CHAPTER 4

MOTIVATION AND THE ASSESSMENT OF SPORTS-RELATED CONCUSSION

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Abstract: This chapter provides a review of the limited information that is available regarding the impact of motivation on the neuropsychological assessment of sports-related concussion. We first outline what is known about the impact of motivation on assessment by identifying how the impact that differential motivation on baseline and post-concussion evaluations may obscure the true cognitive deficits of concussion. Next, we provide a review of two studies which provide some direct empirical evidence for differential motivation in baseline and post-concussion testing. This is followed by a review of possible causative factors associated with poor baseline motivation including: personality style, lack of education, and active misrepresentation. Next, the possible methods for identification of athletes with poor motivation on testing are presented. This includes both the use of objective measures of motivation and the identification of testing patterns consistent with poor motivation. Finally, the chapter concludes with the identification that more empirical research on each of the covered topics is necessary.

Keywords: Concussion; Mild Traumatic Brain Injury; Motivation; Effort; Sports.

1. MOTIVATION AND CONCUSSION TESTING

Much has been written on motivation and concussion or mild traumatic brain injury (MTBI). However, the vast majority of the literature on these topics describes the impact of motivation on concussion in a forensic setting. In one of the first papers describing the enduring effects of concussion, Miller (1961) suggested that the only individuals who develop what he described as "postconcussive syndrome" are those who stand to be compensated for it. There has been much research since that time to support Miller's claim. It has been demonstrated that the most important factor in the resolution the symptoms associated with mild head injury for individuals seeking some form of financial compensation is the amount of time until legal settlement (Binder, Trimbel, & McNeil, 1991), that sub-optimal motivation on neuropsychological testing has been found to occur in approximately one third to one half of all individuals who are seeking some form of personal injury compensation (Binder, 1993; Greiffenstein, Baker, & Gola, 1994; Millis, 1992), and that variables associated with effort can be highly correlated with the overall test battery performance of individuals engaged in head injury litigation (Green et al., 2001). This research suggests that motivation can have an impact on the performance of individuals undergoing neuropsychological testing in a forensic setting. However, the impact of motivation on the assessment of concussion is not likely limited to the area of forensics.

There has been speculation and limited research to suggest that motivation may also impact the neuropsychological testing of athletes who have sustained a concussion (Echemendia & Cantu, 2003; Echemendia & Julian, 2001). These authors suggest that, given the recent increased use of neuropsychological data in return-to-play (RTP) decisions, it stands to reason that athletes would be motivated to minimize symptoms so as to be able to return to play as soon as possible. There are several factors that might result in the motivation to minimize symptoms for collegiate athletes that have suffered an MTBI including devotion to the sport and team, the impact that loss of playing time might have on the athlete's future career in the sport, pressure from coaches and players, etc. Therefore, it may be possible for motivation to impact neuropsychological performance in athletic MTBI populations due to some secondary gain (return to play, resistance to cognitive change, etc.) similar to forensic populations, but the direction of the influence of motivation in the two populations is quite different. In forensic populations, the motivation may be to *exaggerate* experienced cognitive symptoms so as to maximize the likelihood that the assessor may observe cognitive deficits, while athletic populations may be motivated to *minimize* symptoms post-injury so as to increase the likelihood of a positive RTP decision.

