greater activation in the posterior temporal sulcus, which plays a role in continuous fine-grained temporal navigation and stimulus integration related to responsiveness during social interactions (Tylen et al., 2012). Differences in activation suggest there is unique information available to the perceiver during active engagement in social interaction that is unavailable during individual action. While this does not address whether or not social perception is an inferential process, it provides important information about how to approach the study of social perception, as it raises implications about the significance of social interaction in the study of social perception.

Affordances and Theory of Direct Perception

This idea that intentionality resides only in the mind appeals to the dualistic notion that the mind exists separately from the brain and the body. However, many of the cognitive processes exhibited by humans are a product of a tightly coupled *perception-action cycle* (Gibson, 1979). Essentially, humans perceive to act and act to perceive. That is to say, there would be no end, or purpose, to perception if an individual could not act upon what is perceived. Likewise, perception would be impossible without an agent in the world acting on *affordances*. Affordances are opportunities for action in the world that correspond reciprocally to the perceiver and what is being perceived. Perception of the world is therefore *direct*. Gibson's (1979) theory of direct perception proposes the existence of invariant patterns in optic flow that are only present when the affordance is present.

The concept of affordances is often used to describe *personal affordances,* or opportunities available to the *individual.* For example, individuals can directly perceive the "climbability" of a staircase by simply observing different riser heights and judging the stairs as climbable or unclimbable (Warren, 1984). Humans are also able to directly perceive the "passability" of a walkway by observing different aperture widths and making judgments (Warren & Whang, 1987). It is important to distinguish between human action involving inanimate objects and human to human interaction. As stated by Gibson (1979), conspecifics afford many complex interactions such as communicating, fighting, nurturing, mating, and cooperating. Affordances involving interaction between two individuals can be called *interpersonal affordances*. These interpersonal affordances grant animals and humans access to opportunities for action otherwise unavailable to the individual, such as verbal and non-verbal behavior and coordinated action (McArthur & Baron, 1983; Valenti and Good, 1991; Kono, 2009). Some interpersonal affordances can involve multi-modal behaviors between agents working on a collaborative task, including facial expressions and gestures (Louwerse et al., 2012). Other examples include changes in kinematic patterns observed when one interactor requests to be fed by opening of the mouth or gaze direction (Ferri et al., 2011).

Interpersonal affordances are only present in a social interaction context, therefore the pattern for an interactive action will not be present or perceivable if there is no interaction. Communicative intent, for example, is an interactive action. An individual can only communicate in the presence of another person. Sartori et al. (2009a) found that movements made with the intention to communicate are performed slower and more carefully than individual movements. Similarly, Becchio et al. (2008a) observed that grip closing velocity and maximal finger aperture and grip closing velocity decrease significantly when an item is grasped to be passed to a partner compared to being grasped individually. Sudden perturbations in individual intentions involving interacting agents have also demonstrated changes in spatial trajectories. When participants were asked to place an object individually on a target, a partner would suddenly stretch out her arm to ask for the object. This study revealed significant veering of the arm, thus overriding the initial motor plan (Sartori et al., 2009b). However, no such effects occurred when the human partner was replaced by a robot. These findings suggest an interpersonal affordance, or opportunity for action only present and perceivable between two humans interacting. Interpersonal affordances can provide the individual direct information about the interaction and the action necessary to interact efficiently.

Affordances exist to be used by the perceiver and require no inferential processes to be perceived. In contrast to the theory of direct perception, the classical theory of indirect perception proposes that the senses are meaningless and cannot be trusted, therefore, must be inferred. The theory of indirect perception thus supports the ToM hypothesis, suggesting that, in this case, social perception is an inferential process. On the other hand, the theory of direct perception raises implications about the importance of interpersonal affordances serving as a basis for direct social perception.

Embodied Cognition

New ideas in cognitive science are consistent with ideas of direct social perception and the importance of interaction. The *embodied cognition hypothesis*, in this context, suggests that the mind is not the only cognitive resource responsible for complex human behavior and interaction (Wilson & Golonka, 2013). Cognition, instead, manifests itself in the body of the agent. Research shows that human gait patterns can be reproduced by robots without motors or onboard algorithms through careful assembly (Collins et al., 2005), suggesting that gait is the direct result of a particular embodiment. Other findings suggest that social interaction might be embodied. Female crickets, for example, select a mate based on which male cricket produces the loudest song (Barett,2011). Female crickets' eardrums are located on their two front legs and receive directional information about the sound based on amplitude. The eardrums are connected to small interneurons that control turning and respond to a specific frequency produced by the male cricket. Female crickets thus follow the direction of the most active interneuron in order to find a mate. This process is a form of embodiment and requires no inferential process by the female cricket. Children also exhibit signs of embodied cognition at a young age. Children between 7 and 12 months exhibit the A-not-B error when asked to retrieve a hidden object (Thelen et al., 2001). After being hidden under location A multiple times, the object is then hidden in location B in front of the child. The child still reaches for location A. However, observation of looking behavior shows that children look at error trials longer suggesting they know something went wrong. While the child possesses the knowledge of where the object is located, the reaching dynamics cannot yet access this information, suggesting skills believed to entail cognition are instead embodied. An embodied view of cognition sets forth the possibility that an agent's mental states and intentions may be externalized and thus directly perceived by an interacting agent in a social context. Embodied cognition thus replaces the notion that perception of intentions and mental states are hidden away and can only be inferred. This hypothesis supports the idea that social intention is directly perceivable.

Event Perception and the Principle of Kinematic Specification of Dynamics

Human action has unique characteristics that can be distinguished between events. The concept of *event perception* highlights the unique qualities of different events. Johansson (1973) studied event perception using the point-light technique. The point-light technique consisted of the attachment of small lights to the joints of actors and filming them walking in the dark. Participants were then asked to judge the action, which participants accurately identified as walking (Johansson, 1973). In a different study, participants were asked to distinguish biological from non-biological motion using humans and marionette puppets wearing point-lights and exhibiting the same actions (Johansson, 1976). Despite the spatial pattern similarity, participants were able to accurately distinguish biological from non-biological motion. Additionally, humans can accurately determine an actor's intention to deceive by observing only kinematic information

(Runeson & Frykholm, 1981). In this study, the actors wearing reflective tape on their major joints were asked to lift a light box and pretend it was heavy. Participants were able to accurately judge the weight of the box as well as the actor's intention to deceive. The examples above support the principle of *kinematic specification of dynamics*, which states that kinematic patterns contain enough information to specify underlying dynamic properties. In this context, dynamics refers to the underlying causal forces of the movement, which are intentions. Many other studies have demonstrated how kinematic patterns alone provide information about a point-light walker's sex (Kozlowski & Cutting, 1977) and identity (Cutting & Kozlowski, 1977). The kinematic information is therefore directly perceivable by observing agents.

