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Full Length Article

Effects of domain-specific exercise load on speed and accuracy of a domain-specific perceptual-cognitive task

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ABSTRACT

In the context of perceptual-cognitive expertise it is important to know whether physiological loads influence perceptual-cognitive performance. This study examined whether a handball specific physical exercise load influenced participants' speed and accuracy in a flicker task. At rest and during a specific interval exercise of 86.5–90% HR_{max}, 35 participants (experts: $n = 8$, advanced: $n = 13$, novices, $n = 14$) performed a handball specific flicker task with two types of patterns (structured and unstructured). For reaction time, results revealed moderate effect sizes for group, with experts reacting faster than advanced and advanced reacting faster than novices, and for structure, with structured videos being performed faster than unstructured ones. A significant interaction for structure × group was also found, with experts and advanced players faster for structured videos, and novices faster for unstructured videos. For accuracy, significant main effects were found for structure with structured videos solved more accurately. A significant interaction for structure × group was revealed, with experts and advanced more accurate for structured scenes and novices more accurate for unstructured scenes. A significant interaction was also found for condition × structure; at rest, unstructured and structured scenes were performed with the same accuracy while under physical exercise, structured scenes were solved more accurately. No other interactions were found. These results were somewhat surprising given previous work in this area, although the impact of a specific physical exercise on a specific perceptual-cognitive task may be different from those tested generally.

1. Introduction

A large number of studies have examined the perceptual-cognitive skills that distinguish experts from advanced athletes and novices (for overviews see: Mann, Williams, Ward, & Janelle, 2007; Starkes, Helsen, & Jack, 2001). Typically, experts perform superior to novices in structured, domain-specific tasks that contain meaningful (i.e., non-random) stimuli (e.g. Mann et al., 2007; Williams & Ericsson, 2005). Experts' perceptual-cognitive superiority has been shown in several domains including chess (Chase & Simon, 1973), snooker (Abernethy, Neal, & Koning, 1994) and team sports (for a review see: Starkes et al.,

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2001), as well as for skills such as decision making (Mann et al., 2007), cue usage (e.g. North, Ward, Ericsson, & Williams, 2011) and pattern perception (e.g. Abernethy, Baker, & Côté, 2005; Chase & Simon, 1973; Williams & Burwitz, 1993).

Interestingly, these studies, and most of the research on perceptual-cognitive expertise, have considered these skills at rest. However, in real game situations perceptual-cognitive tasks have to be performed while managing the specific physiological demands of the sport (cf. Ando et al., 2005; Pesce, Tessitore, Casella, Pirritano, & Capranica, 2007). Given the assumed specificity of perceptual-cognitive skill (e.g. Williams, Ward, Ward, & Smeeton, 2008), the effect of physical exercise on cognitive functioning, particularly its influence on speed and accuracy of perceptual-cognitive tasks, may be important. It is quite surprising, therefore, that the impact of a sport-specific physical exercise on specific perceptual-cognitive tasks has received little research attention (for exceptions see: Casanova et al., 2013; Elsworthy, Burke, Scott, Stevens, & Dascombe, 2014; Larkin, O'Brien, Mesagno, Berry, Harvey, & Spittle, 2014; Schapschröer, Baker, & Schorer, 2016). The aim of this study was to consider perceptual-cognitive expertise in a time- and accuracy-oriented task at rest and under physiological stress to examine the impact of a sport-specific physical exercise load on a sport-specific perceptual-cognitive skill.

Most studies examining physical exercise and cognition reveal an influence of exercise on cognitive performance. Based on his meta-analysis, Tomporowski (2003) emphasized that most results indicate an influence on participants' response/reaction time in simple and choice reaction time tasks, meaning that responses made during exercise are faster. This has been shown for several cognitive tasks including reaction times (Pesce et al., 2007), complex decision-making (Brisswalter, Collardeau, & René, 2002), and complex problem-solving (McMorris & Graydon, 1997). Tomporowski (2003) deduced that exercise might modify speed of information processing and that submaximal aerobic exercise performed for durations between 20 and 60 min facilitates decision-making tasks and complex problem solving. McMorris and Graydon (2000) concluded that the facilitating effect of physical exercise is limited to improvements in reaction times and only in well-learned, automatic tasks, which suggests particular relevance for experts in specific domains. It is important to note that the effects of physical exercise on general cognitive performance depend on the characteristics of the exercise performed, for example the type and duration of the exercise stimulus (cf. Tomporowski, 2003). Focusing on speed and accuracy, many studies have noted faster processing speed under physical exercise, with accuracy unaffected. Accordingly, these studies show that no speed-accuracy trade off appears, suggesting that an improvement in speed does not lead to a deterioration in accuracy or the other way around (Davranche & McMorris, 2009; e.g. McMorris & Graydon, 1997; for overviews see: McMorris & Hale, 2012; Tomporowski, 2003). The positive effect of physical exercise on cognition is mainly explained by a) enhanced arousal or activation (e.g. Davranche, Hall, & McMorris, 2009; Pesce et al., 2007) b) higher levels of nervous activation (e.g. McMorris & Graydon, 2000) or c) a more efficient use of peripheral motor processes during physical exercise (e.g. Davranche, Burle, Audiffren, & Hasbroucq, 2005).

Lately, researchers have started to consider the impact of physical exercise on cognition in sport. This is especially interesting since athletes are used to perform these tasks while exercising. For example, Davranche, Paleresompoulle, Pernaud, Labarelle, and Hasbroucq (2009) induced a sport specific physical exercise and examined its impact on a general-reaction time task (i.e., Simon task). Results revealed faster reaction times during a 75% maximum heart rate condition compared with a 40% condition while no differences in accuracy were revealed across all conditions. Similarly, McMorris and Graydon (1997) induced a general physical exercise and tested its impact on a soccer-specific cognitive task. Participants had to perform a soccer-specific detection task at rest and while cycling on an ergometer under 70% and 100% of maximum power output. In two experiments, differing in task complexity (2 or 4 choice reaction time task) reaction times and visual search were analyzed. Results revealed that participants' performance during maximal exercise was significantly better than at rest or under 70% of maximum power output. While experiment one found no influence of exercise on accuracy, experiment two revealed a significant effect between rest and the 100% condition, with participants performing better under the maximal exercise condition. McMorris and Graydon (1997) concluded that, in this soccer-specific testing, very high intensity exercises improve speed of visual search and speed of information processing and may improve accuracy for more complex tasks.

One of the very few studies looking at the impact of a sport-specific physical exercise load on sport-specific perceptual-cognitive processes was conducted by Casanova et al. (2013). They combined a soccer-specific intermittent physical exercise with film-based simulations of offensive sequences of soccer games. High- and low-level soccer players performed physical exercise that included varying soccer-specific intensities on a treadmill while watching the videos of game situations. The physical exercise condition included two halves each lasting for 52 min with a break of 15 min in between. Within each of the halves, two identical periods of seven blocks were included (five low-intensity and two high-intensity blocks). In each of the halves two test sessions were performed, resulting in four test sessions as a whole. The perceptual-cognitive task required participants to anticipate which of three possible actions the player with the ball was going to perform. High-level players anticipated specific situations more accurately than low-level players in all of the four test sessions, which was also reflected in differences in gaze behaviors and thought processes. Both groups decreased in anticipation accuracy over time (cf. Casanova et al., 2013). This deterioration over time might be a matter of fatigue (i.e., total duration of 104 min of physical exercise), however, there was no rested condition in this study. Schapschröer et al. (2016) also considered the impact of different intensities of physical exercise on specific perceptual-cognitive skills, this time in handball. They tested participants of different levels of expertise on a handball-specific pattern recall task. Although experienced players recalled patterns of play more accurately, there were no differences in the pattern recall results at rest or under physical exercise. Taking into consideration that pattern recall tasks focus on *accuracy* and physical exercise seems to have a greater facilitating effect on reaction times (for overviews see: McMorris & Hale, 2012; Tomporowski, 2003), it would be interesting