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From attentional control to attentional spillover: A skill-level investigation of attention, movement, and performance outcomes

Sian L. Beilock [a], Rob Gray [b,*]

[a] Department of Psychology, University of Chicago, United States
[b] School of Sport and Exercise Sciences, University of Birmingham, Edgbaston B15 2TT, UK

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ABSTRACT

Two experiments examined the impact of attention on the movement and putting accuracy of novice and experienced golfers. In Experiment 1, attentional control was manipulated via two different secondary tasks: (i) an *extraneous condition* in which participants judged the frequency of an auditory cue presented during their stroke and, (ii) a *skill-focused condition* in which participants judged whether the cue occurred closer to the starting or end point of the swing segment in which it was presented. For experts, putting performance was least accurate in the skill-focused condition and when the cue was presented earlier. This decline in accuracy was associated with a significant reduction in the relationship between downswing amplitude and distance. Novices showed the opposite pattern. In Experiment 2, we manipulated attentional control indirectly by introducing the possibility that participants would stop their swing mid-stroke in response to an auditory cue, thus pushing participants to exert added control over step-by-step execution. Stop-trials were interleaved with normal putting trials in which no instructions were given. Novices were better able to stop their putting stroke and putted more accurately on non-stop trials than experts. These findings are consistent with recent models of putting control.

* Corresponding author. Tel.: +44 (0) 121 414 7239; fax: +44 (0) 121 414 4121.
E-mail address: r.gray.2@bham.ac.uk (R. Gray).

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1. Introduction

What makes skilled athletes different from their novice counterparts? Although the answer to this question commonly revolves around skill-level differences in performance outcomes (e.g., the score of a round of golf or one's baseball batting average), some researchers have argued that it is the underlying cognitive control structures supporting performance that truly distinguish highly skilled individuals from their less skilled counterparts (Abernethy, Maxwell, Masters, van der Kamp, & Jackson, 2007). These control structures rely on particular forms of memory, vary in the demands they place on attention, and are thought to change as practice accumulates and skill proficiency increases. But, it is not just the cognitive demands of performance that distinguish novice individuals from those more skilled, movement patterns have been shown to vary as a function of skill level as well. For example, in golf, the downswing amplitude distinguishes between novice and expert golfers (Delay, Nougier, Orliaguet, & Coello, 1997). While expert golfers regulate their downswing amplitude to appropriately control club head force for different putting distances, novices do not show this amplitude-distance relation (see also Sim & Kim, 2010).

Despite work examining skill-level differences in attentional control (e.g., Beilock, Bertenthal, McCoy, & Carr, 2004; Beilock, Carr, MacMahon, & Starkes, 2002) *and* movement differences in novice and skilled perceptual-motor performance (Delay et al., 1997; Egret, Dujardin, Weber, & Chollet, 2004), relatively few studies have explored how the attentional demands of performance directly relate to movement – and how this might differ as a function of skill level. Insight into this relation is important for developing a comprehensive understanding of what makes a novice performer different from his/her highly-skilled counterpart, and may also shed light on how to optimize skill learning and prevent skill breakdown (e.g., in pressure-filled high-stakes situations) once high-level performance has been achieved.

1.1. Expertise and attention

Theories of skill acquisition suggest that performance proceeds through identifiably different phases as learning progresses that are characterized by changes in the cognitive processes governing execution and changes in performance itself. Although a number of different frameworks have been proposed to capture these skill level differences, in general, novice performance is thought to be based on explicitly retrievable declarative knowledge that is held in working memory and consciously attended in real time (Anderson, 1983, 1993; Fitts & Po). As learning progresses, information is restructured into "procedures" or "programs" (Brown & Carr, 1989; Keele, 1968). This new "proceduralized" skill representation does not mandate the same degree of attention and control that was necessary at lower levels of practice, and is supported by different neural structures than were active early in learning (Milton, Solodkin, Hlustik, & Small, 2007).

The notion that different cognitive processes underlie various stages of skill development – with a trend toward increased proceduralization at higher levels of proficiency – carries implications for the types of attentional manipulations that may influence performance. For example, Beilock et al. (2002) found that introducing a secondary task involving monitoring a stream of auditory tones hurt the putting performance of novice golfers but had no effect on experts. Conversely, introducing a secondary task that required participants to monitor the position of the putter head improved novices' putting accuracy but hurt expert performance.

The finding that high-level skills are disrupted by attention directed toward processes that normally run outside conscious awareness (Beilock & Carr, 2001; Beilock et al., 2002; Lewis & Linder, 1997; Masters, 1992; Masters, Polman, & Hammond, 1993) has also been reported for baseball batting (Castaneda & Gray, 2007; Gray, 2004), golf chip shots (Perkins-Ceccato, Passmore, & Lee, 2003), field hockey (Jackson, Ashford, & Norsworthy, 2006), and soccer (Beilock et al., 2002). Indeed, these negative effects of enhanced attention can not only be seen in complex skills such as golf chipping and baseball batting, but in more basic skills we use every day. For example, it has been suggested that directing performers' attention to their movements through "internal focus" feedback on a dynamic