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On my right or on your left? Spontaneous spatial perspective taking in blind people

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ABSTRACT

Spatial perspective taking is a human ability that permits to assume another person's spatial viewpoint. Data show that spatial perspective taking might arise even spontaneously by the mere presence of another person in the environment. We investigated whether this phenomenon is observable also in blind people. Blind and blindfolded sighted participants explored a tridimensional tactile map and memorized the localization of different landmarks. Then, after the presentation of sounds coming from three landmarks-positioned on the right, on the left, and in front-participants had to indicate the reciprocal position of the two lateral landmarks. Results showed that when the sound coming from the frontal landmark suggested the presence of a speaking (voice) or moving person (footsteps), several blind and sighted people adopted this person's perspective. These findings suggest that auditory stimuli can trigger spontaneous spatial perspective taking in sighted as well as in blind people.

1. Introduction

Since the pioneering works on mental rotation (Carpenter & Eisenberg, 1978; Marmor & Zaback, 1976), several studies support the idea that blind persons are able to construct quite accurate spatial representations (e.g., Thinus-Blanc & Gaunet, 1997) by exploiting senses other than vision (Morash, Connell Pensky, Alfaro, & McKerracher, 2012; Tinti, Adenzato, Tamietto, & Cornoldi, 2006). For example, they can construct spatial representations based on verbal descriptions of an environment (Noordzij, Zuidhoek, & Postma, 2006; Schmidt, Tinti, Fantino, Mammarella, & Cornoldi, 2013) and they can use auditory signals to facilitate self-positioning in space (Latini Corazzini, Tinti, Schmidt, Mirandola, & Cornoldi, 2010; Velten, Ugrinowitsch, Portes, Hermann, & Bläsing, 2016). Blind people can obtain spatial information also through touch, for example by exploring tactile maps (Espinosa & Ochaita, 1998) or matrices (Vanlierde & Wanet-Defalque, 2004; Vecchi, Tinti, & Cornoldi, 2004) in order to memorize the localization of different targets. Finally, they are able to acquire spatial information by directly moving in the environment (Tinti et al., 2006). The capacities of blind people to generate spatial representations in absence of vision could be explained hypothesizing the existence of a supramodal spatial representation system (Barsalou, 1999; Bonino et al., 2015; Cattaneo & Vecchi, 2011; Pietrini et al., 2004; Struiksma, Noordzij, & Postma, 2009; Struiksma, Noordzij, Neggers, Bosker, & Postma, 2011). Such system would exceed modality-specific spatial information and would activate both modality specific brain regions and other supramodal areas devoted to the processing of spatial representations.

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However, although vision is not the unique source for spatial representation formation, its absence could cause lacks in some specific domains. For instance, several studies (e.g. Chiesa, Schmidt, Tinti & Cornoldi, 2017; Coluccia, Mammarella, & Cornoldi, 2009; Pasqualotto, Spiller, Jansari, & Proulx, 2013; Postma, Zuidhoek, Noordzij, & Kappers, 2008; Ruggiero, Ruotolo, & Iachini, 2009) evidenced that blind people are less accurate than sighted people when constructing allocentric (i.e., object-to-object) representations, whereas comparable accuracy can be observed for the egocentric (i.e., self-to-object) ones. In particular, studies that asked participants to create a representation of the space from different points of view, showed a general worse performance in blind than in sighted participants (e.g., Pasqualotto & Newell, 2007). In addition, Fortin, Voss, Rainville, Lassonde, and Lepore (2006) reported that in a tactile spatial orientation task, the early blind were able to create a good representation of the space, but their ability decreased more than that of sighted and late blind people when the task required mental rotation skills. Moreover, studies investigating route- and survey-based representations found that blind individuals had more difficulties to code spatial information using the second form of representations (Millar, 1994; Noordzij et al., 2006). Finally, studies on the spatial memory ability in blind people suggest that they encounter difficulties when the spatial task requires maintaining several elements simultaneously (Cornoldi, Bertuccelli, Rocchi, & Sbrana, 1993; Vecchi, et al., 2004). In order to investigate more in depth blind people's spatial knowledge, we focused on a particular type of non-egocentric representation, i.e. spontaneous Spatial Perspective Taking (SPT). Broadly speaking, perspective taking indicates the human capacity to adopt the point of view of another person in terms of his/her beliefs, desires or intentions (mental perspective taking), or in terms of how another person perceives the space (SPT) (Ferguson, Apperly, Ahmad, Bindemann, & Cane, 2015). In more detail, SPT is a form of spatial representation consisting in the adoption of another person's perspective judging/describing what is perceived from his/her position (Frith & Frith, 2010; Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010). Interestingly, SPT can be activated also spontaneously by the mere presence of another person (Duran, Dale, & Kreuz, 2011), and this phenomenon is common in many daily and social activities (e.g., Duran et al., 2011; Shelton, Clements-Stephens, Lam, Pak, & Murray, 2012). Moreover, the perception of the other's action or potential action seems to further enhance spontaneous SPT (Lozano, Hard, & Tversky, 2008; Mazzarella, Hamilton, Trojano, Mastromauro, & Conson, 2012; Tversky & Hard, 2009), evidence which could find an explanation in the embodied cognition theory (Barsalou, 2008; Wilson, 2002) and which sustains the hypothesis that spontaneous SPT has a fundamental role in the social context (Furlanetto, Cavallo, Manera, Tversky, & Becchio, 2013) where it allows to highly social species to anticipate the others' behavior (Frith & Frith, 2010). SPT has been examined in different clinical populations as, for instance, autism (Pearson, Ropar, & Hamilton, 2013), and left neglect (Becchio, Del Giudice, Dal Monte, Latini Corazzini, & Pia, 2013), while, to our knowledge, only Koustriava and Papadopoulos (2012) investigated SPT in blind people, and spontaneous SPT has never been studied in this population.