Modern Research in Direct Social Perception

Georgiou et al. (2007) found different movement time, amplitude of peak velocity and deceleration time for competitive vs. cooperative movements suggesting a unique kinematic pattern for each intention. According to Becchio et al. (2008b), when individuals are cooperating with a partner displaying the intention to compete, the cooperative partner's kinematic pattern changes to match a pattern similar to the competitive one. Similarly, participants can discriminate between cooperative vs. competitive movements by observing temporally occluded clips of reach to grasp kinematics (Sartori et al., 2011) as well as point-light displays of the same movements (Manera et al., 2011). These results lend empirical support to the idea of direct social perception enabled by the different kinematic patterns of social interaction. A major concern surrounding the discrimination between competitive and cooperative movements by observers is that the speed of the movements may characterize the intentions, as competitive movements are often faster than cooperative movements. Although Sartori et al. (2011) and Manera et al. (2011)

compared cooperative vs. slow and competitive vs. fast in addition to fast vs. slow and competitive vs. cooperative, participants could more accurately distinguish fast vs. slow and cooperative vs. competitive. This raises the question of whether participants are using other cues, namely speed, to determine whether the movement is cooperative or competitive. If true, this would imply that movement speed acts as a social cue for perceptual inference and would be consistent with the Theory of Mind perspective. If the direct social perception hypothesis is to be valid, cooperative and competitive movements should each exhibit unique spatio-temporal trajectories that mirror the actor's intention despite how fast or slow the movement is performed.

Hypothesis

One way to test these claims is by perturbing the speed of the action kinematics. Eight different stimuli were created using point-light displays of reach to grasp movements: *competitive-normal speed, 1 actor; competitive-normal speed, 2 actors; competitive-fast speed, 1 actor; competitive-fast speed, 2 actors; cooperative-normal speed, 1 actor; cooperative-normal speed, 2 actors.* The direct social perception hypothesis would predict that observers should maintain correct judgments across the speed perturbation. If the perturbation induces judgment errors, this would support the Theory of Mind hypothesis. Likewise, the interaction theory predicts that judgments will be more accurate when two actors are visible instead of 1. Findings would suggest the presence, perception, and use of interpersonal affordances during social observation.

CHAPTER 2: METHODS

Participants

Twenty-Eight young adults (*N* = 28) ranging from 18-47 years of age (median age = 19; female = 15, male = 13) were recruited to participate in this study Participants reported normal or corrected-to-normal vision. Participants were recruited from the University of Central Florida's Psychology department's participant pool website. Participants received extra or partial course credit in exchange for their participation.

Materials

The materials consisted of eight video clips of actors performing competitive or cooperative movements. Action kinematics were isolated using the point-light technique. Reflective tape was placed on the actors' major arm joints (shoulders, elbow, wrist, and hand). Actors wore black clothing, and all other surfaces in the background were covered in black cloth. The displays were filmed using a Sony Digital Handicam at 30fps, with aperture settings adjusted to reduce the amount of light admitted by the camera. Room lights were turned off, and the actors were illuminated with a single spotlight from a 4.5W LED bulb placed at a distance of approximately 2.1 meters and located directly above the video camera. In the interaction, the actors performed a task of each placing an 8.9cm square foam block, visible in the display, in the center of the table. Each video clip was edited so that it began just as the reaching movement began and ended as soon as the blocks were placed. Further, video editing software was used to isolate the visibility of just the reflective patches. This was achieved using a manipulation of brightness contrast, a monochromatic filter, and a posterizing filter. Participants were not involved in the stimulus generation process.

Cooperative-Normal Speed, 2 Actors: Actors were instructed to work together to place blocks neatly in the center of the table. Video was presented at normal speed. The duration of this clip is 0.968 sec.

Cooperative-Fast Speed, 2 Actors: Actors were instructed to work together to place blocks neatly in the center of the table. This video was sped up to be similar to the competitive speed, resulting in a duration of 0.367 sec.

Cooperative-Normal Speed, 1 Actor: Two actors were instructed to work together to place blocks neatly in the center of the table. The video was cropped to display only one actor and was presented at normal speed with a duration of 0.934 sec.

Cooperative-Fast Speed, 1 Actor: Two actors were instructed to work together to place blocks neatly in the center of the table. The video was cropped to display only one actor and was sped up to match competitive speed with a duration of 0.367 sec.

Competitive-Normal Speed, 2 Actors: Two actors were instructed to compete by attempting to place their blocks on the table first. The video was presented at normal speed with a duration of 0.367 sec.

Competitive-Slow Speed, 2 Actors: Two actors were instructed to compete by attempting to place their blocks on the table first. The video was slowed down to match cooperative speed with a duration of 0.967 sec.

Competitive-Normal Speed, 1 Actor: Two actors were instructed to compete by attempting to place their blocks on the table first. The video was cropped to display only one actor and was presented at normal speed with a duration of 0.367 sec.

Competitive-Slow Speed, 1 Actor: Two actors were instructed to compete by attempting to place their blocks on the table first. The video was cropped to display only one actor and was slowed down to match cooperative speed with a duration of 0.967 sec.

The video clips were presented on a 27-inch screen BenQ XL2730Z gaming monitor with a resolution of 2560 × 1440, a 120 Hz refresh rate, and a 1ms gray-to-gray latency which minimizes pixel ghosting and improves motion displays. To run the experiment, a Dell Precision workstation T3500 running Windows 7 was used. E-Prime was used for stimulus presentation and response recording, including reaction time data. Data was analyzed using SPSS. Additionally, participants completed a demographic questionnaire

Procedure

The study took place in Room #306 of the University of Central Florida's Psychology department. Participants were welcomed into the lab and provided with an informed consent form. After reading the form and consenting to participate in the study, they were asked to complete a short demographic questionnaire. After completing the questionnaire, participants were seated in a standard office chair facing the display at a distance of approximately 70cm. A standard keyboard was placed on the desk between the display and the participant.

The stimuli consisted of the eight video clips presented five times each, for a total of 40 clips presented in random order. Participants were asked to make judgments by pressing a key on the keyboard as instructed (1 for competitive, 0 for cooperative), using a two-alternative forced choice between competitive and cooperative. Participants were instructed to respond quickly while still trying to be as accurate as possible. The study session lasted approximately 5 minutes.

CHAPTER 3: RESULTS

Outlier checking was conducted based on the RT data across 1120 total trials. Trials with an RT greater than 3SD (RT > ~8s) from the mean were excluded from subsequent analysis. Fifteen such trials were removed, leaving 1105 total trials remaining in the dataset, with a final mean RT = 1.50s. Of the trials removed, 6 were cooperative displays, 9 were competitive, and 9 involved speed perturbations, while 6 were normal speed displays. From the remaining data, mean percent correct and mean RT was calculated for each of the 8 conditions, which were subsequently analyzed using repeated-measures 2×2×2 ANOVA.

<u>Analysis of Percent Correct Data</u>

Assumption of homogeneity of covariance was checked using Mauchly's Test of Sphericity, which was not significant, indicating the assumption was not violated. There was a main effect of intention on percent correct judgments, with competitive videos (64.4% correct) judged more accurately than cooperative videos (52.80%), $F(1,27) = 12.04$, $p = .002$, partial $\eta^2 = .31$. Next, we found a main effect of the speed of the video, with normal speeds (82.7% correct) judged more accurately than perturbed speeds (34.5% correct), $F(1,27) = 46.00$, $p < .001$, partial $\eta^2 = .63$. There was no significant main effect of the number of actors, $F(1,27) = 1.67$, $p = .21$, partial $\eta^2 = .06$.

