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Perspective changing in WalCT and VR-WalCT: A gender difference study [WalCT – VR-WalCT: Gender differences]

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ABSTRACT

We compared the ability of men and women to remember a path from different points of view both in "real" (WalCT) and in virtual reality environments (VR-WalCT). The main aim of the study was to compare the effects of real and virtual reality on recalling environment. A secondary aim was to detect the presence of gender-related differences in the two environments. On the basis of the literature, we did not expect differences between real and virtual WalCT. Moreover, we expected that men would perform better in both environments. Eighty college students (40 men) were assigned to real or virtual environments and had to learn four different paths and then to recall them from 8 different points of view. Results showed that when people have to remember a path from different points of view it is more difficult in a virtual than in a real environment, and that in a real environment women performed best. The results are discussed considering the different spatial strategy used by men and women to recall spatial information and on the basis of visuo-spatial working memory load.

1. Introduction

Environmental knowledge can frequently be acquired by moving through the environment (primary learning) or by using maps (secondary learning) (Hegarty, Montello, Richardson, Ishikawa, & Lovelace, 2006; for a review see Montello, Waller, Hegarty, & Richardson, 2004) or descriptions (Gras, Gyselinck, Perrussel, Orriols, & Piolino, 2013). To know and proficiently use spatial information in environmental orientation, reasoning from imagined spatial perspectives is crucial. For example, when a pedestrian asks directional information about how to reach his/her goal, we typically imagine ourselves at various positions and orientations along the path to specify the landmark position or decide whether a turn should be to the left or to the right. Such a task involves locating a landmark or an object from an imagined perspective, projecting a self-to-object frame of reference (i.e., egocentric frame of reference) into a spatial position, orienting it accordingly, and then using it to compute the location of the target (Avraamides, Ioannidou, & Kyranidou, 2007). Several studies from the spatial cognition domain have analyzed how spatial information is acquired by primary, secondary learning and have tried to describe how navigational memory is organized (Boccia, Nemmi, & Guariglia, 2014; Boccia et al., 2015; Nemmi, Boccia, Piccardi, Galati, & Guariglia, 2013; Nori et al., 2015; Piccardi, Bianchini, Iasevoli, Giannone, & Guariglia, 2011b; Piccardi et al., 2011a). Perspective-taking, a popular task in spatial cognition research, is frequently used to investigate the organizational structure of spatial memory (e.g., Mou et al., 2004; Greenauer & Waller, 2010; Kelly & Avraamides, 2011). More specifically it has been used to examine how people are able to track the egocentric relations (i.e., self-to-object directions and distances) that change both when we image moving and when we really navigate through the environment. The classic paradigm involves acquiring the spatial location of some objects located in a room, environment or map and successively pointing to them before and after moving to a new position/orientation either physically or imaginarily. Generally, these studies (e.g., Nori, Grandicelli, & Giusberti, 2006; Shelton & McNamara, 2004; Wilson, Tlauka, & Wildbur, 1999) have shown that mental representations are memorized according to a preferred point of view, usually aligned with a real or imaginary viewpoint experienced; this property of mental representation is called *orientation dependence*. The orientation-specific representation is

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inferred from the alignment effect, that is to say an easier judgment of relative location when the person's orientation with respect to the spatial array under test (either in reality or in the imagination) is aligned with his/her orientation at learning than when it is contra-aligned (rotated by 180°) such that this relationship is reversed or when it is rotated to different extents (e.g., 45°, 90°, 135° and so on). Many spatial cognition studies have used highly schematized environments or maps (e.g., the typical pathway used in orientation dependence research by Levine, Jankovic, & Palij, 1982; Presson, DeLange, & Hazelrigg, 1987; Nori et al., 2006 and others) to study orientation dependence. Orientation dependence is an important phenomenon also in everyday life because it may result in several judgment errors that the individuals make during spatial orientation, for instance in judging the relationships between where we are and our goal and the right direction to take.

