

ORIGINAL ARTICLE

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Presence and task performance: an approach in the light of cognitive style

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Abstract The paper highlights the relationship between each of four bi-polar dimensions of personality cognitive style, such as extraversion–introversion, sensing–intuition, thinking–feeling and judging–perceiving, and the level of sense of presence experienced. Findings indicate that individuals who are more sensitive, more feeling or more introverted experience a higher level of presence. While not reaching statistical significance, differing cognitive styles appear to impact on task performance. The apparent negative relationship discovered between sense of presence and task performance should be considered in the light of task characteristics. We discuss the implications of these findings and how they contribute to an understanding of the complex relationship that exists between presence and task performance and how this subsequently ought to influence the design of virtual environments.

Keywords Sense of presence · Task performance · Cognitive style · Virtual reality

1 Introduction

One of the psychological phenomena experienced by users while interacting with virtual reality systems is a *sense of presence*. We defined presence as a psychological phenomenon, through which one's cognitive processes are oriented towards another world, either technologically mediated or imaginary, to such an extent that one experiences mentally the state of being there. This experience is similar to that of physical reality, together

with an imperceptible shifting of focus of consciousness to the proximal stimulus located in that other world (Sas and O'Hare 2001, 2003a).

1.1 Presence and task performance

The relationship between presence and task performance is arguable and has given rise to a long-standing debate in the presence research area. Theoretical work and empirical studies have highlighted two possible research positions. The first states that presence is merely an epiphenomenon (Ellis 1996). The second position argues that presence impacts on the performance of tasks carried out within virtual environments (VEs). There are two perspectives on this position. The first one argues for a causal relationship between presence and task performance (Sadowski and Stanney 2002), while the other views presence–task performance as a mediated relationship; that is, both presence and task performance could be in fact related to a third extraneous variable or set of variables (Slater et al. 1996). While these extraneous variables have been related to the technological aspects of VE (Slater et al. 1996), we conjecture that they could be found in both human and technological factors. Since our research question examines the impact of cognitive style on both task performance and presence, we expect to find a relationship between task performance and presence, a relationship which is partly mediated by cognitive style.

1.2 Cognitive style

Cognitive style was referred to as a possible significant issue affecting presence (Heeter 1992), but to the best of our knowledge no experimental study has been carried out to investigate this relationship. The term of cognitive style refers to enduring patterns of cognitive behaviour (Grigorenko 2000) and is rooted in Jung's theory of psychological types (1971). We focused on the

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inner-most layer of cognitive style, namely that of personality cognitive style (Riding and Cheema 1991). In the subsequent section we present a description of its main dimensions as highlighted by Jung (1971).

1.2.1 Jung's psychological types

Jung (1971) has identified *attitude types* on the basis of attitude to the object. While the extravert has a positive relationship with the object, the introvert manifests little interest in it. We will briefly contrast extraverted and introverted based on the *function types*.

The *extraverted type* is predominantly oriented towards the external world, that his entire behaviour could be explained and predicted based on this. *Extraverted thinking* is grounded on the incoming information: discoveries are always grounded on empirical evidence. While *extraverted feeling* could become overwhelmed by the influence of the object, the *extraverted sensitive* values objects for their potential to excite emotions. *Extraverted intuitive* is able to understand relations about things and tries to envisage the widest range of possibilities.

In contrast, for the *introverted types*, who are predominantly oriented by the subjective data, it is more important how they perceive the world, rather than how the world actually is. *Introverted thinking* is originated in the outer world, but ends in the inner world of thoughts. While the extrovert strives to subordinate oneself to the object, the *introverted feeling* strives to subordinate the object. For introverts, *sensation* is based on the subjective component of perception, in terms that they will always find in the object something which does not exist, while *introverted intuition* is related to the content of the collective unconscious.

2 Methodology

The VE was offered by ECHOES system (O'Hare et al. 2000) a non-immersive training environment. ECHOES adopts a physical world metaphor and comprises a virtual multi-story building. Subjects (30 students) can navigate from level to level using a virtual elevator. After users gained familiarity with the VE, they were asked to perform an exploration task, followed by a search task.

2.1 Methods

Presence was measured using a questionnaire consisting of 23 items, which was shown to lead to measurements that were both reliable and valid (Sas and O'Hare 2001, 2003a).

The Myers-Briggs Type Indicator (MBTI) (Myers and McCaulley 1998) measures the strength of preference for the manner in which one processes information. Its development is grounded on Jung's theory of per-

sonality types (Jung 1971) briefly described in Sect. 1.2.1. The four basic dimensions of the MBTI are: extraversion (E)–introversion (I); sensing (S)–intuition (N); thinking (T)–feeling (F) and judging (J)–perceiving (P).

In evaluating task performance, we employed two quantitative measures, namely the time needed to complete the search task, which encodes efficiency, and the number of collisions encountered during navigation, which encodes effectiveness in performing the task.

