Cognitive Influence on Obstacle Avoidance: Auditory and Structural Interference

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INTRODUCTION

Throughout our daily lives we are constantly interacting with and moving through our environment, completing concurrent motor and cognitive tasks in a smooth and efficient manner [1]. While gait was once thought of as an automatic task, we now know that use of the cognitive system, and more specifically executive function [2], is vital for the successful planning and executing goal directed actions, e.g. obstacle avoidance [3]. The ability to perform more than one task at a time has been well studied using dual task paradigms, some of which involve cognitive tasks that result in structural interference [e.g. tasks requiring assessment of visual information for task completion; 4] and other tasks which result in capacitance interference [e.g. tasks requiring rapid/intense mental processes; 5].

The purpose of this study was to investigate how each type of interference (structural and capacitance) affects executive function strategies used to plan the adaptive locomotor patterns for a complex motor task, obstacle avoidance.

METHODS

Thirteen healthy university students were recruited (aged 20.6 ± 1.6 years) for this study. Exclusion criterion included visual perception problems (e.g. strabismus), hearing problems and history of recent musculoskeletal injuries (e.g. sprain within last 2 months). The experimental paradigm is outlined in Figure 1. Gait velocity, minimum foot clearance, takeoff and landing distance from the obstacle were calculated. Data was analyzed at the instant of heel contact 2 steps before (OBS-2), 1 step before (OBS-1) and at crossing (OBS-xing) the obstacle. Response accuracy and response time for the auditory and visual Stroop task was calculated from a microphone fixed to the subjects’ thorax.

Dual task cost (DTC) was also processed for both kinematic and cognitive measures [5]:

\[(\text{Dual task} - \text{Single task}) / \text{Single task}\]

Figure 1(A). Subjects were instrumented with rigid triads of iREDs (100 Hz) and anatomical points were digitized (e.g. heels, toes). A lapel microphone recorded participants audio response times (3000 Hz). (B). First, participants completed 10 baseline walking trials where they stepped over an obstacle set to a height of 30% of their lower limb length with no cognitive task. They then completed 4 different blocks of experimental trials (seated trials always preceded walking over obstacle trials). Half of the participants completed the visual Stroop task prior to the auditory Stroop task (10 congruent/10 incongruent).

A Pearson Chi Square was performed to examine if cognitive accuracy and response time differed between cognitive tasks. A multivariate ANOVA (Stroop Condition X Trial Type) was conducted on mean and variability of obstacle avoidance parameters. A single variable ANOVA was conducted for cognitive measures and another single variable ANOVA was conducted for dual task cost. Significance level was set to p<0.05.
RESULTS AND DISCUSSION

Cognitive task performance. An effect of accuracy for Stroop type was observed with subjects significantly less accurate at identifying the auditory Stroop cue compared to the visual Stroop cue. There was no effect for congruency. For mean response latencies, a main effect of Stroop test was observed; subjects identified the visual Stroop cue significantly faster than the auditory Stroop cue (Figure 2), however no changes in DTC were detected.

![Figure 2: Response latency (s) for the two Stroop tests; visual Stroop cue responses were significantly faster than auditory Stroop responses.](image)

Similarly, a main effect of cognitive task was observed for trail toe clearance; larger dual-task costs were observed for the visual Stroop cue compared to the auditory Stroop cue (Figure 4).

![Figure 4: Significantly larger dual-task costs for the visual Stroop cue were observed for trail toe clearances (p<0.05).](image)

For landing distance, a trend for greater dual-task cost caused by the visual Stroop task was also observed, although this was not statistically significant (p=0.069). It appears that a secondary visual task caused subjects to adopt a more cautious obstacle crossing strategy.

Dual Task performance. Recall that a larger dual-task cost is indicative of an increase in a given obstacle parameter compared to baseline values. Interestingly, there were no detectable differences in gait velocity or takeoff distance across conditions, though a main effect of trial type was observed for minimum lead foot clearance DTC (Figure 3).

![Figure 3: Significantly larger dual-task costs for the visual Stroop cue were observed for minimum lead toe clearances (p<0.05).](image)

CONCLUSIONS

Our results indicate that a more cautious control strategy is used when performing tasks involving visual (structural) interference compared to tasks involving auditory (capacitance) tasks. These results highlight that researchers should carefully consider the impact of structural interference when selecting cognitive tasks for dual task paradigms during gait.

REFERENCES