One might wonder how increased motivation for neuropsychological performance, such as that which might be experienced post-injury in athletic populations, would be problematic. After all, can anyone be "too motivated" for cognitive testing?. The answer is likely *No* – too much motivation is not the problem. However, what might be problematic is the comparison of neuropsychological data which have been obtained under conditions of significantly different levels of motivation. Barth et al. (1989) are the authors credited with the method that has been highly successful and widely adopted in the assessment of MTBI in athletes (Echemendia & Cantu, 2003; Echemendia & Julian, 2001; Erlanger et al., 1999). This methodology requires athletes to undergo testing both prior to (described as a neuropsychological baseline) and then serially after the experience of a MTBI. The original baseline testing allows for the identification of natural strengths and weaknesses that an athlete might demonstrate in the cognitive domains that are thought likely to be impacted by experience of a concussion. The post-injury testing allows for the identification and tracking of any changes from the initial baseline which can be assumed to have resulted from the experience of the concussion. Given the comparative nature of this methodology, obtaining accurate measures of performance within the cognitive domains at both testing times is essential for identifying and tracking the cognitive repercussions of concussion. Therefore, if either the baseline or post-injury tests were inaccurate for any reason the true impact of the concussion may be obscured. Given the possible increased motivation post-injury, it is likely that the post-injury testing would be an accurate reflection of the athlete's cognitive functioning. Again, it may be worth reiterating that increased motivation for testing would likely only reduce measurement error. However, during the baseline testing, those motivating factors that are associated with the post-injury testing (awareness of the importance of testing in making an RTP decision, pressure associated with team or other expectation for athletic participation, etc.) are not present. In fact, there may be other factors (which will be discussed later in this chapter) that may work against an athlete being optimally motivated for test performance at baseline. The reader should not make the assumption that athletes may be actively malingering or attempting to feign poor performance on the baseline testing. No such evidence exists and this topic will also be touched upon further later in this chapter. However, even increased levels of general disinterest and apathy at baseline could obscure the measurement of the true cognitive repercussions of concussion given a highly motivated approach to testing post-injury. The following clinical example demonstrates the process whereby differential motivation at baseline and post-injury testing may mask the effects of concussion.

Table 1. Case Example

Measure	Baseline Standard Score	Post-Concussion Standard Score	Change	Descriptor
HVLT	103	113	+10	Borderline Improved
SDMT	91	100	+9	Stable
TMT-A	78	116	+38	Improved
TMT-B	64	96	+32	Improved
COWA	87	92	+5	Stable
DST	78	97	+19	Improved
Stroop-W	96	89	-7	Stable
Stroop-CW	88	91	+3	Stable
Vigil CPT	93	105	+12	Borderline Improved

HVLT = Hopkins Verbal Learning Test, SDMT = Symbol Digit Modalities Test, TMT-A = Trail Making Test, Part A, TMT-B = Trail Making Test, Part B, COWA = Controlled Oral Word Association, DST = Digit Span Test, Stroop-W = Stroop Task, Word Portion, Stroop-CW = Stroop Task, Color of Word Portion, Vigil CPT = Vigil Continuous Performance Test.

Table 1 provides the standard scores (M = 100, SD = 15) on a concussion battery for a Caucasian, male collegiate soccer player at both baseline and 1 week post-concussion. The athlete was 18 years old at the time of the baseline and 19 years old at the time of the concussion. He reported having no previous head injuries or ever having undergone any previous neuropsychological testing. The athlete was right handed and academic records showed that he obtained a Scholastic Aptitude Test (SAT) Total Score of 1070. This athlete sustained a concussion while playing at his forward position on the soccer field where he sustained head to head contact that did not result in loss of consciousness. However, it did result in reported anterograde post-traumatic amnesia that lasted a little under 30 minutes. As can be seen by this athlete's scores, if the general standard used by neuropsychologists of change that is equivalent or greater than or equal to one standard deviation (15 standard score points; Lezak, Howieson, & Loring, 2005) is used, then it not only appears as though the athlete's cognitive performance has returned to baseline, it appears as though the athlete has improved on several measures (both Trail Making Test portions and Digit Span) while possibly increasing his score in a meaningful way on both two other measures (the Hopkins Verbal Learning Test and the Vigil Continuous Performance Test). In fact, the change on the Trail Making Test portions is well over 2 standard deviations of improvement which is much more than one would expect from practice effects or test reliability issues alone. Again, it is important to keep in mind that this athlete had sustained a relatively serious concussion only a week prior to when the post-injury data were collected. What could explain such findings? Could it be that the concussion actually increased the soccer player's ability in the areas of processing speed, visual tracking, cognitive flexibility, and memory? This answer of course is *probably not.* A more likely alternative would be that the Low Average or below performance obtained on the Trail Making Tests and Digit Span Test at baseline was likely below the athlete's true cognitive ability (which might be estimated as solidly Average based on his SAT performance). This could be due to sub-optimal motivation on that baseline (or at least those measures); however, this cannot be adequately determined given that no true measure of motivation was obtained at either the baseline or post-concussion testing. Therefore, the neuropsychologist who is asked to make a RTP recommendation based on the obtained data would be in the uncomfortable position of having to make a determination regarding whether the soccer player is ready for competitive play while questioning the accuracy of the baseline used for comparison. Had the soccer player put forth optimal effort at baseline, the neuropsychologist would likely have little difficulty giving a positive recommendation for RTP; however, what if the player could have scored in the High Average (110-120) range on several of the measures prior to the concussion and now the vast majority of his performance falls into the Average range? The need for accurate baseline measures and the consistent motivation across evaluations is illustrated by this case.