There was a significant interaction between intention and speed. The effect of the speed manipulation was more pronounced on cooperative displays (63.1% difference) compared to competitive displays (33.3% difference), $F(1,27) = 20.03$, $p < .001$, partial $\eta^2 = .43$. This effect is depicted in Figure 1. There was no interaction between speed and number of actors in the display, $F(1,27) = 2.98$, $p = .10$, partial $\eta^2 = .01$. The percent correct difference between normal and perturbed displays was 52% for the 1-actor condition and 45.3% for the 2-actors condition (Figure 2). A significant interaction was found between intention and number of actors, $F(1,27) = 11.04$, $p = .003$, $\eta^2 = .29$, pointing to an increased accuracy for cooperative displays and a decreased accuracy for competitive displays in the presence of two actors (Figure 3). No significant three-way interaction was found between intention, speed, and number of actors $F(1,27) = .02$, $p = .90$, $\eta^2 = .001$.

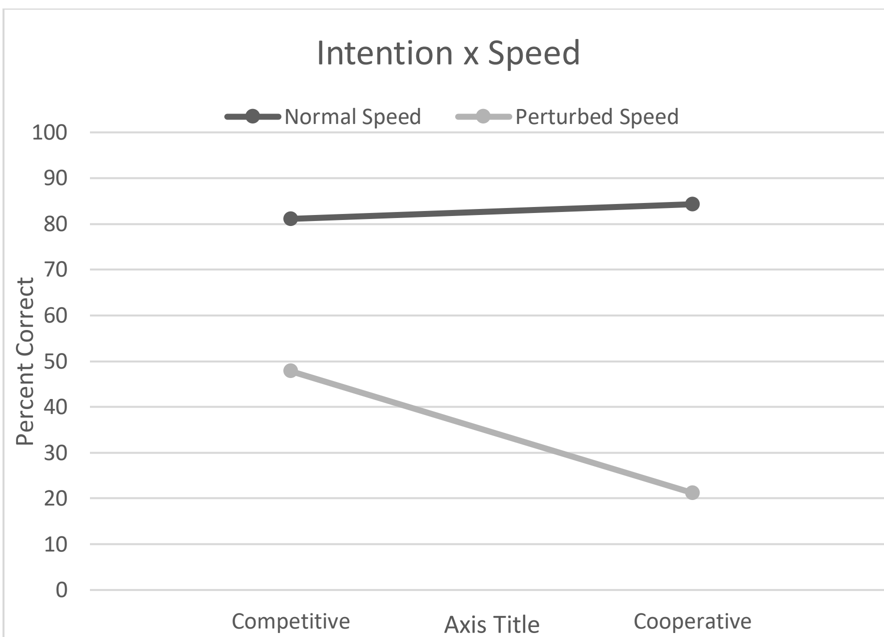


Figure 1. Significant interaction between movement intention and speed manipulation on percent correct data. The effect of the speed perturbation is more pronounced for cooperative displays.

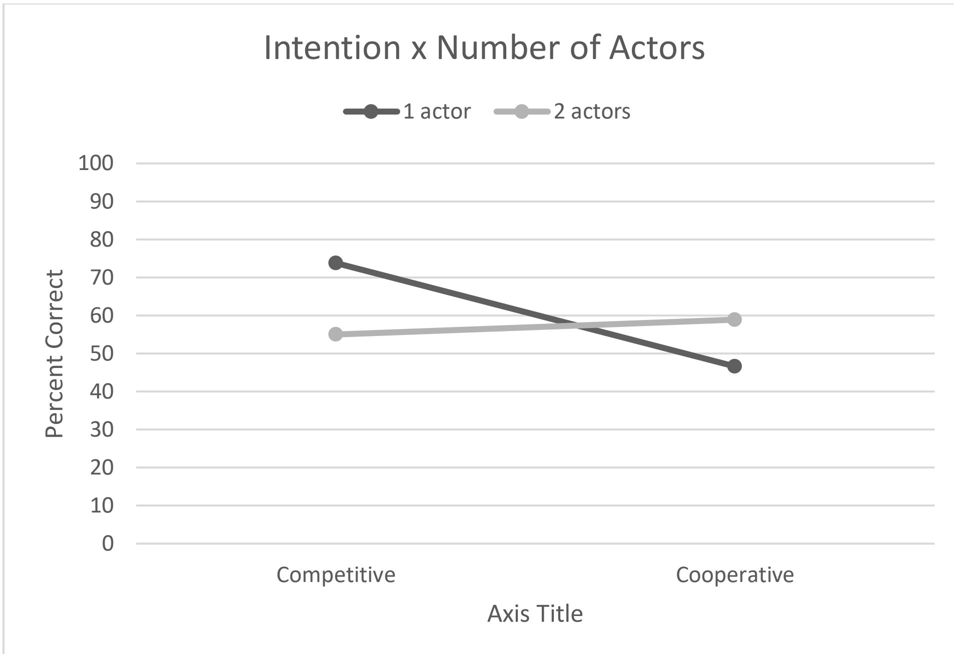


Figure 2. Significant interaction between movement intention and number of actors visible in the display on percent correct data. The presence of two actors decreased accuracy in competitive displays but increased accuracy in cooperative displays.

<u>Analysis of Reaction Time Data</u>

There was a main effect of intention on RT, with competitive displays (1.66s) having longer RT than cooperative displays (1.41s), $F(1,27) = 33.61$, $p <.001$, $\eta^2 = .56$. The main effect of number of actors was not significant, $F(1,27) = .06$, $p = .82$, partial $\eta^2 = .002$. A significant main effect for speed was found. Participants exhibited longer RTs for perturbed displays (1.67s) compared to normal displays (1.39s), $F(1,27) = 19.0$, $p < .001$, partial $\eta^2 = .41$.A significant interaction between speed and intention revealed that the speed perturbation increased RT only for competitive displays (mean difference = 0.76s) while the perturbation decreased RT in cooperative displays (mean difference = -0.20s), $F(1,27) = 65.1$, $p < .001$, partial $\eta^2 = .71$ (Figure 4). There was no significant interaction between intention and number of actors, $F(1,27)$

= .01, p = .91, partial η^2 = .00. There was also not a significant interaction between number of actors and speed, $F(1,27) = 3.61$, p = .07, partial η^2 = .12. Finally, a significant three-way interaction was found between number of actors, speed, and intention, $F(1,27) = 10.5$, p = .003, partial η^2 = .28, signifying an increased RT not only for competitive displays, but particularly for those containing only one actor (Figure 5).

