'BEING IN' A VIRTUAL ENVIRONMENT: THE RELATIONSHIPE BETWEEN THE EXPERIENCE OF PRESENCE AND SPATIAL ABILITIES

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ABSTRACT

Current theories within the discipline of psychology suggest that a number of factors influence the experience of presence in virtual environments (VEs). Such factors include, among other things, the quality and degree of sensory stimulation offered by the VE, the degree of realism of the material presented to the user, personal interests of the user, and characteristics of the user such as willingness to suspend disbelief and spatial ability. Spatial ability is hypothesized to influence the degree of presence experienced in a VE because spatial ability is related to the construction of spatial situational models of VEs (Vorderer et al, 2003; 2004). It is also related to users' ability to navigate the VE. The purpose of the present study was to examine the relationship between the sense of presence experienced in VEs, users' spatial abilities, and performance on a virtual maze task. It was hypothesized that males would outperform females on mental rotation tasks, and therefore also feel more present in the VE than females. In addition, increased mental rotation ability was hypothesized to improve performance on the virtual maze task. Fifty participants (28 female) completed several tasks used to assess spatial ability, experience of presence, and performance in a VE consisting of a first-person perspective (FPP) virtual maze environment. Spatial abilities were assessed using a redrawn version of the Vandenberg and Kuse Mental Rotation Test (MRT-A), the Object-Location Memory test (Silverman & Eals, 1992), and by asking participants about their use of mental maps. The results provided some support for the hypothesis that the experience of presence in VEs, and users' performance in VEs, is related to the spatial ability of the user. A significant gender difference on the mental rotation task and on the use of mental maps to aid navigation was observed however, males did not feel significantly more present in the VE than females in the present study. Nevertheless, males performed somewhat better than females on the virtual maze task. These findings are discussed in light of participants' previous experience with playing digital games, and recommendations for future research are provided.

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This project has been reviewed and approved by the Massey University Human Ethics Committee, Wellington Application 05/22. If you have any concerns about the conduct of this research, please contact Professor Sylvia Rumball, Chair, Massey University Campus Human Ethics Committee: WGTN telephone 06 350 5249, email humanethicswn@massey.ac.nz.

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INTRODUCTION

Virtual environments (VEs) are an increasingly popular topic of study within academic disciplines such as game studies, computer software development, human centred informatics (HCI), philosophy, psychology, and educational studies. The term 'virtual' is often associated with something that does not physically exist as such, but is made by software technology to appear to do so (Steuer, 1992). The most common examples of such VEs are Virtual Reality (VR) simulators. VR simulators involve the stimulation of a large number of sensory modalities including vision, sound, touch, and proprioceptive sensory channels. They include a 360 degree enclosed 3D environment provided through a head-mounted display, wired gloves, and position trackers. Sherman and Craig (2003) define virtual reality as "a medium composed of interactive computer simulations that sense the participant's position and actions and replace or augment the feedback to one or more senses, giving the feeling of being mentally immersed or present in the simulation" (p.13).

However, the term *virtual environment* also refers to a *virtual space* that can only be experienced as a result of the involvement of mental processes (Biocca, 1997). A VE inhabits dimensions of height, depth, and width that are perceived by the individual interacting with that VE. Thus, it can be considered to be a specific structure not physically existing as such, but made by mental processes to appear to do so. The experience of feeling present within a VE is therefore dependent upon the interaction between the medium and human mental processes. The medium provides direct perceptual stimuli that, in the combination with mental process, are perceived as a (virtual) space. Examples of media types considered to facilitate user interaction with a VE, other than VE simulators, include digital games, movies, and books.

Perceiving virtual space involves the operation of mental processes similar to the way we perceive our everyday physical surroundings (Biocca, 1997). When playing digital games a prerequisite for successful movement in the virtual game environment is that users obtain knowledge about and get a sense of the virtual space they are acting within. When watching TV or movies at the cinema, the viewer applies mental processes to perceive the environment

presented on the screen as a three-dimensional space. When reading books we imagine the (virtual) space in which the characters of the book are interacting. A term commonly used to describe user experience with different media is *immersion*. The Oxford English Dictionary (2000) defines immersion as "absorption in some condition, action, interest etc." (p.684). Other terms commonly used to describe the immersive experience include engagement, engrossment, absorption, and even addiction.