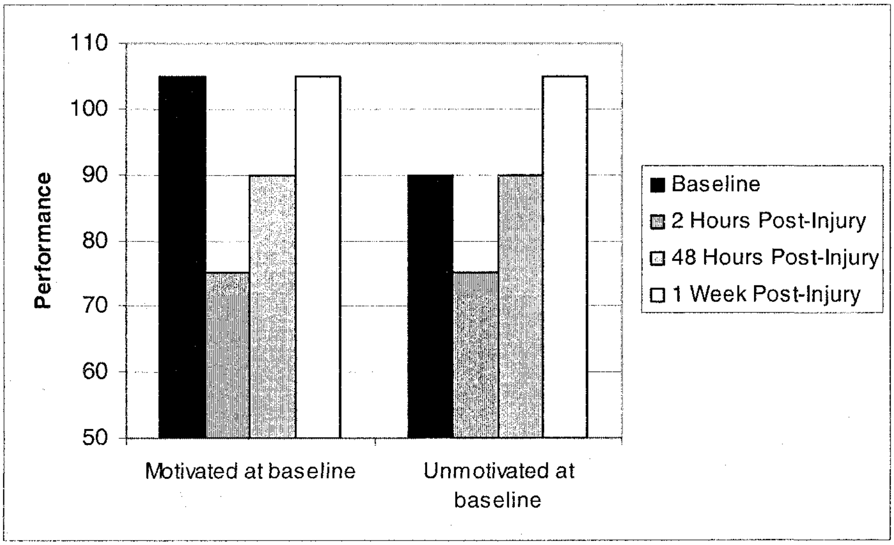

Fig.1. Hypothetical Example of the Influence of Motivation at Baseline

To further clarify the impact of differential motivation at baseline, Figure 1 provides a hypothetic scenario. It must first be assumed that both athletes depicted in Fig. 1 have the same cognitive ability, experienced the same level of injury, and that no RTP decision was made until after the 1-week post-injury testing. In the case of the athlete with consistent motivation on both baseline and post-injury testing, a notable change in cognitive performance is observed by the 2-hours post-injury testing, cognitive performance increased but remained below baseline at 48-hours post-injury, and returned to baseline by 1-week post-injury. For the athlete who did not put forth optimal effort at baseline and then greatly increased effort during the post-injury testing, the baseline performance was below the athlete's true cognitive ability. Therefore, though the concussion had a notable impact at 2-hours post-injury, it appears that the athlete has returned to baseline by 48-hours post-injury and has notably improved over the baseline by 1-week post-injury. Performance consistent with this second profile could explain the performance obtained from the soccer player above, but a neuropsychologist who did not make any assessment of motivation at baseline would not objectively know. Situations such as these might have dangerous repercussions for the clinical decisions made based on inaccurate baseline data given that an athlete may appear to be back to baseline well before the true cognitive impact of the concussion has resolved. Such issues with motivation may, therefore, result in a RTP recommendation prior to when such participation would be appropriate and could result in increased likelihood of further injury (Gerberich et al., 1983; Guskiewicz et al., 2000), prolonged experienced of cognitive symptoms (Gennarelli et al., 1982), and even death on rare occasions (Cantu & Voy, 1995).

