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Do enhanced states exist? Boosting cognitive capacities through an action video-game

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ABSTRACT

This research reports the existence of enhanced cognitive states in which dramatic temporary improvements in temporal and spatial aspects of attention were exhibited by participants who played (but not by those who merely observed) action video-games meeting certain criteria. Specifically, Experiments 1 and 2 demonstrate that the attentional improvements were exhibited only by participants whose skills matched the difficulty level of the video game. Experiment 2 showed that arousal (as reflected by the reduction in parasympathetic activity and increase in sympathetic activity) is a critical physiological condition for enhanced cognitive states and corresponding attentional enhancements. Experiment 3 showed that the cognitive enhancements were transient, and were no longer observed after 30 min of rest following video-gaming. Moreover, the results suggest that the enhancements were specific to tasks requiring visual-spatial focused attention, but not distribution of spatial attention as has been reported to improve significantly and durably as a result of long-term video-game playing. Overall, the results suggest that the observed enhancements cannot be simply due to the activity of video-gaming per se, but might rather represent an *enhanced cognitive state* resulting from specific conditions (heightened arousal in combination with active engagement and optimal challenge), resonant with what has been described in previous phenomenological literature as "flow" (Csikszentmihalyi, 1975) or "peak experiences" (Maslov, 1962). The findings provide empirical evidence for the existence of the enhanced cognitive states and suggest possibilities for consciously accessing latent resources of our brain to temporarily boost our cognitive capacities upon demand.

1. Introduction

The existence of optimal experiences, in which specific cognitive processes (e.g., attention, perception) are dramatically enhanced for limited durations has been suggested by phenomenological research (qualitative analysis of narrative data, Csikszentmihalyi, 1990; Maslow, 1999; Wilson, 1972), but overlooked in the domain of experimental psychology. Csikszentmihalyi (1975, 1990, 1997) termed such experiences as *flow*, and Maslow (1962) as *peak experiences* (1965), and they defined them as unique, energized yet effortless, states of consciousness, characterized by a number of qualities, such as the merging of action and awareness (the awareness is entirely focused on the activity, and all distracting stimuli are ignored), the loss of awareness of oneself (as a social actor), intense concentration, and distorted sense of time. These states have been reported during the creative processes of visual artists (Getzels & Csikszentmihalyi, 1976), where they persisted on painting "single-mindedly, disregarding hunger, fatigue, and discomfort" (Nakamura & Csikszentmihalyi, 2002, p. 89) as well as during various gaming experiences, such as basketball, chess, or video-gaming (e.g. Keller & Bless, 2008; Moller, Meier, & Wall, 2010). The critical situational conditions allowing an individual to reach the state of flow in any domain of expertise, identified consistently across the phenomenological research, are: (1) the direct involvement in the activity, so an individual must not just be an observer, but "actively engaged in some form of clearly specified interaction with the environment" (Csikszentmihalyi, 1975, p. 43), and (2) the presence of significant challenge (termed *optimal challenge*), which pushes one's skills to their limit, but not beyond one's capacities (Csikszentmihalyi, 1975).

Despite a wealth of phenomenological reports on the existence of flow or peak experiences, and the circumstances that produce these experiences, there have been only a few experimental studies investigating the existence of enhanced cognitive states, in which a person experiences a temporary boost of cognitive capacities. For instance, Kozhevnikov, Louchakova, Josipovic, and Motes (2009)

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reported the existence of temporary meditative states, in which enhancements on a number of visual-spatial reasoning tasks requiring focused visual attention were observed after specific types of Tibetan meditation (holding the focus of attention on an internally generated image of a Tibetan deity), and persisted for 15–20 min after meditation had ended. May et al. (2011) reported improved performance on the temporal aspects of attention as measured by attentional blink task following "loving kindness" meditation, which involves focusing attention on specific mental images of selected people. Similarly, although the so-called "Mozart effect" (Rauscher, Shaw, & Ky, 1993) was not consistently replicated and was questioned (Chabris, 1999), a more recent study by Ho, Mason, and Spence (2007) observed that listening for 10 min to a Mozart sonata resulted in short-term improvement in the temporal aspects of attention as measured by an attentional blink task. Taken together these studies suggest that certain activities may lead to temporary enhancement of particular type of attention and visual-spatial cognition.

A number of researchers have speculated that action video-gaming (mainly a genre called first-person shooter or FPS) might induce a state of flow (e.g. Cowley, Charles, Black, & Hickey, 2008; Klasen, Weber, Kircher, Mathiak, & Mathiak, 2011; Procci, Singer, Levy, & Bowers, 2012; Sherry, 2004; Weber, Tamborini, Westcott-Baker, & Kantor, 2009) due to a high level of "absorption" (Weber et al., 2009, p. 403), "intense attentional focus" (p. 397), and "merging action with awareness" (Klasen et al., 2011, p. 2). Despite this conjecture, there has been no empirical research conducted to examine the possibility of attaining enhanced cognitive states as a result of video-gaming. Empirical research investigating the influence of video-games on cognition has been focused primarily on the long-term (durable) effects of video gaming (e.g. Castel, Pratt, & Drummond, 2005; Dye, Green, & Bavelier, 2009; Green & Bavelier, 2003, 2006a, 2006b; Li, Polat, Makous, & Bavelier, 2009; see also Mayer, 2014) for a review). These studies report that playing FPS games has a long-term positive effect on several aspects of visual attention, such as enhanced peripheral vision (Green & Bavelier, 2003), target discrimination, identification and contrast (Green & Bavelier, 2007; Li et al., 2009), and multiple object tracking capacity (Green & Bavelier, 2006a; Spence & Feng, 2010).

Out first goal was to examine whether FPS action video-gaming can bring about an enhanced cognitive state, similar to those observed in previous experimental literature (Ho et al., 2007; Rauscher et al., 1993) and meditative experiences (Amihai & Kozhevnikov, 2014, 2015; Kozhevnikov et al., 2009; May et al., 2011). Our second goal was to investigate the physiological correlates of such states. Since several physiological studies have reported that action video-games can elicit temporary autonomic changes (e.g., increase in heart rate, blood pressure and oxygen consumption) characteristic of heightened arousal (Hébert, Béland, Dionne-Fournelle, Crête, & Lupien, 2005; Segal & Dietz, 1991) along with corresponding improvements on attentional tasks (Skosnik, Chatterton, Swisher, & Park, 2000), we hypothesized that arousal might be a critical component of such enhanced cognitive states. Finally, we were interested in examining the cognitive correlates of such states, that is, to explore and specify the particular cognitive processes that are enhanced. Based on the results of previous experimental studies on meditative experiences (Kozhevnikov et al., 2009; May et al., 2011) and the Mozart Effect (Ho et al., 2007)), we hypothesized that the specific cognitive capacities improved during these states are the temporal aspects of attention measured by the attentional blink task, and visual-spatial focused attention. As a control we explored changes in the functioning of *other* attentional networks, which do not require focused visual attention, such as alerting, orienting, and conflict (Posner & Rothbart, 2009), which other researchers (e.g., Weber et al., 2009) have suggested to improve during the flow states induced by action video-gaming.

In order to study these enhanced states experimentally, although one cannot interrupt the activity itself without disrupting the state, our assumption was that it can be studied during its dissipation period.[1] In Experiment 1, we compared the performance of experienced action video-game players on the temporal aspects of attention (attentional blink) immediately after FPS video gaming, and after a rest period. Furthermore, to investigate whether the enhanced states resonated with the phenomenological experience of flow, we interviewed our participants about their experiences and correlated their cognitive enhancement with their scores on a flow questionnaire. In addition, to test the first claim from phenomenological literature (Csikszentmihalyi, 1975) that the enhanced states occur only during direct involvement in an activity, we compared the changes in attentional blink as a result of actively playing an FPS video-game versus merely watching. In Experiment 2, to test the second claim (Csikszentmihalyi, 1975) that the enhancements occur only when there is an optimal challenge-skill balance, we manipulated the skills-demand compatibility between participants' skills and difficulty of the video game. Furthermore, we hypothesized that cognitive enhancements induced by FPS action video gaming are related to changes in the autonomic nervous system. To assess autonomic changes, we used electrocardiographic (EKG) measures that have been shown to be reliably correlated to the activity of the autonomic system (e.g. Amihai & Kozhevnikov, 2014; Camm et al., 1996; Pagani et al., 1986; Pomeranz et al., 1985; van de Borne, Nguyen, Biston, Linkowski, & Degaute, 1994; van Dijk et al., 2013). In Experiment 3, to examine which other cognitive processes may be improved during enhanced cognitive states, we compared the performance of experienced action video-game players on the Attention Network Test (Fan, McCandliss, Sommer, Raz, & Posner, 2002), which measures conflict, orienting, and alerting components of attention, as well as on two visual tasks (visual memory and spatial transformation) immediately after FPS video-gaming versus after a rest period.

2. Experiment 1

2.1. Method

2.1.1. Participants

Thirty-two video-game players (N = 27 males) with 9 months to 16 years of experience in action video-gaming (M*years* = 8.64, SD = 3.96; M*age* = 21.3, SD = 1.31), were recruited from the online portal of the Research Participation (RP) Programme of the Department of Psychology at the National University of Singapore for course credits. The participants were naïve to the purpose of the study.

All participants had normal or corrected-to-normal vision. We required expertise in FPS action video gaming to ensure that the participants would be skilled enough to control the game, which is necessary for the induction of flow according to the phenomenological literature (Csikszentmihalyi, 1975; Seger & Potts, 2012). Thus, we only enrolled players that had spent more than 4 h per week playing video games during the 6 months prior to the experiment, similar to criteria adopted in other studies of expert gamers (e.g. Castel et al., 2005; Green & Bavelier, 2006b). In the current experiment, participants reported an average of 13.26 (SD = 9.57) hours of video game playing per week.

2.2. Materials and apparatus

2.2.1. FPS

The action video game chosen for this study was a first-person

[1] Any state, mental or physical, takes a certain period of time to develop, peak, and dissipate. In physics, an excited state of a system (such as an atom, molecule or nucleus) is any state that has a higher energy (excitation) than the ground state. The lifetime of a system in an excited state is relatively short; the return to a lower energy level is often loosely described as decay, dissipation, or relaxation. Similarly, the state of flow, which has been described as a state that occurs in the course of intense activity, does not end instantaneously after the activity has stopped but it thought to persist for about 15–20 min even after the activity has stopped (dissipation period).