SPATIAL PERCEPTION DURING CONROL WITH ANOTHER: THE 'OTHER' AS POTENTIAL PERTURBATION

J. Scott Jordan, Andrew Kenning, Jim Clinton, Justin Durtschi
Department of Psychology, Illinois State University, Normal, IL, USA

Abstract

The perceived vanishing point of a moving stimulus is displaced beyond the actual vanishing point. This forward displacement (FD) decreases with implied friction (i.e., the stimulus appears to move across a surface). The effect reverses when participants control stimulus movements (via right- and left-key presses) versus observe them. This reversal is consistent with economy-of-action (EOA) effects in which variables such as perceived pitch are influenced by the energy-demands implied by a stimulus (e.g., a steeper hill). The present talk presents experiments that reveal EOA effects when two participants control stimulus movements together, each having access to one of two control buttons. Specifically, FD increases across implied friction, regardless who controls the stimulus when it vanishes. Since participants are basically observers as the other participant controls the stimulus, the increase of FD during such observation indicates participants perceive the other-controlled stimulus movements in terms implied effort (i.e., EOA).

When observers are asked to indicate the vanishing point of a moving stimulus, they indicate perceived vanishing points that are displaced beyond the actual vanishing point, in the direction of stimulus motion (Hubbard, 1995, 2005). These forward displacements (FD) have been found to vary systematically as a function of dynamic stimulus properties such as implied friction (i.e., the stimulus appears to move across a surface). Specifically, FD decreases as the degree of implied friction increases (i.e., the stimulus appears to move between two surfaces). These findings are often accounted for in terms of *representational momentum*, the idea being that the brain evolved to represent dynamic as well as static stimulus properties. Thus, at the moment the stimulus vanishes, the representation of its dynamics continues for some time, in a manner consistent with the momentum properties of those dynamics. And when participants are then asked to indicate the vanishing point, they use a representation that has since, 'moved on', as it were, beyond the vanishing point, due to representational momentum.

While early investigations of representational momentum utilized stimulus movements controlled by the computer, recent research has placed the movements under the control of the participant. Jordan and Knoblich (2004), for example, designed an FD experiment in which participants were asked to make a dot stimulus move back and forth across a computer monitor via right- and left-arrow key presses. If the dot was moving to the right, right-presses accelerated the dot to the right, while left-key presses decelerated the dot. If the dot was moving to the left, the opposite relationship obtained. An analogue of this task is driving a car, in that, pressing a button to decelerate the dot is like putting on the brakes, and doing so to accelerate, like pressing the gas pedal. In order to assess the extent to which the action planning associated with such actions might influence FD, Jordan and Knoblich programmed the key presses to have either high or low impact, the former constituting the driving equivalent of good brakes, and the latter, bad breaks. In addition, participants did the task either alone, or as a member of pair. In the alone condition, they controlled both keys. In the pair condition, each member controlled one key. The driving analog would be driving alone and having control of both the brakes and the gas, versus driving as a team, with one member controlling the brakes, and the other, the gas. This influences the anticipation surrounding each button press because for those in the alone condition, the right hand knows what the left hand is doing, for both hands belong to the same brain. In the pair condition, the two hands belong to different brains. Hence, uncertainty regarding what the other will do at any given moment leads to the need for more anticipation, just as sharing control over a car with another requires one to begin braking earlier than if one is alone, so as to have enough time to compensate should the other prove to be uncooperative. The results of the experiment were consistent with the notion that FD is influenced by the types of action plans that are necessarily generated during action control. FD was larger in the low-impact (i.e., bad brakes) versus the high-impact (i.e., good brakes) condition. It was also larger in the pair versus alone condition.

In a recent experiment, Jordan, Coey and Tsippaaoutis (2008) investigated the extent to which action planning interacts with stimulus factors such as implied friction. This question is important because researchers such as Proffitt (2006) report that perception entails the energy demands of behaving in a particular environment, what Proffitt refers to as 'economy-of-action'. For example, hills are perceived to steeper the more tired one is. To test for such effect in the dot-control paradigm, Jordan et al. (2008) had participants control the movements of a square stimulus back and forth across the computer monitor in different 'implied-friction' contexts (i.e., the stimulus appeared on the screen either by itself—low implied friction, as if moving across a single surface—medium implied friction, or as if moving between two surfaces—high implied friction). Results indicated that as implied friction increased, FD from controllers (i.e., participants actually controlling the movements of the stimulus) increased, while FD from observers (i.e., participants who simply watched stimulus movements controlled by another participant) decreased. This latter finding, that FD decreases with implied friction for observers, constitutes a replication of Hubbard's (1995) classic finding of representational friction. The former finding however, that FD increases with implied friction for controllers, constitutes a reversal of the classic Hubbard finding. In addition, it is consistent with an 'economy-of-action' account, in that, participants perceived the movements of the stimulus in terms of the amount of effort implied by the friction context. That is, making a stimulus move through a high-friction context implies the need to generate more force than would be needed to move it through a low-friction context. Thus, even though the actual work required to move the stimulus back and forth (i.e., the number of button presses) is the same across different implied-friction contexts, the implied work is different, and the difference reveals itself in the participants' FD.

