



Fine and gross motor skills: The effects on skill-focused dual-tasks



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ABSTRACT

Dual-task methodology often directs participants' attention towards a gross motor skill involved in the execution of a skill, but researchers have not investigated the comparative effects of attention on fine motor skill tasks. Furthermore, there is limited information about participants' subjective perception of workload with respect to task performance. To examine this, the current study administered the NASA-Task Load Index following a simulated shooting dual-task. The task required participants to stand 15 feet from a projector screen which depicted virtual targets and fire a modified Glock 17 handgun equipped with an infrared laser. Participants performed the primary shooting task alone (control), or were also instructed to focus their attention on a gross motor skill relevant to task execution (gross skill-focused) and a fine motor skill relevant to task execution (fine skill-focused). Results revealed that workload was significantly greater during the fine skill-focused task for both skill levels, but performance was only affected for the lesser-skilled participants. Shooting performance for the lesser-skilled participants was greater during the gross skill-focused condition compared to the fine skill-focused condition. Correlational analyses also demonstrated a significant negative relationship between shooting performance and workload during the gross skill-focused task for the higher-skilled participants. A discussion of the relationship between skill type, workload, skill level, and performance in dual-task paradigms is presented.

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1. Introduction

To assess resource demands attributed to primary and secondary tasks, researchers utilize dual-task methodology (Beilock, Bertenthal, McCoy, & Carr, 2004; Beilock & Carr, 2001; Beilock & Gray, 2012; Gray, 2004). This methodology requires individuals to perform a primary task while simultaneously performing a secondary task (Wright & Kemp, 1992). The secondary task is used to direct participants' attention to aspects of skill execution (skill-focus attention: see Castaneda & Gray, 2007; Gray, 2004) or other characteristics that are distinct to skill execution (extraneous focus attention). The performance results from dual-task studies are clear in that they demonstrate a benefit for inexperienced performers for skill-focused attention rather than an extraneous focus of attention (Beilock, Carr, MacMahon, & Starkes, 2002; Jackson, Ashford, & Norsworthy, 2006), but higher-skilled performers display superior performance for extraneous focus attention relative to skill-focused attention (de-automatization of skills hypothesis – see Castaneda & Gray, 2007; Gray, 2004) The

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majority of dual-task research, however, has employed skill-focused manipulations that direct attention towards a gross motor skill (e.g., swinging a bat). It is unclear how the relationship for attention, skill level, and performance would be affected if the skill-focus manipulations were directed towards a fine motor skill, particularly in skills that require fine motor skill attention (e.g., squeezing the trigger of a pistol; Charles & Copay, 2003).

An over emphasis on the primary motor skills required for successful skill execution, may have resulted in investigations of motor skills and cognitive resources that overlook a simple comparison between gross and fine motor skills in healthy adults. More recent research related to the dual-task methodology has investigated mainly gross motor skills that require a functional level of fine motor skill to successfully execute a task. Typically these tasks include a skill-focused manipulation directed at the gross motor skill. For example, verbally reporting the direction the bat was moving after an auditory tone was played (Gray, 2004), reporting the position of the golf club upon hearing an audible stimulus (Beilock et al., 2002; experiment 1), position of their foot's last position with a soccer ball on hearing an audible stimulus (Beilock et al., 2002; experiment 2). It is plausible that the beneficial performance effects during skill-focused compared to extraneous focus dual-tasks exhibited by novice performers was the gross motor skill that these manipulations required. While many motor skills require attention towards gross body movements, such as swinging a golf club, some skills require more strategic attention to fine motor skills. Since gross motor skill-focused manipulations are disadvantageous to higher-skilled performers, but the effects on novices are less detrimental, comparing fine versus gross motor skill types across skill levels adds to the discussion of resource demands that skill-focused manipulations require. In addition, it raises an interesting question regarding whether attention directed at gross and fine motor skill types on primary task performance in a dual-task paradigm will be different for lower and higher-skilled performers.

To assess resource demands in dual-task paradigms, researchers often assess secondary task performance (e.g., Beilock & Gray, 2012; Beilock et al., 2004; Gray, 2004); however, a subjective psychometric measure of workload could provide additional unique information. Workload can be conceptualized as the perceived amount of resources (e.g., attentional demands, physical requirements) required during a task. The impact dual-tasks have on participants' perception of workload is unclear, given that secondary task performance has primarily been investigated to determine the resource demands available during dual-tasks across skill (e.g., Gray, 2004). Feasibly, a subjective psychometric approach may provide us with this information; and help explain differences across skill level and potentially skill type during skill-focused dual-tasks specifically workload demands elicited during dual-tasks. The National Aeronautics and Space Administration-Task Load Index (NASA-TLX; Hart & Staveland, 1988) is a validated psychometric tool that permits a subjective assessment of different workload dimensions (i.e., resource demands). Task demands can be separated into physical, temporal, and mental demands, and an assessment of performance efficiency with respect to the task is measured concurrently. The NASA TLX has been used extensively in human performance research utilizing dual-task methodology (e.g., DiDomenico & Nussbaum, 2008; Peter, Silvia, Yolanda, & Klaus, 2009; Recarte, Pérez, Conchillo, & Nunes, 2008) and has wide applicability across physical and mental domains (see Stanton, Salmon, Walker, Baber, & Jenkins, 2005). The inclusion of the NASA TLX into a dual-task paradigm that requires fine and gross motor skill attention will allow us to quantify and compare how each skill type influences overall performance and workload.

To our knowledge, little research has utilized a dual-task methodology to examine skill-focus type, subjective perceptions of workload, and their relative influence on performance. Therefore the purpose of this study was to explore the effects of attention directed at skill types on primary task performance using a dual-task paradigm for different skill level. Secondly, we aim to provide a cognitive explanation for performance changes via a subjective measure of workload. We believe that skill-focused attention directed at gross motor skills may affect the resource demands differently than attention directed at a fine motor skill. Specifically we made four primary predictions: (1) during a simulated shooting dual-task, participants would perform significantly greater when their attention was directed towards their shoulder (gross motor skill) compared to when their attention was directed at their trigger finger (fine motor skill); (2) higher-skilled participants would perform similarly across the two attention conditions, but the lower-skilled participants would perform significantly greater when attention was directed toward a gross motor skill rather than a fine motor skill producing a skill level by condition interaction; (3) that participants' subjective perceptions of workload would be higher during the fine skill-focused dual-task than the gross skill-focused dual-task, regardless of skill level. We believed that higher-skilled performers would still report that the fine motor skill manipulation required more resources than the gross motor skill, but due to skilled individuals' ability to make adaptive compensatory movements to reach a desired performance outcome (Button, Davids, Bennett, & Savelsbergh, 2002), no performance differences would be exhibited in higher-skilled individuals; (4) significant negative relationships between shooting performance and workload for both skill levels during both dual-tasks. Specifically, as shooting performance increased, workload would decrease for the lower and higher-skilled participants during both skill-focused dual-tasks.

2. Methods

2.1. Participants

Thirty-six healthy participants ($n = 17$ males; $n = 19$ females) volunteered to participate in this study. Participants were naïve to the purpose of the study, but may have had some experience with shooting a gun for recreational purposes – no participants had any formal weapons training (e.g., law enforcement training). The institutional ethics committee approved the project and informed consent was obtained prior to the study commencing. No ages were obtained from the participants, but consisted of undergraduates attending a major university.

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