The main aim of this study was to investigate spontaneous SPT in blind and in blindfolded sighted participants by using an auditory-based paradigm. In fact, humans can perceive the presence and the spatial location of other persons not only by relying on vision but also by relying on other sensorial modalities. In particular, hearing other people's voice and/or movement could permit to understand their localization in the environment and the direction of their movement (Kohler et al., 2002). Hence one might wonder whether spontaneous SPT might be activated also by specific auditory inputs, like the voice of another person, and whether the auditory perception of another's movement might even enhance this effect.

To answer these questions, we examined spontaneous SPT in blind and blindfolded sighted people modifying a paradigm proposed by Tversky and Hard (2009) and using auditory rather than visual stimuli. In the study of Tversky and Hard (2009), participants were presented with three different pictures: the first showed two objects on a table with no person present (no person scene); the second showed a person looking at one of the two objects placed on a table (looking scene); and the third showed a person reaching out to one of two objects on a table (movement scene). When researchers asked participants where one of the two objects was located with respect to the other, most of them used their own perspective in the 'no person' condition, while the tendency to adopt the perspective of another person emerged when a person was present in the scene. Moreover, this same tendency was particularly pronounced when the picture presented a person moving towards one of the objects. By adapting the Tversky and Hard (2009) paradigm, in our study, blind and blindfolded participants had to explore a tactile map with different landmarks and then they had to indicate the relative positions of two landmarks in three conditions: no person present in the scene, presence of a static speaking person, and presence of a person who is moving towards one of the two landmarks. The positions of the landmarks and the person were signaled by different sounds as will be specified more in detail below (see Section 2.3).

We predicted that the presence of another person captured through auditory inputs could trigger spontaneous SPT in blind and blindfolded sighted participants. Additionally, according to the fact that the perception of an acting person enhances the phenomenon (Tversky & Hard, 2009), we hypothesized that the presence of a moving person would further facilitate spontaneous SPT. Finally, given the blind people's difficulties in processing allocentric representations, we expected to observe a lower presence of spontaneous SPT in the blind than in the sighted participants.

2. Method

2.1. Participants

The study involved 30 participants, divided in two groups. The first included 15 early and totally blind adults (8 women) recruited with the help of the Turin UICI (Unione Italiana Ciechi e Ipovedenti). We considered people to be totally blind when they were not able to perceive objects' shapes and positions, and early blind when the visual deficit was present at birth or appeared in the first three years of life (Thinus-Blanc & Gaunet, 1997). Fourteen blind participants had been blind since birth and one became blind at the age of two years. Their blindness was due to various aetiologies: optic nerve damage (6 participants), retrolental fibroplasia (3),