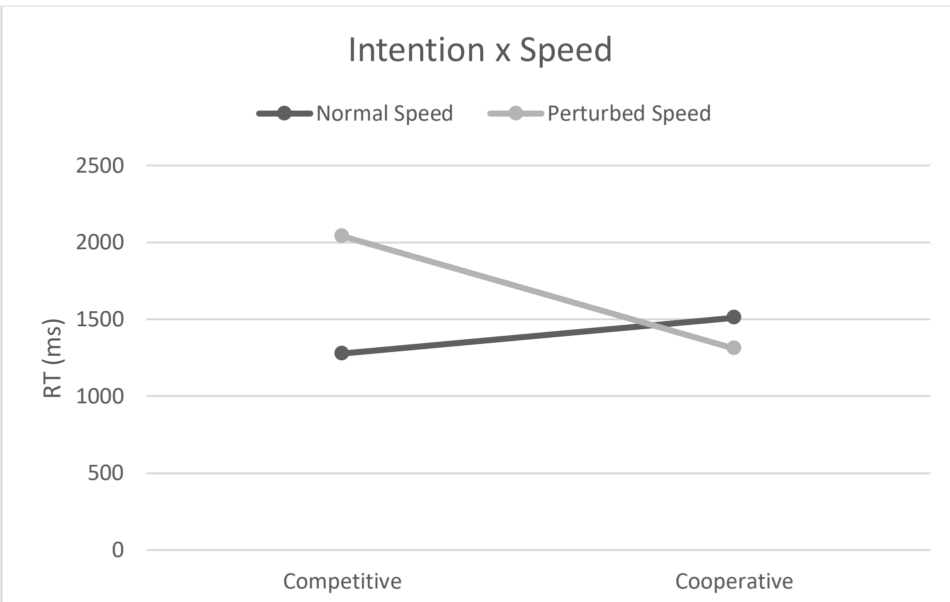
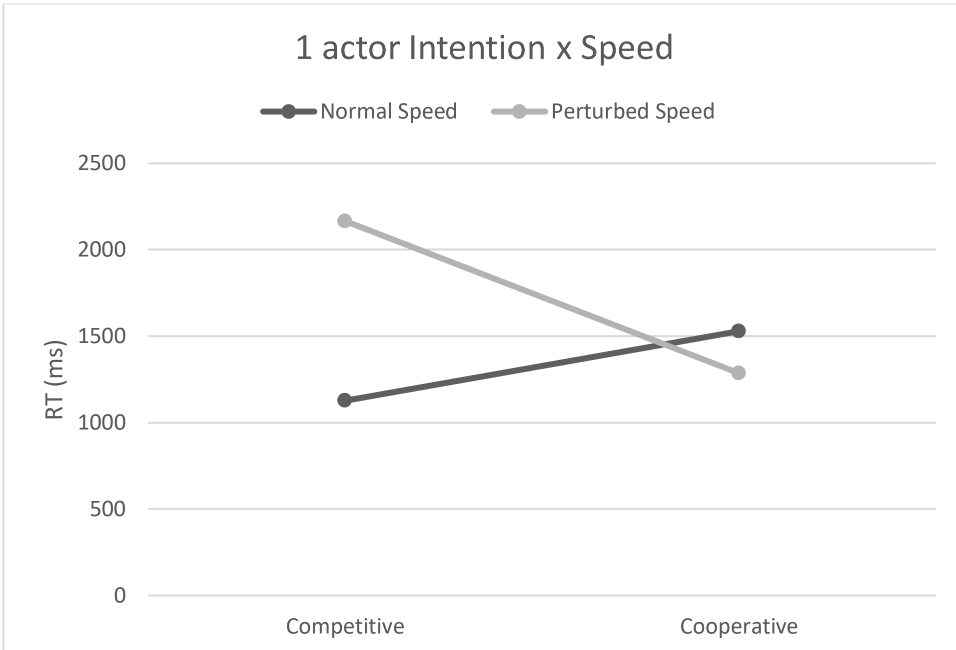


Figure 3. Interaction between movement intention and speed manipulation on RT data. Note the increase in RT in particular for the perturbed competitive displays.



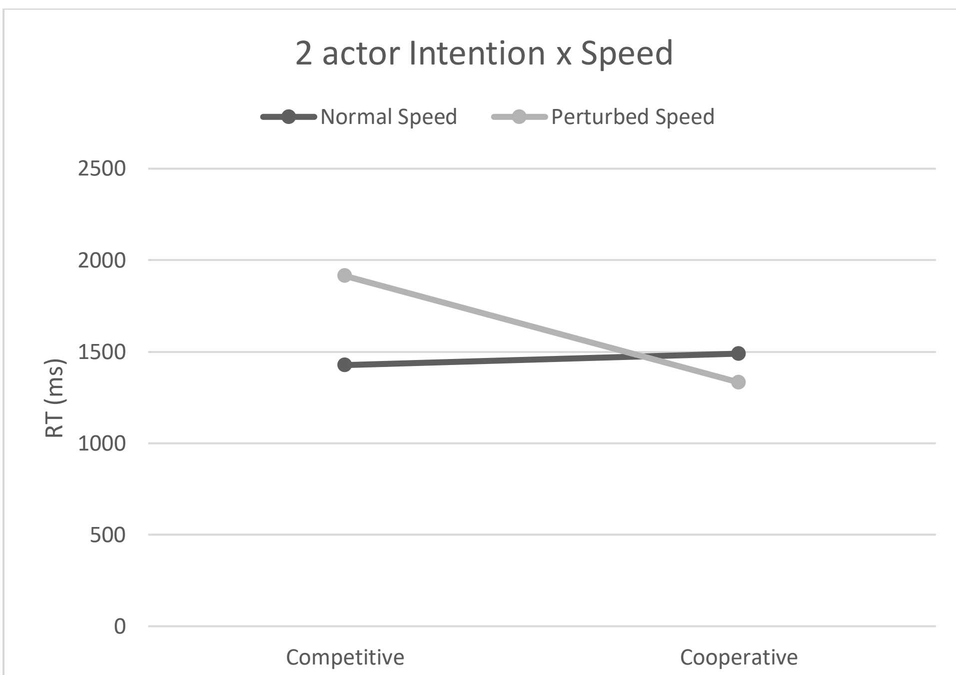


Figure 4 and 5. Significant three-way interaction on the RT data, revealing longest RT for competitive 1-actor perturbed displays. The effect of the speed perturbation is most pronounced in the competitive 1 actor condition.

CHAPTER 4: DISCUSSION

The goal of this study was to determine whether the intentions of others can be directly perceived or if they require inferential processing. We hypothesized that judging actors' intentions correctly despite perturbation in the speed of the movements would suggest social perception is direct. Additionally, we hypothesized that more accurate judgments in clips showing two actors would suggest the perception and use of interpersonal affordances. However, the difference in accuracy between normal and perturbed speed fails to support the direct perception hypothesis.