This chapter will discuss both the information that is known about the impact of motivation on the assessment of sports-related concussion as well as describe the possible areas of future research which could further illuminate the relationship of motivation to baseline neuropsychological performance. First, the limited research that has been conducted within this area will be reviewed to further emphasize the importance of motivation on sport-related concussion testing. Second, possible factors which may be responsible for poor motivation on baseline testing will be reviewed. Finally, a discussion of possible methods for identifying individuals with poor motivation at baseline will be provided.

2. EMPIRICAL RESEARCH FOR DIFFERENTIAL MOTIVATION

Before describing what research has been conducted regarding the impact of motivation on concussion testing, the paucity of research on the topic must be acknowledged. Though it is thought to be a notable factor by the clinicians and professionals administering the testing (Echemendia & Cantu, 2003; Echemendia & Julian, 2001), little research has been conducted to empirically demonstrate the impact of differential motivation on sports-related neuropsychological performance. Therefore, research to demonstrate the level of impact that motivation has on test performance or to identify the best method for distinguishing those individuals who are putting forth appropriate and inappropriate levels of motivation at baseline is yet to come. In this section, we will provide a review of some of our own research regarding the impact of motivation on neuropsychological testing and the implications of such research.

The first project that we will review was not initially intended to identify the influence of motivation on sports-related concussion assessment. Instead, we stumbled across the effect while attempting to identify indices that would increase the sensitivity of a neuropsychological battery to the cognitive repercussions of concussion (Bailey, Echemendia, & Arnett, under submission). It was noted that in the concussion (or MTBI) literature, there had been limited research to demonstrate the importance of performance errors on testing in the identification of the effects of sports-related concussion. Given that errors were often recorded during testing but rarely used as measures of importance, we tested separate groups of concussed athletes (n = 38 – 74) and non-concussed controls (n = 43 – 69) at baseline, 2 hours post-injury, 24-48 hours post-injury, 1 week post-injury, and 1 month post-injury. We then computed the number of performance errors that the concussed athletes and controls committed for each evaluation period across a battery of five neuropsychological measures of attention and speeded information processing. It was hypothesized that the concussed athletes would make more errors compared to the control groups at each of the evaluations demonstrating sensitivity to the cognitive impact of concussion. To test this hypothesis we conducted logistic regression analyses for each evaluation to determine whether the total number of errors committed across the battery of tests was able to predict the group membership of the participants (the concussed MTBI group or non-concussed control group) even after removing the previously validated measures of time to completion of the timed tasks and the total number of correct answers given for appropriate tasks. The logistic regression analyses demonstrated that at 2 hours post-injury and 1 week post-injury, the total number of performance errors was indeed a significant predictor of group membership even after the removal of other previously validated measures. However, we were surprised to find that, though they significantly predicted group membership, the analyses suggested that the concussed athletes were less likely to commit *fewer* errors across the battery of tests than the controls. Also, though the differences were not significant for the 24-48 hour evaluation, the raw number of errors committed by the concussed group was less than the raw number committed by the control group. Though we recognized that these might be spurious findings, the consistency of the concussed group making fewer errors over at least two evaluations suggested that an important process might underlie the results. To ensure that the previously validated measures of time to completion and total number of correct responses were consistent with the sports-related concussion literature, post-hoc analyses were run. The results were indeed consistent, with the concussed group taking longer and supplying fewer correct responses than the controls across the majority of the evaluations. To explain the results, we suggested that the performance of the concussed group could be related to increased motivation in the concussed athletes given that the control group did not have the vested interest of wanting a positive RTP. Also, given the slower time to completion and lower number of total correct responses while also making fewer errors at 2 hours and 1 week post injury, we suggested that the athletes could be using a strategy of trading speed for accuracy during the post-injury testing. Such a strategy would explain both the fewer errors than non-concussed controls as well as longer times to completion and fewer total correct responses (given that slower speed often affects the total correct due to time limitation). Though this was not the intention of the project, these unexpected findings sparked our interest in the possibility that motivation was an important factor associated with sports-related concussion performance.

The second project that will be reviewed was a follow-up to the performance error study and was designed to actively determine if motivation had a significant impact on sports-related concussion testing (Bailey, Echemendia, & Arnett, under review). We recognized that the area where motivation would likely have an effect and which would have the strongest clinical implications was at baseline for the reasons identified in the above section. However, we were faced with the problem of identifying which athletes were and were not putting forth optimal motivation at baseline without having actively assessed the athletes from the Penn State Concussion Project using measures of motivation. We devised an approach to address this problem that involved separating the athletes by their baseline performance. We selected those athletes who had sustained a concussion over the course of their college career and divided them into those individuals who had performed one standard deviation or more above the mean at baseline (the High Motivation at Baseline group; HMB group) and those who performed one standard deviation or more below the mean at baseline (the Suspect Motivation at Baseline group; SMB group). This was done separately for each measure so as to obtain a HMB and SMB group on each instrument. It must first be pointed out that we recognized that certainly not everyone within these groups was appropriately putting forth high and suspect motivation (some members could even be putting forth effort consistent with the opposing group). However, the goal of the group differentiation was to identify the motivation level of the majority of the individuals which fell into the appropriate groups. Also, it is important to acknowledge that the group membership was based on the assumption that to perform one standard deviation or more above the mean, the participants were likely putting forth appropriate effort while those individuals who fell one standard deviation or more below the mean may not have been. Once the groups were divided for each instrument, the performance at baseline and 1 week post-injury for the SMB and HMB groups was compared using ANCOVA analyses (removing the effect of SAT which, not surprisingly, significantly differed between the groups as well). We hypothesized that if the SMB group was truly not putting forth optimal effort while the HMB group was, then the SMB group would show larger increases in performance post-injury than the HMB group. The time period of 1 week post-injury was specifically chosen because this is a time when the RTP decision has typically not been made and the concussion literature suggests that most symptoms often will have resolved (Barth et al., 1989; Alves, Macchiocchi,

& Barth, 1993; Vanderploeg, Curtiss, & Belanger, 2005). Also, regression to the mean was controlled by using a True Score Adjustment (Speer, 1992; Speer & Greenbaum, 1995). On the Trail Making Test (parts A and B), Digit Span Test, and Stroop - Color portion, the expected result was obtained. A second analysis was also conducted which broke the SMB and HMB groups down further into the groups of Declined, Stable, and Improved based on reliable change indices (RCI). In forming the RCI groups, we took both regression to the mean and test reliability into consideration and then compared the SMB and HMB groups. On the Trail Making Test (A and B), Stroop - Color portion, and Vigil Computerized Performance Test the SMB group displayed greater improvement compared to the HMB group. It should also be noted that the SMB group showed at least a trend toward greater decline on the Stroop - Word only portion in both analyses. We interpreted the results as suggesting that motivation did have a significant impact on at least some neuropsychological tests at baseline – especially, the Trail Making Test and the Stroop – Color portion. However, some tests could be relatively resistant to motivation fluctuation (such as the Stroop – Word portion). It is also worth reiterating that it was not thought that the group selection would totally encompass all of the individuals who had suspect and high motivation at baseline, but that only the majority of the individuals within the groups would be appropriately labeled. In fact, several individuals (both within the SM and HM groups) had substantially larger increases from baseline (3 standard deviations or more) than would be expected, especially given that they had recently experienced a head injury. Table 2 presents the clinical examples that are used in the article that is under review by Bailey et al. These case examples further support the need for more research to help identify which individuals are not putting forth optimal effort and which ones are.

Table 2. Illustrative Cases of Suspect Motivation at Baseline from Both the SMB and HMB Groups

	SMB group				HMB group			
Measure	Case #	Baseline SS	1 Week SS	Change	Case #	Baseline SS	1 Week SS	Change
SDMT	1	74	120	+54	2	118	181	+63
TMT-A	3	51	108	+57	- -	- -	- -	- -
TMT-B	4	70	119	+49	- -	- -	- -	- -
COWA	5	76	120	+44	6	117	166	+49

DST	7	74	145	+71	--	--	--	--
Stroop-W	8	60	110	+50	--	--	--	--
Stroop-CW	9	75	127	+52	--	--	--	--
Vigil	10	84	131	+47	--	--	--	--

SMB = Suspect Motivation at Baseline Group; HMB = High Motivation at Baseline Group; SS = Standard Score. Note: The case numbers listed above were substituted for the actual identification numbers used in the current study to maintain the highest level of confidentiality for the participants as possible while demonstrating that each of the above scores are associated with different cases within the respective samples.

Though there are certainly many questions left unanswered by the review of this limited research, the data do suggest that motivation has some impact on baseline concussion testing and that there are likely some athletes who do not put forth optimal effort. In the future, the use of measures sensitive to possible apathy and indifference of some athletes at baseline testing will allow for the direct measurement of motivation during the testing and identification of the extent to which testing is affected by motivation. Until then, the related question of what might lead athletes to not be optimally motivated at baseline is worth some discussion. After all, to be able to identify who has a specific trait or testing profile, it often helps to understand why the person has the trait or profile initially.

3. POSSIBLE CAUSATIVE FACTORS OF POOR MOTIVATION ON BASELINE CONCUSSION ASSESSMENT

There are several possible factors that may result in decreased motivation at baseline. Though we intend to describe how these factors may be applied to sports-related concussion assessment and the relevant associated research to suggest this, it is important to again recognize that the causative factors are purely speculative. We are not aware of any research that directly measures these factors and their relationship to the neuropsychological performance of athletes at either baseline or post-concussion testing. This only further highlights the need for future research on this topic. Despite the lack of empirical evidence, we intend to discuss three likely influential factors: personality style, lack of education, and possible coaching or active misrepresentation.

3.1. Personality Style

Cognitive and personality testing are usually treated as relatively distinct entities, yet research has demonstrated predictable correlations between the two arenas (Chamorro-Premuzic & Furnham, 2005). Chamorro-Premuzic and Furnham note that the cognitive and personality interface has been empirically identified by correlating known personality constructs such as the Big Five personality factors of Extraversion, Neuroticism, Openness, Conscientiousness, and Agreeableness to measures of intelligence. We will discuss some of the relevant literature associated with these personality factors individually; however, a general model by which these personality factors might influence the performance on cognitive tests can be provided. Given that a person's approach to the world is at least partially determined by a personality style, it is possible that athletes under no duress, with no current post-concussive symptomatology, and no RTP recommendation associated with the testing (as it is at baseline) may naturally resort to an approach that is consistent with personality style. However, once cognitive symptoms do exist and there is pressure to RTP, the athletes may be able to alter the manner by which they approach the testing. Therefore, it may be especially important to identify general personality style to identify a likely approach to baseline testing.

The trait of extraversion refers to the level of sought activity, the level of positive emotion experienced, level of impulsiveness and assertiveness, and tendency toward social behavior of an individual (Busato, Prins, Elshout, & Hamaker, 2000). Extroversion is one of the Gigantic Three identified by Eysenck (Eysenck, 1967; Eysenck, 1994) and has been linked to both cognitive and academic performance (Chamorro-Premuzic & Furnham, 2005). Eysenck suggested that extroversion was linked to levels of neural arousal especially arousal of the ascending reticular activating system. He suggested that individuals with high levels of activation within the reticular activating system and associated structures were likely to be overwhelmed by high levels of external stimulation, resulting in low levels of extraversion (high introversion). However, Eysenck hypothesized that individuals with low levels of cortical arousal within the associated neural structures would actively seek external stimulation, and thus show high levels of extraversion. On intelligence tests findings have been mixed, with both positive (Acerman & Heggestad, 1997; Austin et al., 2002; Lynn, Hampson, & Magee, 1984) and negative correlations (Furnham, Forde, & Cotter, 1998; Moutafi et al., 2003) with performance reported. It has been proposed that these differential findings may be limited to the type of test used given that tests of higher perceived difficulty might appeal to individuals who are high on extraversion and be overwhelming to individuals with low levels of extraversion and vice versa (Eysenck, 1994). Also, Chamarro-Premuzic and