Given this relationship between action control and stimulus factors, the purpose of the present experiments was to assess the extent to which the social factors addressed in Jordan and Knoblich (2004) would interact with stimulus factors such as implied friction. That is, while controlling the stimulus with another, what happens to FD across different levels of implied friction?

Experiment 1

Methods

To test the relationship between social and stimulus factors during action control, participants controlled the movements of a square stimulus back and forth across a computer monitor in one of three implied friction contexts: Low (i.e., square by itself) and medium (i.e., square appeared to move across the top of a surface). These stimuli were designed, to the pixel, after stimulus descriptions reported in Hubbard (1998). There were 83 pairs of participants. Members of a pair sat next to each other, 50 cm in front of a shared computer monitor. Each was given their own game controller, and the two controlled the movements of the square (via the key-press method of Jordan and Knoblich, 2004) back and forth across the computer monitor. At an unpredictable moment during each trial, the square vanished, and one of the participants indicated the perceived vanishing point. The same participant indicated perceived vanishing points on every trial, regardless which participant was actually decelerating the square when it vanished. As a result, half of the perceived vanishing points derived from trials during which the square vanished while the designated participant was decelerating it herself (i.e., self), while the other half was derived from trials during which the 'other' participant was decelerating it (i.e., other). Each pair experienced 20 trials of each of two implied-friction condition (i.e., low and medium) in blocked fashion. This allowed us to compare 'self' versus 'other' FD across different levels of implied friction.

Results and Discussion

The difference between the actual and perceived vanishing point was determined for every trial, and trials entailing a difference larger than 100 pixels were excluded. Figure 1 depicts the average FD, in pixels, per condition. A 2 x 2 within-subjects ANOVA revealed a significant main effect of self vs. other, $F(1,82) = 15.22$, $p < .05$, with other FD being larger than self FD, a significant main effect of implied friction; $F(1,82) = 9.43$, $p < .05$, with FD increasing with implied friction, and no significant interaction.

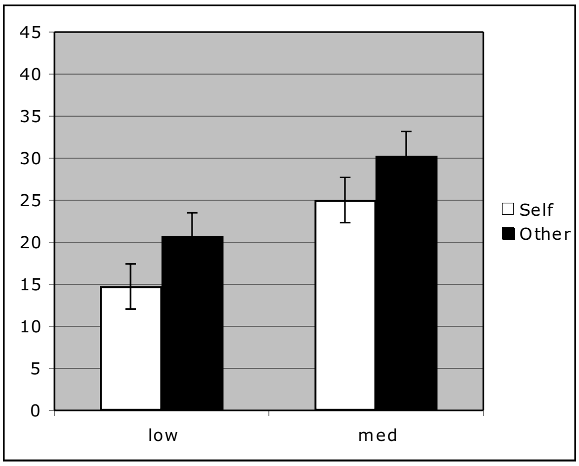

Fig. 1. FD in pixels as a function of controller (i.e., self versus other) and degree of implied friction (i.e., low versus medium).

As can be seen in Figure 1, FD increases with implied friction. This constitutes a replication of the Jordan, Coey, and Tsippaaoutis (2008) finding. In addition, the larger FD for other versus self constitutes a replication of Jordan and Knoblich (2004). This latter finding is especially interesting, for during the 'other' trials, the stimulus vanished while the participant indicating the perceived vanishing point was not controlling it (i.e., the other was actually controlling its deceleration), yet FD still *increased* with implied friction (versus decreased with implied friction, as was the case for 'observers' in the Jordan, Coey, and Tsippaaoutis (2008) study. This implies the participant was perceiving the movements of the stimulus in terms of the 'effort' the other was using to decelerate it.

Experiment 2

Experiment 1 indicated that people working to control an event together perceive each other in terms of 'economy-of-action' dynamics. Experiment 2 was designed to test whether or not this depends upon ones ability to actually see the behavior of the other. Data indicate the answer may be 'no.' Specifically, in Experiment 3 of Jordan and Hunsinger (2008), observational learners (OLs) sat next to a controller who controlled the movements of the dot stimulus back and forth across the screen. When these OLs later served as observers themselves (i.e., they observed dot movements generated by another, and indicated perceived vanishing points), their FD was just as large as that of someone who had previously controlled the stimulus movements (versus having only observed someone else control stimulus movements). However, if, during the observational learning phase, OLs were not allowed to see or hear the controller's key-presses (i.e., they were denied access to information regarding the controllers actions), the FD was as small as that of a naïve observer. Collectively, these data indicate that having access to another's action-effect contingencies (i.e., the lawful relationship between key presses and stimulus movements) leads to one perceiving the other in terms an economy-of-action framework.

To test whether or not the data of Experiment 1 could be accounted for in terms of access to action-effect contingences, we replicated Experiment 1, save for the fact the members of the pair were isolated form one another while they jointly controlled the movements of the stimulus. If the positive relationship between implied friction and FD during 'other' trials is due to access to action-effect contingencies, then not having such access should negate the self-other difference.

Method

The procedure was exactly the same as in Experiment 1, except for the fact participants sat in separate rooms during the experiment. Specifically, the video signal from the computer was sent to two separate monitors, each situated in a different room. As a result, members of a pair were able to control the movements of the stimulus, but while doing so, did not have access to information regarding the other's actions (i.e., button press). Participants were told they were cooperatively controlling the stimulus with a participant in another room.

Results and Discussion

Data were processed as in Experiment 1. A 2 x 2 within-subjects ANOVA revealed a significant main effect of self-other, $F(1, 47) = 7.94$, $p < .05$, a significant main effect of implied friction, $F(1, 47) = 32.11$, $p < .05$, and a significant interaction, $F(1, 47) = 8.18$, $p < .05$. Collectively, these data indicate that even though participants had no action information about each other, the 'other' was still perceived in an economy-of-action framework (i.e., FD in the 'other' condition increased with implied friction). This indicates that the self-other difference may have more to do with how one is 'modeling' another during action planning, than with whether or not one can actually 'see' the other. Experiment 3 examined this possibility.

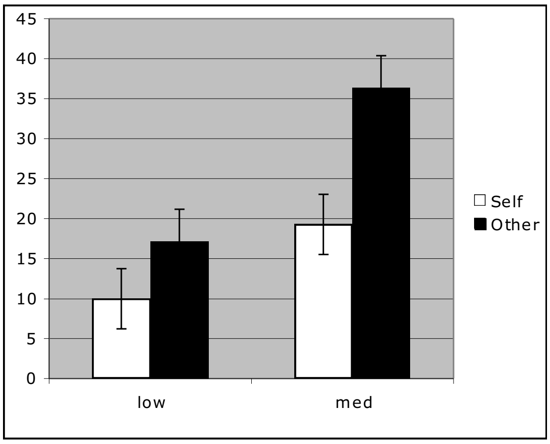

Fig. 2. FD in pixels as a function of controller (i.e., self versus other) and degree of implied friction (i.e., low versus medium)

Experiment 3

If the self-other effect is due to a model of the 'other' that one generates during cooperative action, the self-other effect should vanish if one models the task as if controlling the stimulus alone. To test this, we had a single participant control the stimulus during an initial practice phase (i.e., the participant utilized both buttons). During the experimental phase, the participant completed the task as if controlling the stimulus alone (i.e., they pressed both buttons). However, unbeknownst to the participant, one of the buttons on their control pad had been deactivated, and the stimulus movements controlled by that button were actually controlled by an experimenter in another room. In short, participants believed they were controlling the stimulus movements themselves, while they, in fact, were not.

Method

The experimental arrangement was exactly the same as in Experiment 2, except for the fact there was only one participant. An experimenter sat in the other room and controlled one of the buttons that influenced the stimulus' movements.

Results and Discussion

Data were processed as in Experiment 1. A 2 x 2 within-subjects ANOVA revealed a significant main effect of implied friction, $F(1, 38) = 12.84$, $p < .05$, but no main effect of self-other, or an interaction. As can be seen in Figure 3, FD increases with implied friction for both self and other, but there was no difference between the two. This indicates that although the participant was actually controlling the stimulus with another person, they perceived the vanishing point as if they were controlling it themselves. In other words, they perceived the stimulus in terms of an action plan that did not entail a model of the potential effects of the other.

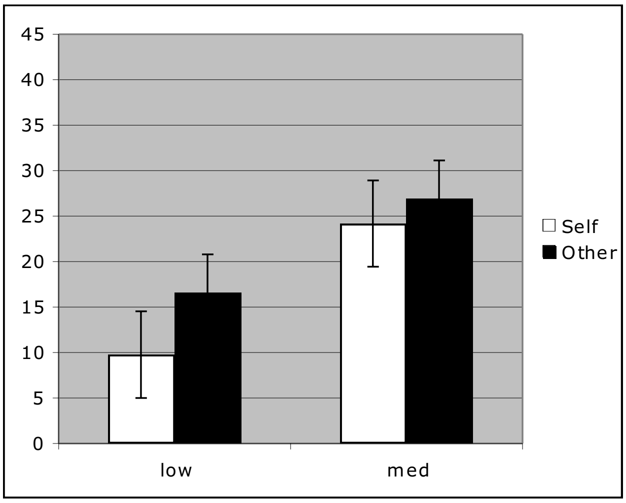

Fig. 3. FD in pixels as a function of controller (i.e., self versus other) and degree of implied friction (i.e., low versus medium).

General Discussion

Collectively, the data from these three experiments indicate that during cooperative action, we perceive the actions of the other in an 'economy-of-action' framework, much like we do for our own actions. But what we are 'perceiving' about the other is not so much the action-effect regularities they generate, for if this were the case, the self-other difference would have vanished in Experiment 2, when the two participants did not have access to one another's action-effect contingencies. Rather, Experiment 3 indicates we perceive the 'other' in terms of the possible impacts they might have on the event we are jointly controlling. In short, we perceive others in terms of potential perturbation.

References

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