3 Results and discussion

3.1 Cognitive style and presence

In order to test the impact of cognitive style on presence we conducted *t*-tests, comparing the level of sense of presence experienced by groups of users, identified on the basis of their scores for cognitive style dimensions (Sas and O'Hare 2003b). The differences were noticeable, with two significant at the level 0.05, indicating that persons who are more feeling ($t(28)=1.97, p < 0.05$) or sensitive type ($t(28)=1.95, p < 0.05$) experienced a higher level of presence. Without being statistically significant, findings suggest that individuals who are more introverted are more inclined to experience presence.

The Feeling type is the more empathic one ($r = 0.53, p < 0.05$), and since this type can experience a greater level of empathy, it experiences also a greater sense of presence (Sas and O'Hare 2001). The other findings should be considered in relation to the task characteristics: a highly perceptual one, suitable for sensitive types. It seems that sensitive people are better anchored in the concrete, tangible reality (even when this is virtual). In order to feel presence, intuitive individuals probably need to be stimulated with novel, symbolic information which challenges their abilities of grasping ideas. Study tasks were also solitary in nature and therefore more suitable for introvert types. We expect that in collaborative VEs, Extroverted individuals will experience a greater level of *social presence*.

3.2 Cognitive style and task performance

Without being significant, the findings suggest that the more extroverted, intuitive or thinking an individual is, the shorter the time required for the search task, and accordingly the higher the associated task performance. No significant differences were found along the dimensions of cognitive style, measured within the two groups of users identified on the basis of the collisions encountered.

Extraverted people are predominantly orientated towards the external world, which probably leads to an increased level of spatial awareness. On the (S)–(I) continuum, intuitive people look at the entire picture

which emerges from the constituent parts, but go beyond it. The search task is a complex one, and its solution requires information perceived through our senses. However, this does not suffice, and the user has to perceive something which is beyond the immediate content. In order to be successful one needs an internal representation of the spatial layout, or a so-called cognitive map. Most likely intuitive individuals are able to take a bird's eye view, as they would see the space from above. The thinking type grounds the decision on logic and analysis. The need to organise both things and ideas within one's environment could prove beneficial in understanding it.

3.3 Presence and task performance

Findings suggested that the individuals who accomplished the searching task in a shorter time experienced a reduced level of sense of presence ($t(28)=2.02$, $p < 0.05$). There is also a significant collision rate effect, with the group producing more collisions (above average) experiencing a higher level of sense of presence ($t(28)=2.00$, $p < 0.05$). Thus, the more the user acts within the environment in terms of moving, navigating, or even bumping into things, the more present they become.

4 Conclusions

The analysis of results highlights two distinct configurations of personality traits, identified in relation to cognitive style, configurations which seem to impact differently on sense of presence and task performance.

One profile expressed in terms of extroversion, intuition and thinking seems to facilitate users in performing more efficiently, but has no impact on task effectiveness. Regardless of whether the goal of a VE is to induce presence or to enable users to perform better, account should be taken of the various personality trait bundles. For example a VE for games should be specifically designed to allow extrovert, intuitive and thinking type individuals not only to perform better in spatial tasks but to experience presence as well. It is anticipated that a range of possible interaction modes, a large variety of tasks including collaborative ones, and elaborated scenarios could enhance the extroverts' sense of presence. More abstract, strategic tasks consisting of the manipulation of symbolic data could help intuitive users to experience presence.

In contrast, a profile characterising individuals as more introvert, sensitive and feeling enables users to experience a higher level of sense of presence. For particular applications, where performance rather than presence is an imperative, these types should be specifically supported in order to successfully accomplish spatial tasks. Introverted people are predominantly oriented towards the inner world, an aspect which

probably leads to a diminished level of spatial awareness.

One way to increase the spatial awareness is to provide additional landmarks. The search task is a complex one, requiring *information* perceived through all our senses, to which the sensing type is particularly sensitive. However, the user has to perceive something that is beyond the immediate information, in order to build an internal representation of the spatial layout. The sensorial deprivation specific to VEs and in particular to desktop VEs, can put additional demands on sensing types, impeding them in building a *cognitive map*. This drawback can be addressed by increasing the interaction modalities, e.g. multimodal input and by providing direct access to a map of the VE.

The personality cognitive styles are traits which impact upon the way we both perceive and interact with the world, either physical or virtual. The way we express ourselves (e.g. creating or designing) is the way we enjoy having things shaped, in order to experience enjoyment and ease in using them. Madden (2001) discovered preferred patterns of design which she thought could be related to personality types.

We believe that the design of VEs needs to take into account the individual differences. The potential for a VEs to accommodate presentation preferences of user groups based on cognitive style could lead to a heightened sense of presence and improved task performance.

Future work will focus on the relationship between the subjective factors and their impact on both task performance and sense of presence. Particular skills which enhance task performance will also be considered, while the independent variables will be defined in terms of task characteristics. Ultimately one could envisage VEs which dynamically configure the world to address these individual differences.

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