We also note that the effect of the speed perturbation was greater in the cooperative condition than the competitive displays, suggesting the perturbation was more pronounced in the former. The current methods are insufficient to explain this finding, but the analysis of reaction time data showed an increase in RT for perturbed competitive displays and a decrease in RT for perturbed cooperative displays. We may conclude from this that the perturbation increased the "computational load" of the participant while observing competitive displays, indicating use of cues, but that this increase in workload revealed a possible compensatory mechanism that resulted in improved judgments in the perturbed competitive videos. The findings reject the hypothesis that social perception is direct.

Despite the lack of support for the direct perception hypothesis in terms of the speed perturbation, there is potential support for it in terms of the manipulation of the number of actors visible. The presence of two actors lowered the accuracy for competitive displays while increasing the accuracy in cooperative displays. There was also a longer RT found for competitive displays, especially the ones containing only one actor. This may suggest participants are more likely to infer cooperative intentionality when observing two individuals engaging in a task together. Whether this is a form of cue-based inference or reveals the possibility that observers may perceive an interpersonal affordance between two actors is unclear. Overall, the findings suggest participants are relying on cues, namely speed, to make their judgment.

Limitations

A few limitations were encountered in the process of conducting this study. First, the competitive displays appeared to be in "slow motion" when the speed was perturbed compared to the more natural appearance of the perturbed cooperative displays. This also relates to the second issue regarding the creation of the stimuli. Stimuli were created using reflective tape and were edited by speeding up and slowing down video footage. A research-quality motion tracking system could provide more realistic displays and thus make the kinematic information more pronounced. Finally, all the video clips presented contain the same two actors toggling between intentions. It is possible the one or both of the actors exhibited movement artifacts that biased judgments.

Future Research

For future research, it is recommended that researchers address the limitations previously stated. In order to obtain more authentic intentions, it is suggested that actors complete a survey about their level of competitiveness and cooperativeness. Those who score higher on competitiveness will be recorded for the competitive condition. Likewise, individuals who score higher on the cooperative trait will be recorded for the cooperative condition. A research-quality tracking system is also recommended in order to capture each actor's motion. This will prevent any artifacts in action kinematics and provide a more realistic picture in the perturbed displays.

Further, the importance of interaction in social perception needs to be emphasized. In the current study, we employed an interactive task between two actors. However, the research participant remained a third-person observer of this interaction. It is possible that the novelty of the task made it difficult for participants to recognize any potential invariant patterns that specify competitiveness and cooperativeness, respectively. An improved design may involve allowing the participant to engage in the block-placing task under both competitive and cooperative instructions. This would allow them to attune to the information, assuming it is present. Previous event perception work has emphasized the importance of perceptual learning and attunement to task-specific information, especially in experimentally contrived tasks and displays (Bingham, McConnell, & Muchisky, 2001). It was previously discussed that research on ToM often involved participants making judgments from a third-person perspective and using static images. While the actors in the video were engaging in the action, the participant still observed from a third person perspective. It is possible interpersonal affordances are more likely to be perceived when the individual is the one actively participating in the interaction.

Conclusion

The purpose of the current study was to determine whether social perception is direct or if individuals use inferential processes to understand others' intentions. The study also sought to determine if interpersonal affordances are present and perceived by individuals during social interaction. The results rejected both hypotheses, thus suggesting social perception is indirect and requires inference.

APPENDIX A: FIGURES

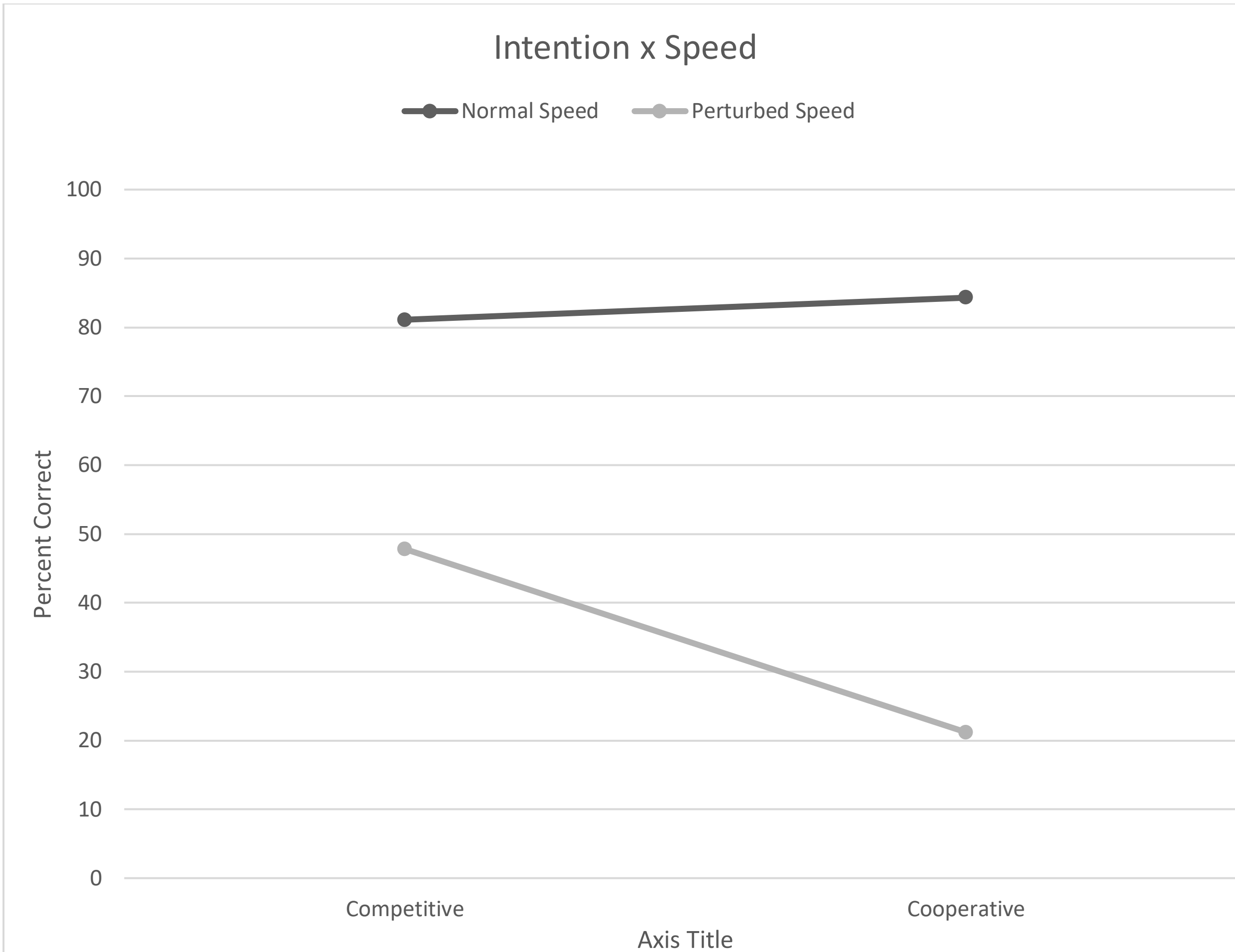


Figure 1. Significant interaction between movement intention and speed manipulation on percent correct data. The effect of the speed perturbation is more pronounced for cooperative displays.

