Developing an Auditory and Visual Cross-Modal Continuous Performance Task for Evaluating Concussion

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Summary

Neurocognitive tests like the SCAT3 and ImPACT have become standard concussion assessment tools. Although these tests have adequate sensitivity, specificity, and reliability, they are unimodal in nature. Consequently, the tests do not fully assess the range of processing that can be affected by concussion (Thompson, 2012). Therefore, we developed a cross-modal continuous performance task to examine cognitive processing post-concussion. Forty-three middle school school lacrosse players, college students, and physical therapy graduate students participated in the study. Twelve of these participants had been previously diagnosed with a concussion. Participants completed a symptom checklist from SCAT3 along with other demographic information (e.g., previously concussed, last concussion). They then completed the continuous performance task starting with visual detection followed by visual inhibition, auditory detection, and auditory inhibition. Older subjects were more accurate than younger subjects on the detection task ($F(1, 84) = 20.61$, $p < .001$). Subjects were also more accurate on the visual task than the auditory task ($F(1, 84) = 21.47$, $p < .001$). Both age ($F(1, 84) = 5.65$, $p < .02$) and previous concussion ($F(1, 84) = 4.49$, $p < .04$) interacted with test modality. College and graduate students who had previously been concussed performed the same as those who had not been concussed. However, middle schoolers who had been concussed did significantly worse on the auditory task than those who had not been concussed. Similarly, older subjects were more accurate than younger subjects on the inhibition task ($F(1, 84) = 4.91$, $p < .03$). Older subjects were also significantly more accurate on the visual task than the middle schoolers ($F(1, 84) = 5.33$, $p < .03$; Figure 2). However, no differences were found based on previous concussion.

Introduction

Clinical practice guidelines for concussion management recommend neurocognitive tests for baseline and post-injury assessment (e.g., VA/DoD Clinical Practice Guideline for Management of Concussion/Mild Traumatic Brain Injury). Computerized neurocognitive tests have become increasingly popular since they are a convenient format for assessing a number of athletes at once (Guskiewicz et al., 2004). Although these tests demonstrate good reliability and validity (e.g., Collie, Darby, & Maruff, 2001; Makdissi et al., 2001; Bleiberg et al., 1997), the tests are visually dominant. Thompson (2012) has argued that unimodal testing or testing that is not vigorous in nature fails to completely capture the full picture of concussions and their effects on athletes. For instance, there is anecdotal evidence an athlete "passing" a neurocognitive assessment when examined in a quiet, distraction free environment but performing poorly on the same test when background noise is introduced. While performance in one setting suggests recovery, testing in the other setting highlights continued cognitive impairment. Failure to capture this discrepancy in performance is an important concern when making return to play decisions given the potentially fatal consequences of secondary concussion. Therefore, assessments that complement existing neurocognitive tests may be valuable for more accurately evaluating the severity of impairment thereby improving diagnostic and prognostic determinations (cf., Guskiewicz, et al., 2013). In the present study, we examine whether or not cross-modal tasks can improve concussion assessment. Specifically, we examine visual, auditory, and cross-modal versions of a continuous performance task to determine if the cross-modal task is more sensitive to impairment than either of the visual or auditory tasks alone.

Methods

Subjects

Forty-three middle school school lacrosse players participated in the study. Three of these subjects had been previously diagnosed with a concussion. Forty-five college and graduate students also participated in the study. Twelve of these subjects had been previously diagnosed with a concussion.

Measure

A continuous performance task was created. The task included a detection phase and an inhibition phase for both visually and auditorily presented letters. Each phase consisted of 80 randomly presented trials in which the letter X was presented 30 times and the remaining letters were presented twice each.

Procedure

Subjects completed a symptom checklist from SCAT2 along with other demographic information (e.g., previously concussed, last concussion). They then completed the continuous performance task starting with visual detection followed by visual inhibition, auditory detection, and auditory inhibition.

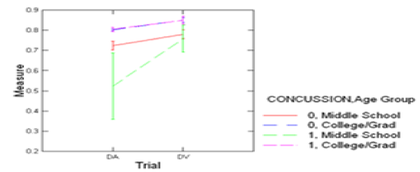
Results

Accuracy rates for detection and inhibition are presented in the below table by age group for those who had and had not been previously been diagnosed with a concussion.

Age Group	Previously Concussed	Visual		Auditory	
		Detection	Inhibition	Detection	Inhibition
Middle School	No	.824	.454	.724	.450
Middle School	Yes	.759	.361	.523	.402
College/Grad	No	.851	.568	.802	.441
College/Grad	Yes	.850	.535	.805	.436

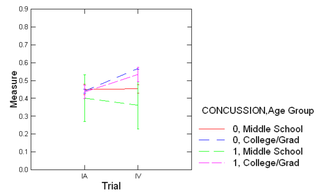
Detection

Overall, older subjects were more accurate than younger subjects on the detection task ($F(1, 84) = 20.61$, $p < .001$). Subjects were also more accurate on the visual task than the auditory task ($F(1, 84) = 21.47$, $p < .001$). Both age ($F(1, 84) = 5.65$, $p < .02$) and previous concussion ($F(1, 84) = 4.49$, $p < .04$) interacted with test modality. As shown in Figure 1, college and graduate students who had previously been concussed performed the same as those who had not been concussed. However, middle schoolers who had been concussed did significantly worse on the auditory task than those who had not been concussed.



Inhibition

Overall, older subjects were more accurate than younger subjects on the inhibition task ($F(1, 84) = 4.91$, $p < .03$). Older subjects were also significantly more accurate on the visual task than the middle schoolers ($F(1, 84) = 5.33$, $p < .03$; Figure 2). However, no differences were found based on previous concussion.



Discussion

This was conducted to evaluate the utility of cross-modal tasks in concussion management protocols. The results suggest that cross-modal continuous performance tasks may more effectively detect differences between concussed and non-concussed athletes within a younger population than the counterpart unimodal tasks. College and graduate students showed no differences between conditions. These findings show an interesting interaction between performance and age that could influence how different age groups are assessed for concussion. However, it is important to note that, given the nature of this research, we are dependent upon subjects having previously been diagnosed with a concussion. Due to our sample size and the incidence rate of concussion in middle school lacrosse players, there were only three middle schoolers with a concussion. Therefore, the findings from this study should be interpreted with caution. More research is required to determine if the present trend can be replicated with a larger number of concussed athletes.

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