Re: Validity of Axon Sports Computerized Cognitive Assessment Tool (CCAT)

This letter aims to introduce the Axon Sports Computerized Cognitive Assessment Tool (CCAT), describe its relationship to the CogState Sport product upon which it is based, and present the scientific foundation for its validity.

The Axon Sports CCAT is "powered by CogState" which means it's an online version of the CogState Sport computerized tasks. CogState Sport has been used throughout the world to assist with medical return-to-play decisions after concussion since 2002. CogState Ltd is a publicly traded Australian company that has specialized in computerized cognitive testing over the past 10 years. CogState has extensive experience in providing high-quality cognitive testing solutions to large pharmaceutical companies and government agencies, with customers including Pfizer, Astra Zeneca, Lundbeck, Merck, the National Institutes of Health and the Walter Reed Army Medical Centre. CogState technology has been presented to the US FDA in support of drug therapy efficacy claims. More detail is available from the CogState website (www.cogstate.com).

The Axon Sports CCAT uses tasks developed by CogState specifically to measure change in cognitive function in individual people. Changes in cognitive function of individuals can occur for many different reasons, one of which is sport-related head injury. The tasks were designed to be easy and practical to administer and easy to understand. Performance on the tasks does not improve with repeated administration even over short re-test intervals. In addition, the performance measures for each task have been selected based on their sound statistical principles such that they are optimal for parametric statistical analyses.

For the past 10 years validation studies have continually proven the advantages of the CogState tests for detecting cognitive change. The validation efforts began with establishment of the psychometric properties necessary for the detection of change in cognitive function under a variety of challenges including concussion arising from sports-related head injury, central nervous system (CNS) active drugs (e.g. benzodiazepines, alcohol) and physical challenges such as fatigue due to sustained wakefulness, physical exertion and stress (e.g. Falleti et al 2003, 2006).

Some of these challenges in healthy people have also resulted in the development of a framework for understanding and communicating the magnitude of any cognitive change detected. For example, the magnitude of changes observed in athletes who have been concussed can be understood in terms of the magnitude of the change observed with increasing blood alcohol levels or after long periods of sustained wakefulness. Two early reviews of this area specific to sports concussion assessment with neuropsychological instruments might help put this into context (Collie et al 2001, 2003a).

Subsequent research has investigated impairment in performance on the CogState tasks in a wide range of neurological and psychiatric conditions that include traumatic head injury, schizophrenia, depression, HIV-related cognitive impairment, Alzheimer’s disease, attention deficit hyperactivity disorder (ADHD), anesthesia and concussion. Several of these articles are included below. These additional validation studies demonstrate that in addition to being sensitive to cognitive change, performance on the tasks is also abnormal in established neurological and psychiatric diseases. There are currently many studies ongoing in which these CCAT tasks are being used to quantify and characterize cognitive impairment in a range of diseases and disorders. Publications covering these areas are available at www.cogstate.com (see below).

The Axon Sports CCAT is designed to be brief, interesting and reliable for repeated testing, and an aid to medical return-to-play decisions after concussion. It consists of four cognitive tasks, each of which uses a simple paradigm in which a playing card appears face-down centrally, and then suddenly turns face-up awaiting a response to a simple question. The questions vary to allow evaluation of cognitive domains including Processing Speed (using a simple reaction time paradigm), Attention (using a choice reaction time paradigm), Learning (visual recognition memory)
and Working Memory (one-back paradigm). Examples of the display from the four cognitive tasks and the familiarization phase of the CCAT are given in the Figure below.

![Figure: Screen shots from the Axon Sports CCAT tasks show the familiarization task for response keys (A), and examples of the displays for the Processing Speed (B), Attention (C) and Learning/Working Memory (D) tasks.](image)

For the detection of concussion, the approach taken in the Axon Sports CCAT is to compare an optimal (“best effort”) pre-season Baseline performance to that recorded in any subsequent assessment conducted after a sports-related head injury. This approach is different than that used in conventional neuropsychological assessments where performance recorded After-Injury would be compared to some population-based normative data that was partitioned by age and other relevant demographic factors such as gender or education. However, comparisons to population-based normative data can result in true impairment being missed especially when individuals have above average intelligence or high levels of education. Comparing an individual’s concussion-related cognitive change to their own baseline can detect more subtle changes because the variability in performance that is associated with cognitive measurements is much smaller when individuals are compared to themselves, than when compared to their peers, as is the case with the use of population-based normative data. With the CCAT, the known range of normal variability in performance within healthy athletes assessed over time is used to establish threshold values for normal change. If performance on one or more of the CCAT tasks exceeds this threshold, they are classified as “statistically significant” changes and flagged as not returned to baseline automatically on the CCAT report.

Overall, these studies have shown face, criterion and construct validity with one example of these studies included (Maruff et al 2009) which reports the impairment in patients with mild traumatic brain injury (mTBI). There are also two articles cited below addressing the validity of CogState Sport (then called CogSport) and whether symptomatic status in concussed athletes affects cognitive performance which in essence confirm criterion and test-retest validity in athletes and concussion (Collie et al 2003b, 2005a).

The Moriarity et al 2004 paper was included because of its surprising finding. As neuroscientists, we believed empirically that being hit repeatedly in the head would be a bad thing for cognitive performance! However, the study by Dr. Moriarity found no significant changes in cognitive function, including reaction time, occurs in amateur boxers after one or more bouts in which the referee did not stop the fight. Reaction time changes were found when the referee stopped the fight. Therefore, where careful medical supervision was operative and in amateur boxing at least (where scoring is not just based on blows landed to the head or knock-outs), the computerized testing revealed cognitive impairment only where brain injury was likely. This supports criterion validity in that the computerized cognitive tests are specific for real changes in cognition only.

The study described in the paper by Makdissi et al 2010 is the first to our knowledge to show that concussion-related cognitive performance on the Axon Sports CCAT returns to Baseline levels on average two to four days later than both symptoms and paper & pencil testing (using DSST and TMT tests). This suggests that the CCAT tasks are measuring abilities more sensitively in real athletes post-concussion than the other techniques and therefore have a major role in concussion management after symptoms have recovered. In addition, it supports the use of the CCAT for objectively measuring changes after concussion even in athletes who, for whatever reason, are hiding their symptoms. Studies comparing the CCAT to other commonly used techniques including balance testing, evoked potentials and MRI techniques are underway.

There is also an independent study by Broglio et al 2007 which compares the test-retest reliability of various computerized tests (noting that an earlier version of the CogState Sport test was called Concussion Sentinel in this paper). These results suggest reasonable test-retest reliability but did not address all aspects of repeatability and stability which our studies suggest are also important in measuring change reliably. The study did criticize the rate of abnormal tests found in the healthy subjects on repeat testing, but apparently was not aware that this is a statistical phenomenon based on the threshold used to indicate “significant” change. In clinical practice, this is rarely an issue since a single abnormal test will likely be normal with repeated testing in a healthy individual, while it is likely to remain abnormal where there is true cognitive impairment.
This introduction to the science behind the Axon Sports CCAT has really only scratched the surface of this very large body of work. We have placed all papers addressing applications of CogState tasks in support of the validity as PDFs at the following URL if you wish to view them independently:
1. Go to www.cogstate.com/go/sport/
2. Click on the "Publications" link
3. Search by keyword
4. If prompted for a login please use "library" and "rapid."

We are very excited to be able to provide the CogState tasks for the Axon Sports CCAT and hope you will find the work put into establishing the scientific validity for aiding return-to-play decisions in sport convincing. I would welcome any further specific questions.

Yours sincerely,

[Signature]

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References:


