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Priming biological motion changes extrapersonal space categorization

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ABSTRACT

Recent results have shown that the way we categorize space varies as a function of the frame of reference. If the reference frame (RF) is another person vs. an object, the distance is judged as reduced. It has been suggested that such an effect is due to the spontaneous processing of the other's motor potentialities. To investigate the impact of movement representation on space perception, we used biological motion displays as a prime for a spatial categorization task. In Exp. 1, participants were presented with a point-light walker or a scrambled motion, and then judged the location ("Near" or "Far") of a target with a human body or an inanimate object as RF. In Exp. 2, participants were primed with point-light walkers of different speeds: a runner, a normal walker and a slow walker. In Exp. 3 they were primed with a point-light display depicting a human body sitting down on or standing up from a chair, with a human body RF either oriented or not oriented towards the target. Results showed a reduced judged distance when the human body RF was primed with a point-light walker (Exp. 1). Furthermore, we found an additional reduction of the judged distance when priming with a runner (Exp. 2). Finally, Exp. 3 showed that the human body RF has to be target oriented as a precondition for priming effects of the point-light walker.

1. Introduction

Space perception is not independent from the motor potential intrinsic to the body.
Previous research has shown that within reaching (or peripersonal) space the perceiver's ability to perform an intended action influences the perceived distance: we perceive an object as closer if we can interact with it (Witt, Proffitt, & Epstein, 2004, 2005). Also, when viewing a distance in the extrapersonal space (i.e. beyond the reaching space) we scale the distance according to the specific motor potential and action intention we have. When we plan to walk a distance, the perceived distance is scaled by how much walking effort would be required to traverse it, whereas viewing the same distance with the intention to throw a ball would evoke a scale based on throwing effort (Proffitt, 2006; Proffitt, Stefanucci, Banton, & Epstein, 2003; Witt & Proffitt, 2008; Witt et al., 2004). In other words, specific anticipated action seem to shape our space perception following an optimal economic principle (see Proffitt, 2006).

Interestingly, it has been demonstrated that space is also socially scaled. It seems that when observing another person around us, we automatically assume her visuo-spatial perspective (see Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010; Tversky & Hard, 2009) and we process the environment from literally "her body".

In the reaching space, affordances are not only related to our own motor potentiality and intention but are also related to other people's motor potential. An object may afford a suitable motor act not only when it can be reached by our own hand but also when it is reachable by someone else (Cardellicchio, Sinigaglia, & Costantini, 2013; Costantini, Ambrosini, Tieri, Sinigaglia, & Committeri, 2010; Gallotti & Frith, 2013). In the same way, when we see a graspable object, the other's action opportunities modulate our perception: observing someone reaching an object with a tool, enlarges our own peripersonal space (Bloesch, Davoli, Roth, Brockmole, & Abrams, 2012; Costantini, Ambrosini, Scorolli, & Borghi, 2011). These evidences support that one's own actions and others' actions are represented in a functionally equivalent way (Sebanz, Knoblich, & Prinz, 2003).

While the research outlined above primarily relates to the peripersonal space, recent data suggest that similar effects are also present in the extrapersonal space. We recently exploited 3D virtual reproductions of a realistic environment and asked our participants to judge the location ("Near" or "Far") of a target object located at progressively increasing or decreasing distances from an instructed reference frame (RF) (extrapersonal space categorization task through the psychophysical limit method) (see Fini, Brass, & Committeri, 2015; Fini, Committeri,

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Müller, Deschrijver, & Brass, 2015; Fini, Costantini, & Committeri, 2014). The data showed that the target object is judged as being closer to a human body than to another static object. Critically, this effect emerges only when the observer can attribute to the RF the intention or the potential to move (Fini, Brass, et al., 2015).

Further support for this comes from the observation that by manipulating the abstract belief that the wooden dummy is "living", the effect is re-established. Specifically, a video extracted by the "Pinocchio" movie, in which Pinocchio behaves like a real human, has been used as a prime before the extrapersonal space categorization task. The more participants attributed to "Pinocchio" a biological nature, the more they perceived the distance as compressed with a wooden dummy adopted as RF (Fini, Brass, et al., 2015; Fini, Committeri, et al., 2015). So, the perceptual or the abstract representation of the RF as a biological agent, able to walk the distance, appears to be crucial to determine the effect. Overall, these results suggest that, similar to what has been previously shown for the peripersonal space, the perception of a human body implicitly activates the representation of its motion potentiality or intention (i.e., the walking action to travel the distance) thus leading to a compression of space. In the present study, we aimed at testing this hypothesis more directly. We reasoned that if space compression in the presence of a human body is due to the spontaneous representation of motor intention and potentiality, the manipulation of the properties of this representation, should affect space perception accordingly.