The concept of immersion has a long history of discussion within the traditions of visual art, or visual representation. During the Middle Ages, the idea of visual art was to create a painting that did not inhabit three-dimensional dimensions in itself, but that this three-dimensional space would be created within the viewers own imagination. The 'vanishing point' of the painting during this era was therefore located within the viewer, in his or her imagination (McLuhan & Parker, 1968). It was the idea itself, or what the painting represented, that was important, and the viewer was expected to use his or her imagination to place him-or herself within the context of the represented image. During the Renaissance however, artists started experimenting with creating the representation of a visual three-dimensional space within the painting itself. The revolutionary idea of placing the 'vanishing point' of the image representation within the painting rather than within the viewer created the illusion of an extended space between the painting and the viewer. It was a space created by the medium and the viewer's imagination (i.e., a virtual space). Grau (2003) gives a comprehensive account of immersion in 360 degree works of art through the ages, from villa paintings in Pompeii to nineteen century panoramas to contemporary VEs:

> Immersion arises when the artwork and technical apparatus, the message and medium of perception, converge into an inseparable whole. At this point of calculated "totalisation", the artwork which is perceived as autonomous aesthetic object, can disappear as such for a limited period of time: this is the point where being conscious of the illusion turns into unconsciousness of it. As a general rule, one can say that the principle of immersion is used to withdraw the apparatus of the medium of illusion from the perception of the observers to maximize the intensity of the message being transported. The medium becomes invisible (Grau, 2003, p. 249).

This conception of immersion places great importance upon the spatial properties of the environment in question. The most salient characteristic of immersion is the sense of inhabiting a represented space. Within the current research literature, especially in psychology, this phenomenological experience of feeling present in the represented space has been labelled 'presence' (e.g., Lombard & Ditton, 1997; Sheridan, 1992; Slater & Steed, 2000; Slater & Wilbur, 1997; Vorderer et al., 2003). Thus, *presence* refers to the experience of *being in* a virtual, or mediated, space. Psychological research has focused on both technological and psychological factors to understand this concept, including visual display characteristics (e.g., graphics quality, camera techniques), level of realism of the VE, illusion of non-mediation, level of interactivity (e.g., between the user and the VE), willingness to suspend disbelief, knowledge of and experience with the medium, and the spatial ability of the user. Although spatial ability has been recognized to be an important factor in the experience of presence in VEs, most research has focused the relationship between presence and navigation rather than its relationship to specific spatial abilities.

Following these trends within psychological research on presence, the overall aim of the present thesis is to investigate the relationship between the sense of presence experienced in virtual environments (VEs) and users' spatial abilities. More specifically, the relationship between mental rotation ability, object-location ability, gender, presence in a VE, and performance in a virtual maze task was assessed. Thus, two tests, the Vandenberg and Kuse Mental Rotation Test (MRT-A) and the Object-location Memory Test (OLMT), were used. In addition, a virtual maze was developed and a presence measure, the MEC Spatial Presence Questionnaire (MEC-SPQ), was used to evaluate users' experience of presence in that VE. This thesis also aims to show how mental rotation ability in particular, influences the experience of presence in first-person-perspective (FPP)[1] VEs. Both mental rotation ability and the construction of a spatial-situational model of the VE (i.e., which is considered necessary for presence to occur according to the MEC model of presence) require an ability to hold complex spatial information in working memory (Cornoldi & Vecchi, 2003; Vorderer et al., 2003). Similarly, the use of mental maps puts demands on working memory capacity (Cornoldi & Vecchi, 2003). Thus, participants' mental rotation ability was investigated in

[1] See chapter 3, section 3.3.2 for a more thorough definition of this term.

relation to users' sense of presence and use of mental maps. Further, this thesis aims to show how a FPP VE puts increased demands on a user's ability to hold complex spatial information in working memory as compared to a third-person-perspective (TPP) VE. In addition, it aims to show how the use of mental maps may be particularly important when navigating a VE from a FPP as opposed to a TPP. Thus, both mental rotation ability and the use of mental maps are investigated in relation to performance in a FPP VEs.

To summarize, the relationship between presence, mental rotation ability, the use of mental maps to aid navigation, and navigation in a FPP VE is the focus of this thesis. Chapter 1 of provides an overview of the project's research aims, chapter descriptions and a description of different types of VEs (see above). Chapter 2 examines a variety of theoretical perspectives of presence. Various aspects of several different positions on presence are combined to provide a working definition that will be used throughout this work. Chapter 3 leads on from the theoretical discussion of presence to examining various measures of presence, including both subjective and objective measures of presence. One measure, the MEC-Spatial Presence Questionnaire (MEC-SPQ), is selected for use in this project based on its comprehensive theoretical model which fits well with the working definition of presence used throughout this thesis. Hence, discussion of the MEC-SPQ is the primary focus of this chapter. Chapter 4 examines the second key variable of interest for this thesis: namely spatial ability. The critical discussion of spatial ability reveals that spatial ability can be conceptualized as consisting of a number of underlying sub-factors which are affected by general cognitive factors such as attention and processing speed. In addition, these factors influence navigation and way-finding, and strategies used to complete navigational tasks. Gender differences in some of these spatial abilities have been observed (and are also investigated in the present study), and the influence of specific spatial abilities on navigation in VEs is discussed. Chapter 5 and 6 describe the empirical research component of this thesis. The present study applies a quasi-experimental design. As mentioned above, spatial ability is measured by the MRT-A and the OLMT, and participants' experience of presence in a VE is measured by the MEC-SPQ after interaction with a virtual maze. Performance on the virtual maze task is measured in terms of time to complete the virtual maze and the

number of errors made while navigating it. Chapter 6 includes a discussion of the results and conclusion of the present study, as well as recommendations for future research.