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Playing counter-strike versus running: The impact of leisure time activities and cortisol on intermediate-term memory in male students

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Abstract

The everyday life of students is characterized by hours of learning in order to pass exams. After learning they tend to opt for an occupation that provides them with a great deal of entertainment. It is obvious that it would be advantageous if the chosen activity had a positive impact on memory consolidation. Due to the circumstance that such activities can lead to stress and that memory is affected by stress we wanted to look at these coherences. We examined the effect of two different common leisure time activities on cortisol and memory to be able to formulate recommendations for society. For this purpose, a group was tested before and after playing a violent computer game while the second group was tested before and after running. In addition, a control group was set up. Salivary cortisol was measured at the beginning, during, and at the end of the experiment.

Our data demonstrates that running increases cortisol levels and, performed immediately after a learning period, facilitates memorization of neutral information. In contrast, playing a violent computer game tends to impair memorization.

The results of the present study have practical implications for the choice of recreational activities in the context of learning.

Keywords: Stress; Cortisol; Memory; Computer games; Sports activities

1. Introduction

The everyday life of pupils and students is often characterized by hours of learning a wide range of facts in order to pass exams at school or university. After such a learning cycle they tend to opt for an occupation that provides them with a great deal of entertainment and, as such, allows them to take their minds off the current tasks. It would be advantageous if the chosen activity had a positive impact on memory consolidation given the assumption that it is the interest of students to maximize learning success. Hence, it would be advantageous if such chosen activities improve, or at least do not impair, consolidation.

Today we are still a long way off from comprehensively identifying those mechanisms responsible for successful retention of knowledge (e.g., Dudai, 2004; Festini & Reuter-Lorenz, 2013; Quas, Rush, Yim, & Nikolayev,

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2014). However, it is plausible to assume that the immediate period after learning is crucial for memorization. In this paper we want to shed light on the effects of pastimes that follow a learning period on intermediate-term memory (ITM; lasting up to 3 h; e.g. Rosenzweig, Bennett, Colombo, Lee, & Serrano, 1993; Sangha, Scheibenstock, McComb, & Lukowiak, 2003). Since the number of activities to be carried out after a learning cycle is highly versatile we focused on those activities which are most popular in pupils and students. As part of a pilot-study in $n = 200$ students (52% male, 48% female) we identified two activities which are particularly popular among young men, **counter-strike** (CS; stated by 55% males) and **running** (stated by 21% males). Due to the fact that preferences for recreational activities were more diverse in females, we chose a sample consisting of men only.

As we will argue later on, such activities can lead to a release of numerous transmitters, peptides, and hormones such as cortisol (for a review see Joëls & Baram, 2009). These physiological processes are vital in order to be able to cope with different, sometimes stressful situations and to bring the human organism back into homeostasis (e.g. Joëls, Fernandez, & Roozendaal, 2011; Schwabe, Joëls, Roozendaal, Wolf, & Oitzl, 2012).

Further, memory performance is affected by stress due to the release of catecholamines and cortisol. Existing literature on stress and memory illustrates that stress can either facilitate or impair memory processes dependent on the valence of the learning material and on whether the stress occurs before, after, or during the encoding phase (e.g. Cahill, Gorski, & Le, 2003; Roozendaal, 2002; Roozendaal & McGaugh, 2011; Schwabe & Wolf, 2010; Schwabe et al., 2012; Smeets, Otgaar, Candel, & Wolf, 2008). In this context, it should be noted that stressful events are distinguished between *psychological* and *physical stressors* (Dayas, Buller, Crane, Xu, & Day, 2001). *Psychological stressors* are triggered by social evaluation threats. *Physical stressors*, *on the other hand*, represent either the anticipation of a harmful injury such as blood loss or a trauma (e.g. Dickerson & Kemeny, 2004; Joëls, Pu, Wiegert, Oitzl, & Krugers, 2006) or the need of the body to find a new dynamic equilibrium because of physical exercise (Mastorakos, Pavlatou, Diamanti-Kandarakis, & Chrousos, 2005). According to this definition physical stress is not necessarily associated with the presence of a threat.

However, both physical and physiological stressors cause a fast secretion of catecholamines that interacts with the amygdala to shift several brain regions like hippocampus, prefrontal cortex or the caudate nucleus, into activity (Dayas et al., 2001). This reaction may be consistent with the so called 'memory formation mode' (Schwabe et al., 2012) that supports the cognitive capacities in coping with the current situation. After a delay, glucocorticoids are secreted and shift the brain into a 'memory storage mode' that enables a better memorization of information about the stressful situation. In that mode, all other information is considered to be competing and therefore suppressed to reduce interferences (Schwabe et al., 2012). Such a process helps to improve the chances to survive in the future. Joëls et al. (2006) argue that stress-induced elevated cortisol levels only enhance memory retention if a convergence between a learning task and a specific stressor exists in *time* and *space*, which basically means that a "coinciding activation of the circuit involving the basolateral amygdala and the local presence of stress hormones promotes the memory of salient but not neutral information" (Joëls et al., 2006, p. 154). As a consequence, elevated cortisol levels caused by stressors *before* or *after* learning neutral information should impair the memorization of such information. Even if subsequent work supports a contradictory view (e.g. a study of Preuß & Wolf, 2009 shows that post-learning stress enhances the consolidation of neutral material) we follow the above rationale and assume that elevated cortisol levels caused by stressors after learning neutral information will impair memory consolidation. The explanation for our assumption is that the results of Preuß and Wolf (2009), as stated by themselves, were completely unexpected for neutral information. This is why we think that these results were accidentally.

Following this line of thinking, we deduce the following hypotheses in more detail. **CS** is a so-called first person shooter game where the player takes the perspective of the game's protagonist. One characteristic of this game is that the weapons, in most cases freely chosen, loom in the field of vision and as such, stimulate an authentic view. By doing so, the player can either play alone against a digital world or he can compete with other players on the internet, mainly in team constellations. CS, in particular, is mostly set up around combat situations between terrorists and anti-terrorist squads where specific tasks have to be undertaken depending on the scenario chosen. The opposing team seeks to prevent the gamers from carrying out their missions. This is usually done by killing the opponents. Despite a rather outdated visualization, CS still enjoys high popularity among male youngsters (see Fig. 1; a display of a typical game situation).

Playing CS could be classified as a *psychological stressor* (Maass, Klöpper, Michel, & Lohaus, 2011) because players

Fig. 1. Counter-strike: a typical game situation.