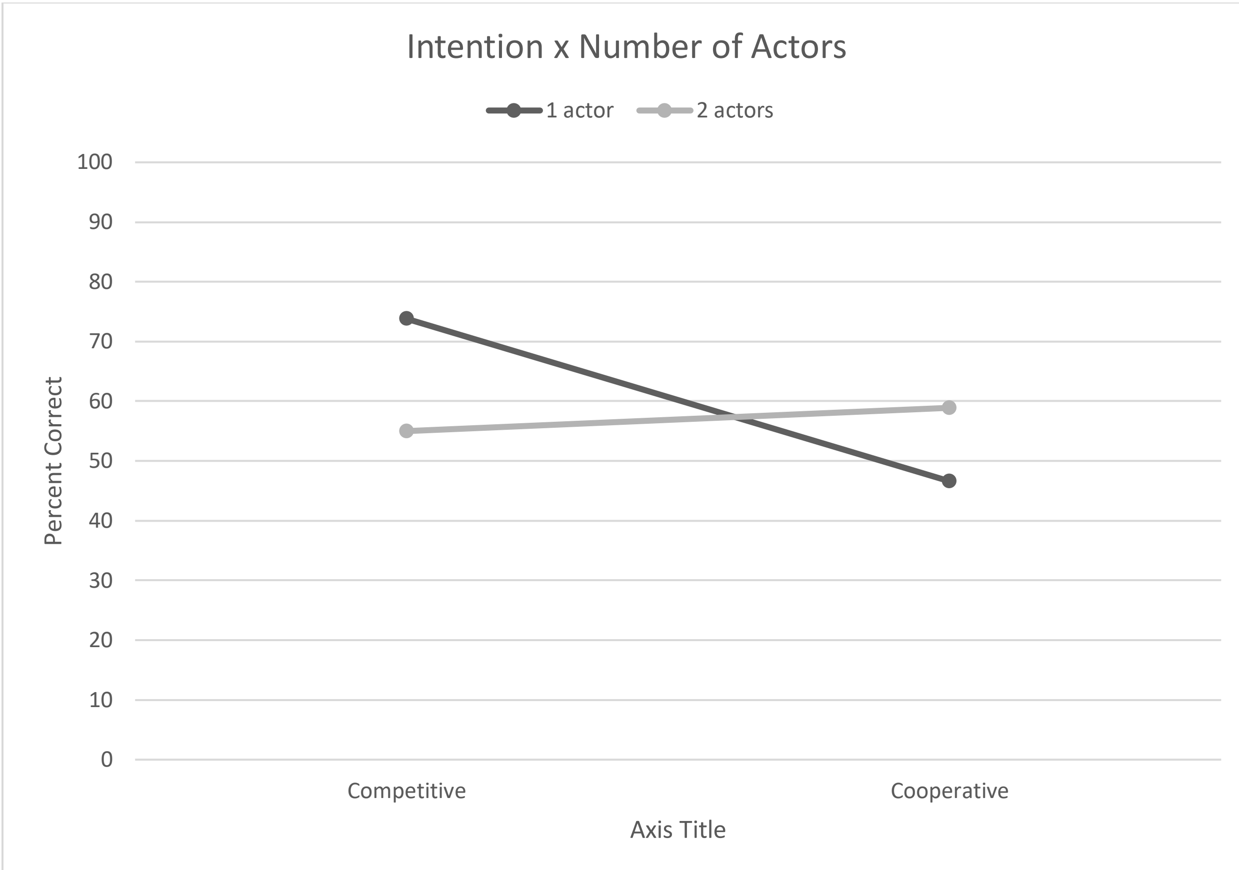


Figure 2. Significant interaction between movement intention and number of actors visible in the display on percent correct data. The presence of two actors decreased accuracy in competitive displays but increased accuracy in cooperative displays.