Shelton and McNamara (2001), McNamara (2003), McNamara and Kelly (2010) proposed a series of studies considering the relationship between the experimental layout and the experimental room with respect to the orientation dependence. For example, in a prototypical work by Shelton and McNamara (2001), participants learned the locations of seven objects placed on a square mat, which lay on the floor of a rectangular room. Based on their findings and other related works, Shelton and McNamara (1997, 2001), Mou and McNamara (2002), McNamara (2003), Shelton and McNamara (2004), Kelly and McNamara (2008), McNamara and Kelly (2010) have concluded that orientation dependence can be determined by a variety of factors, including the perspectives one experienced when learning the imagined space, the structure of the space and the position, the body orientation of the person during the recall of the information, the instructions, the symmetry of the layout, the geometric structure of the enclosing space, and external cues. But in certain circumstances the effect of orientation dependence does not occur or does not alter the performance or mitigate it. There are various factors that contribute to the disappearance or the reduction of the alignment effect: familiarity with the environment (Nori & Piccardi, 2011; Piccardi et al., 2011a, 2011b), environmental characteristics (Sholl & Nolin, 1997), the motor, proprioceptive and vestibular information (Richardson, Montello, & Hegarty, 1999; Rossano, West, Robertson, Wayne, & Chase, 1999; Sun, Campos, & Chan, 2004), primary learning (Presson & Hazelrigg, 1984) and the strategies or spatial cognitive style used to acquire spatial information (Nori & Giusberti, 2003; Nori et al., 2006; Rossano, Warren, & Kenan, 1995). Regardless of the way spatial information is learned, women seem to be less proficient than men in orienting themselves during navigation (e.g., Halpern, 2000). Specifically, women and men use different navigation strategies, that is the former employ landmark or route strategies whereas the latter adopt a survey approach. The landmark strategy is based on perceptually salient patterns while the route strategy is based both on perceptually salient patterns and where to turn at a specific landmark along the path (egocentric coordinates). The survey strategy, on the other hand, is based on global reference points (allocentric coordinates; Lawton, 1994, 1996).

Recently, thanks to the greater opportunities for studying spatial cognition provided by technological innovations, "real" and virtual environments have been compared to assess whether acquiring spatial information in virtual reality involves the same abilities involved in the real environment. Chrastil and Warren (2012) pointed out that moving in a virtual reality setting is quite different from walking around in a real environment. In any case, comparisons between real and virtual navigation have led to contrasting results. For example, some studies concluded that in virtual navigation people use most of the abilities involved in real navigation (e.g., Morganti, Carassa, & Geminiani, 2007; Waller, 2000, 2005) but others did not (e.g., Hegarty et al., 2006). To our knowledge, most of the studies comparing virtual and real environments did not use the same environmental setting or expose the same sample to the same environment (for a review see Chrastil & Warren, 2012). Very recently, Nori et al. (2015) have investigated the effects of real and virtual reality learning environments on the acquisition of spatial information considering the same environment, that is the WalCT (Piccardi et al., 2008, 2011a), which has been proved to measure topographical memory, and its virtual reality version, VR-WalCT (Nori et al., 2015). The results did not show any difference between virtual and real environments, thus supporting the equivalence of the two tests.

The main aim of the study was to analyse deeply the WalCT and VR-WalCT features in order to identify similitude or differences in using the same environment in two different versions, that is in real and in virtual reality. Specifically, we compare the orientation dependence effects (alignment effect), using a perspective-taking task, in two different environments (real vs. virtual) by using WalCT vs. VR-WalCT tasks to analyse whether virtual and real environments determine the same performance in retrieving and processing spatial information when people have the necessary time to acquire them (familiarity with the environment). Moreover, unlike the prototypical layout used in these types of studies, WalCT and VR-WalCT reproduce a more true-to-life situation: people learn spatial information directly by navigating through the environment and then have to reproduce it either from the same point of view or from different ones. This condition is similar to when a person moves through a city, learns a path and then has to imagine and reproduce it from another point of view. A further aim of the present study was to determine whether gender-related differences were present in the two experimental settings. Indeed, it has been reported that men are more proficient than women in learning both environments (Nori et al., 2015; Piccardi et al., 2008), real and virtual, because they use different navigational strategies (see Grön, Wunderlich, Spitzer, Tomczak, & Riepe, 2000). However, in the present study we investigate the presence of gender differences in the retrieval phase, different from Piccardi et al. (2011a, 2011b, 2014) we expected to observe some differences since we hypothesized that not only the environments could be coded in different way when an individual has to retrieve long-term navigational information, but that in this case the task requirements could modulate such differences.

2. Methods

2.1. Participants

In order to estimate the sample sizes, we performed the sample size analysis to indicate the right number of the sample. On the basis of the statistical Power = .75, α = .05 and σ = 1.25, we needed at least 14 men and 14 women for real and virtual environments (see Hinkle & Oliver, 1983). In order to stress gender differences, we enrolled 80 participants (40 men: mean age = 28.55 yrs, S.D. = 4.78; mean education = 15.10 yrs, S.D. = 2.76 and 40 women: mean age = 27.22, S.D. = 3.94) of whom 87.5% were right-handed, 7.5% left-handed and 5% ambidextrous (Salmaso & Longoni, 1983) and all had normal or corrected to normal (soft contact lenses or glasses) vision. They were recruited at the Department of Psychology of Bologna University and at the Department of Life, Health and Environmental Science of L'Aquila University, Italy. Specifically, 20 women and 20 men were randomly assigned to the WalCT or the VR-WalCT learning and retrieval condition. In a preliminary interview no participants reported neurological or psychiatric diseases. Moreover, we asked participants how many times they had played videogames to analyse the relationship between past experience and proficiency in the VR-WalCT. The