With this idea in mind, we adopted a priming procedure in which biological motion sequences were presented before an extrapersonal categorization task. In three experiments, motion parameters of the priming stimulus (i.e., the motion type, the speed and the intention to walk towards the target) were systematically manipulated.
Point-light biological motion stimuli are animations composed solely of a dozen of points of light attached to the joints of a moving agent, allowing us to represent movement information in isolation (Johansson, 1973). It has been suggested that perceivers use their own implicit motor knowledge for the interpretation of biological motion stimuli (Casile & Giese, 2006; Grèzes & Decety, 2001). Saygin, Wilson, Hagler, Bates, and Sereno (2004) have shown the contribution of the motor system (inferior frontal and premotor areas) to biological motion perception and during action observation. These areas are crucial nodes, together with the posterior superior temporal sulcus (pSTS) and the inferior parietal lobe, of the mirror neuron system, or "action-perception system (APS)" (Buccino, Binkofski, & Riggio, 2004; Rizzolatti & Craighero, 2004; van Kemenade, Muggleton, Walsh, & Saygin, 2012). This neural network is engaged during motor execution, simulation, verbalization and observation (Grèzes & Decety, 2001). The observation of a walking movement would induce a greater distance compression when a human vs. an object is the RF. We assume that, since a human is categorized as a biological agent, able to potentially perform a movement, this already present "biological" representation would be further strengthened by the observation of a walking movement.

In the first Experiment, we investigated whether the space compression is modulated by observing a walking movement. We first presented a point-light walker (Chang & Troje, 2008; Troje, 2002) or a scrambled motion, and then performed the same extrapersonal space categorization task described above, using as RFs a human body (Avatar RF) or an inanimate object (Object RF). In the second experiment, we tested whether the type of movement and the speed of the prime also affected the extrapersonal space judgment.
Thus, a runner point-light walker, a canonical point-light walker or a slow point-light walker were entered as primes in the task, adopting as RF a human body (Avatar RF).

Finally, in the last experiment we investigated whether the inferred intention to walk towards the target is necessary to obtain the space compression. We thus manipulated the potential intention of the prime (standing up or sitting down) and the orientation of the human body RF (towards the object or away from the object).

2. Experiment 1

The aim of this experiment was to investigate whether the portion of space categorized as "Near" was modulated by a priming displaying a walking action as compared to a non-walking moving stimulus. In particular, participants were presented with a point-light walker displaying a walking motion or a spatially-scrambled motion before performing a Near/Far spatial categorization task. In the scrambled display, the starting point of each point of light is misplaced while the motion trajectory (i.e., speed and direction) is kept constant. As a result, the scrambled display does not longer represent a human body. Our expectation was that, if a walking motion was primed and participants had to judge the distance between a human body and an object, this distance would be judged as being shorter compared to being primed with a scrambled motion. Furthermore, we predicted that this effect induced by priming biological motion would be restricted to situations with a human body as RF.

2.1. Method

2.1.1. Participants

Thirty healthy participants recruited at Ghent University took part in this experiment (23 females, all but 5 right handed, mean age 20.9 years, range 18–30), all with normal or corrected-to-normal vision. Participants received financial compensation for their participation. The study was in accordance with the Declaration of Helsinki and approved by the local ethics committee.

2.1.2. Materials

Stimuli included a 3D scene created by means of 3D modelling software (3D Studio Max 4.2, Autodesk, Discreet). The scene was a 3D environment, representing a square arena defined by the two short lateral wings and the long central wing of a palace (Fig. 1). In the first set of stimuli (Fig. 1A) a human body (Avatar RF) was located 45° to the right (left) of the central camera representing the participant's perspective, and a target red beach umbrella was located along a central vector aligned with the avatar at 27 different distances (from 2 m to 54 m). The avatar and the umbrella were 177 cm and 192 cm tall, respectively, resembling their ecological relative proportion in a real scenario.

The second set of stimuli (Fig. 1B) was identical to the first one, except for the presence of a green beach umbrella instead of the avatar (Object RF). Note that the avatar and the green umbrella had the same spatial extension in the anterior direction.

We administered the stimuli using the method of limits. This is a method for measuring perceptive thresholds, in which the subject is presented with series of stimuli with progressively increasing or decreasing (in steps of a predetermined value) intensity (distance in our case), until he/she reports to feel a change.
Each experimental series was preceded by a video lasting 3000 ms in which a point-light biological motion display was presented on a black background. Stimuli were derived from point-light sequence of a walking human. There were two biological motion displays: a canonical walker and a spatially-scrambled version of it (scrambled stimulus). The human walker, computed as the average walker from motion-captured data of 50 men and 50 women (Chang & Troje, 2008; Troje, 2002), was depicted by a set of 11 white markers representing the main joints and the head of a person. The translating component of the walk movement was removed such that the human displayed stationary walking. The walker was shown with a gait frequency of 0.93 Hz. The spatially scrambled stimulus was obtained by shifting the starting position of each dot, but leaving the motion trajectory unaltered (see Troje & Westhoff, 2006). The point-light stimuli were oriented 45° from the sagittal plane and displayed in the same position as the RF in the scene (Fig. 1). On the black background the borders of the arena were reproduced with a thin white line.