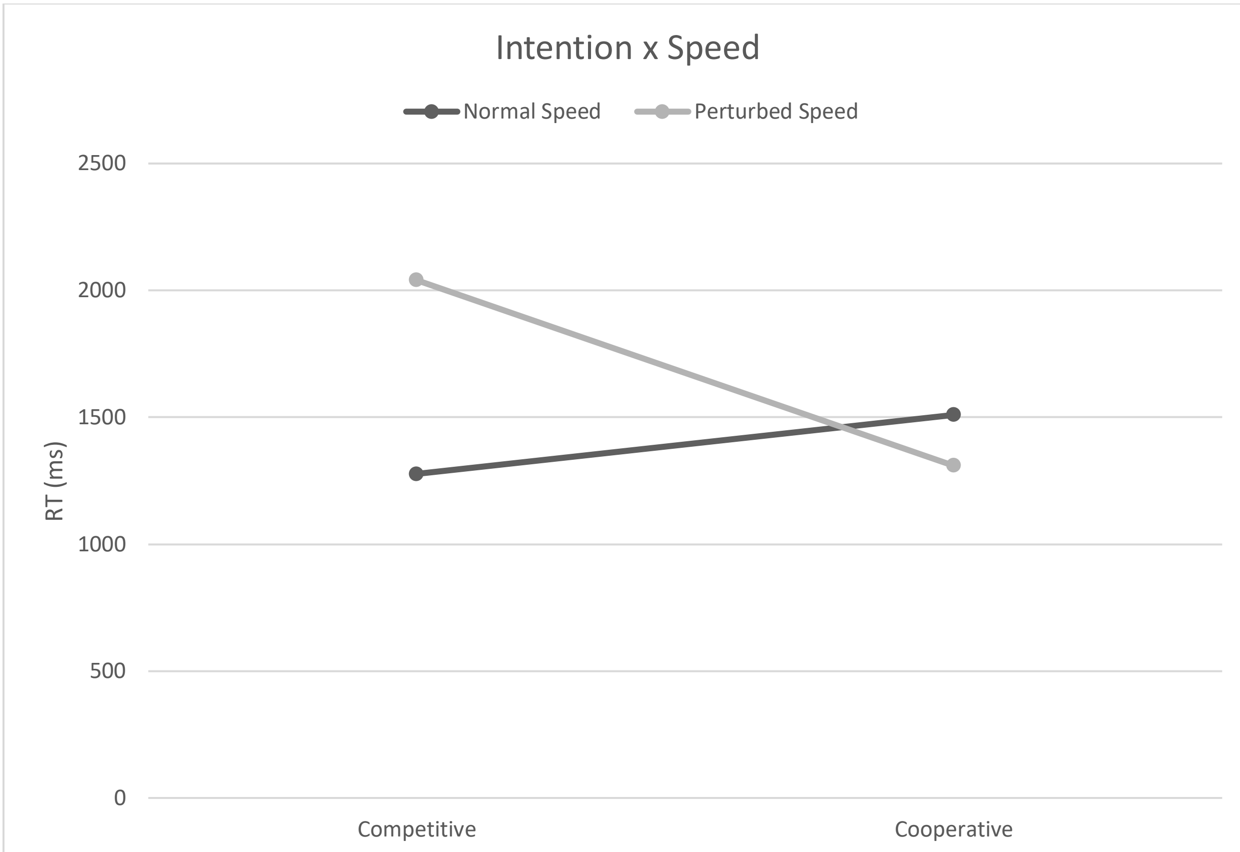
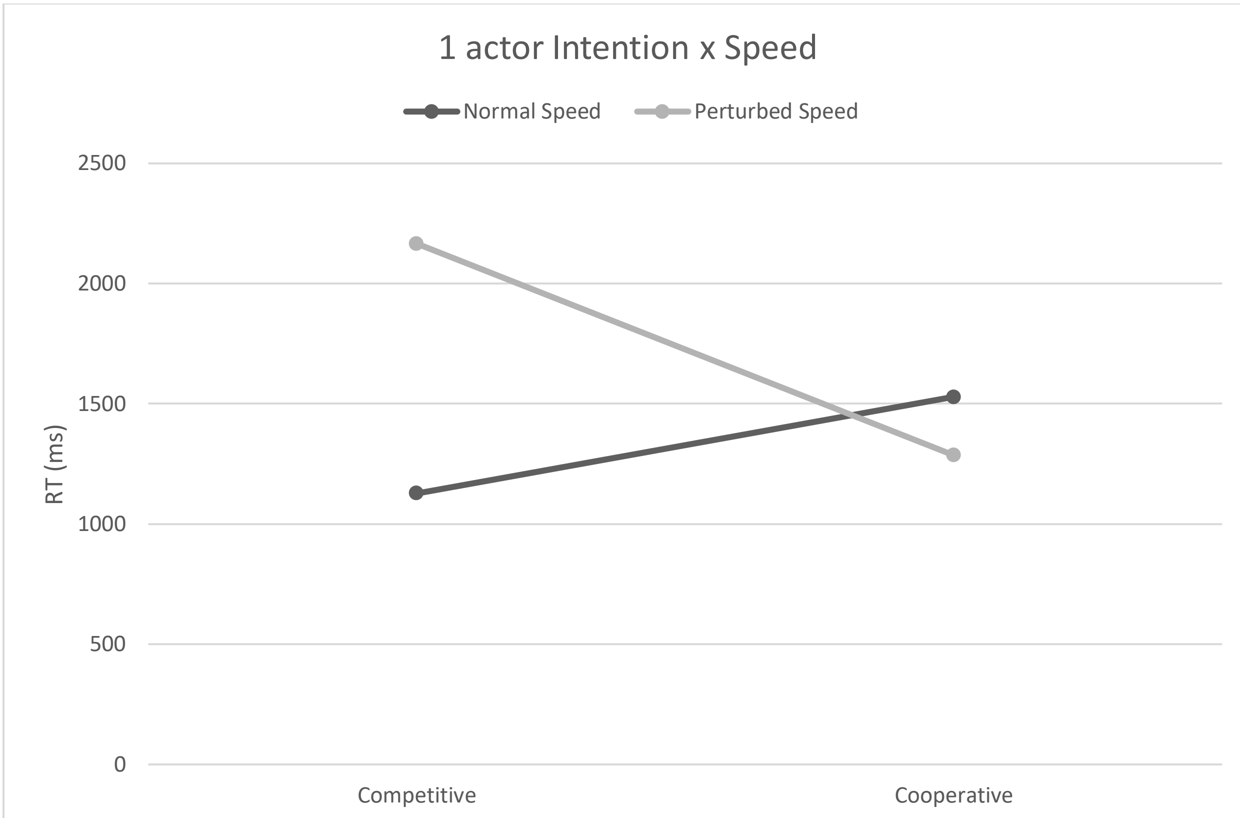


Figure 3. Interaction between movement intention and speed manipulation on RT data. Note the increase in RT in particular for the perturbed competitive displays.


1 actor Intention x Speed
Normal Speed
Perturbed Speed
2500
2000
1500
1000
500
0
RT (ms)
Competitive
Cooperative

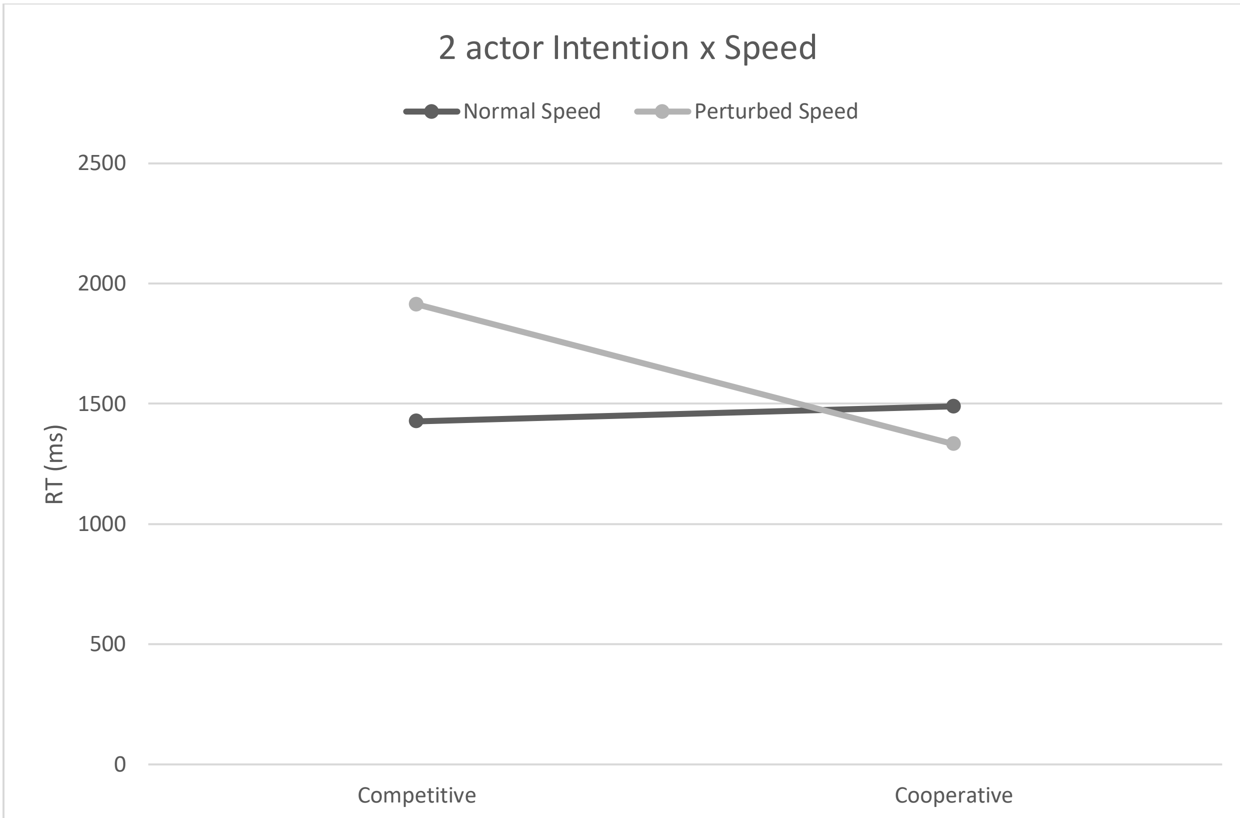


Figure 4 and Figure 5. Significant three-way interaction on the RT data, revealing longest RT for competitive 1-actor perturbed displays. The effect of the speed perturbation is most pronounced in the competitive 1 actor condition.

References

Barrett, L. (2011). *Beyond the Brain: How the Body and the Environment Shape Cognition*. New Jersey: Princeton University Press.

Becchio, C., Sartori, L., Bulgheroni, M., & Castiello, U. (2008a). The case of Dr. Jekyll and Mr. Hyde: A kinematic study on social intention. *Consciousness and Cognition, 17*, 557–564.

Becchio, C., Sartori, L., Bulgheroni, M., & Castiello, U. (2008b). Both your intention and mine are reflected in the kinematics of my reach to grasp movement. *Cognition, 106*, 894–912.

Bingham, G.P., McConnell, D.S., & Muchisky, M.M. (2001). Commentary on Jacobs and Michaels (2001): Calibration and perceptual learning in event perception. *Perception & Psychophysics*, *63*(3), 572-574.

Collins, S., Ruina, A., Tedrake, R., and Wisse, M. (2005). Efficient bipedal robots based on passive dynamic walkers. *Science*, *307*, 1082–1085.

Cutting, J. E., and Kozlowski, L. T. (1977). Recognizing friends by their walk: Gait perception without familiarity cues. *Bulletin of the Psychonomic Society,* 9, 353–356. doi: 10.3758/bf03337021

Di Paolo, E. D., and De Jaegher, H. D. (2012). The interactive brain hypothesis. *Frontiers in Human Neuroscience,* 6:163. doi: 10.3389/fnhum.2012.00163

Ferri, F., Campione, G. C., Dalla Volta, R., Gianelli, C., and Gentilucci, M. (2011). Social requests and social affordances: how they affect the kinematics of motor sequences during interactions between conspecifics. *PLoS One* 6:e15855. doi: 10.1371/journal.pone.0015855

Gallagher, S. (2008). Direct perception in the intersubjective context. *Consciousness & Cognition.* 17, 535–543. doi: 10.1016/j.concog.2008.03.003

Gallagher, S., and Varga, S. (2013). Social constraints on the direct perception of emotions and intentions. *Topoi* 33, 185–199. doi: 10.1007/s11245-013-9203-x

Georgiou, J., Becchio, C., Glover, S., & Castiello, U. (2007). Different action patterns for cooperative and competitive behaviour. *Cognition, 102*, 415–433.

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. *Perception & Psychophysics*, 14, 201–211. doi: 10.3758/bf03212378

Johansson, G. (1976). Spatio-temporal differentiation and integration in visual motion perception. *Psychological Research,* 38, 379–393. doi: 10.1007/bf00309043

Kono, T. (2009). Social affordances and the possibility of ecological linguistics. *Integrative Psychological and Behavioral Sciences,* 43, 356–373. doi: 10.1007/s12124-009-9097-8

Kozlowski, L. T., and Cutting, J. E. (1977). Recognizing the sex of a walker from a dynamic point-light display. *Perception & Psychophyics*, 21, 575–580. doi: 10.3758/bf03198740

Louwerse, M. M., Dale, R., Bard, E. G., and Jeuniaux, P. (2012). Behavior matching in multimodal communication is synchronized. *Cognitive Science,* 36, 1404–1426. doi: 10.1111/j.1551-6709.2012.01269.x

Manera, V., Becchio, C., Cavallo, A., Sartori, L., and Castiello, U. (2011). Cooperation or competition? Discriminating between social intentions by observing prehensile movements. *Experimental Brain Research, 211*, 547–556. doi: 10.1007/s00221-011-2649-4

McArthur, L. Z., and Baron, R. M. (1983). Toward an ecological theory of social perception. *Psychological Review,* 90, 215–238. doi: 10.1037//0033-295x.90.3.215

Przyrembel, M., Smallwood, J., Pauen, M., and Singer, T. (2012). Illuminating the dark matter of social neuroscience: considering the problem of social interaction from philosophical, psychological and neuroscientific perspectives. *Frontiers in Human Neuroscience.* 6:190. doi: 10.3389/fnhum.2012.00190

Runeson, S., and Frykholm, G. (1981). Visual perception of lifted weight. *Journal of Experimental Psychology: Human Perception and Performance*, 7, 733–740. doi: 10.1037//0096-1523.7.4.733

Sartori, L., Becchio, C., Bara, B.G., & Castiello, U. (2009a). Does the intention to communicate affect action kinematics? *Consciousness and Cognition, 8*, 766–772.

Sartori, L., Becchio, C., Bulgheroni, M., & Castiello, U. (2009b). Modulation of the action control system by social intention: unexpected social requests override preplanned action. Journal of *Experimental Psychology: Human Perception and Performance, 35*, 1490–1500.

Sartori, L., Becchio, C., and Castiello, U. (2011). Cues to intention: the role of movement information. *Cognition*, *119*, 242–252. doi: 10.1016/j.cognition.2011.01.014

Thelen, E., Schöner, G., Scheier, C., and Smith, L. B. (2001). The dynamics of embodiment: a field theory of infant perseverative reaching. *Behavioral and Brain Science,* 24, 1–86.

Tylén, K., Allen, M., Hunter, B. K., and Roepstorff, A. (2012). Interaction vs. observation: distinctive modes of social cognition in human brain and behavior? A combined fMRI and eye-tracking study. *Frontiers in Human Neuroscience.* 6:331. doi: 10.3389/fnhum.2012.00331

Valenti, S. S., and Good, J. M. M. (1991). Social affordances and interaction I: Introduction. *Ecological Psychology*, 3, 77–98. doi: 10.1207/s15326969eco0302_2

Warren, W. H. (1984). Perceiving affordances: Visual guidance of stair climbing. *Journal of Experimental Psychology: Human Perception and Performance*, *10*(5), 683–703. https://doi-org.ezproxy.net.ucf.edu/10.1037/0096-1523.10.5.683

Warren, W. H., Jr., & Whang, S. (1987). Visual guidance of walking through apertures: Body-scaled information for affordances. *Journal of Experimental Psychology: Human Perception and Performance, 13*(3), 371–383. https://doi-org.ezproxy.net.ucf.edu/10.1037/0096-1523.13.3.371

Wilson, A. D. & Golonka, S. (2013). Embodied Cognition is Not What You Think It Is. *Frontiers in Psychology, Vol 4 (2013)*. https://doi-org.ezproxy.net.ucf.edu/10.3389/fpsyg.2013.00058/full

Wiltshire, T. J., Lobato, E. C., McConnell, D. S., & Fiore, S. M. (2015). Prospects for direct social perception: A multi-theoretical integration to further the science of social cognition. *Frontiers in Human Neuroscience, 8,* https://doi.org/10.3389/fnhum.2014.01007/full