Furnham (2005) review literature which suggests that extroversion may be associated with speed-accuracy tradeoffs in that extraverts may have higher processing speed and lower rates of accuracy while introverts may have the opposing style of lower rates of processing speed and higher accuracy. A more recent study of personality and intelligence testing supports the association of extroversion with speed-accuracy tradeoffs (Moutafi, Furnham, & Paltiel, 2005). These authors found that extroversion was related to numerical, verbal, and abstract reasoning on the administered battery. They reported that extroverts outperformed introverts initially and displayed faster processing speed, but performed worse on these indices by the end of the battery. These investigators hypothesized that the extroverts' better performance and faster processing speed initially was due to their higher arousal, while their relative decline in performance was due to them becoming under-aroused (bored) by the end of the battery. This research may suggest that baseline cognitive performance may very by test and individual given the level of extraversion and test difficulty. However, it clearly identifies speed-accuracy tradeoffs, a phenomenon noted in the above research by Bailey et al. (under submission), as being linked to extraversion.

Neuroticism is also one of Eysenck's Gigantic Three (Eysenck, 1967; Eysenck, 1994), and has been described as the tendency to experience negative emotions including depression, anxiety, and anger (Busato et al., 2000). Like extroversion, Eysenck identified neuroticism as being related to cortical arousal, though he linked it to the arousal of the structures of the limbic system (Eysenck, 1994). He suggested that high base rates of arousal within the limbic system were associated with high levels of neuroticism and vice versa. Research has also typically shown that neuroticism has relatively moderate negative correlations to intelligence performance (Chamorro-Premuzic & Furnham, 2005). The theory behind this relationship is that the increase in trait experience of depression and anxiety are likely to increase the likelihood of high states of depression and anxiety (Boekaerts, 1995). Therefore, the experience of test anxiety and states of depression which might interfere with test procedures could possibly be related to high levels of neuroticism and therefore, poor baseline effort/performance. The association anxiety and depression with poor performance on tests of memory, attention, and speeded information processing is well-established in the neuropsychological literature (Calvo & Carreiras, 1993; Eysenck, 1989; Hartlage, Alloy, Vazquez, & Dykman, 1993; Veiel, 1997). However, Moutafi et al. (2005) found neuroticism to be related only to numerical reasoning and abstract reasoning, but not to verbal reasoning, suggesting that some tests may be unaffected by the states associated with generally high levels of neuroticism. Nonetheless, the weight of the literature clearly shows consistent relationships between many effortful cognitive functions, like those typically measured for baseline concussion testing, and anxiety and depression.

Costa and McCrae (1992) divided Eysenck's third trait from the Gigantic Three (psychoticism) into three separate traits: openness to experience, conscientiousness, and agreeableness. Openness to experience is described as the likelihood of involvement in intellectual activities and to seek out new sensations and experiences (Busato et al., 2000). Zeidner and Matthews (2000) claim that openness to experience is one big five trait that has been most consistently found to be correlated with intelligence testing. Moutafi et al. (2005) review literature that shows correlations as high as .58 with general intellectual performance. However, some authors have also suggested that openness to experience is mainly correlated to more school-acculturated, crystallized abilities and not to the full range of intellectual skills (Brand, 1994). Chamarro-Premuzic and Furnham (2005) also review literature suggesting that openness to experience may be associated with psychometric intelligence (the ability to perform on psychometric tests) and general test engagement. Therefore, individuals with high levels of openness might be more likely to have high levels of engagement in the testing and better performance suggesting that they would be more likely to put forth maximal effort on baseline concussion testing.

Conscientiousness is also one of the three factors that Eysenck's Gigantic trait of psychoticism was broken into by Costa and McCrae (1992). Busato et al. (2000) describes conscientiousness as an individual's responsibility, persistence, and strive for achievement. Conscientiousness has had a controversial relationship with intelligence test performance (Chamarro-Premuzic and Furnham, 2005). Given that the trait is a measurement of the need to achieve, it seems likely that it would be associated with higher test performance. However, several recent studies including Moutafi, Furnham, and Crump (2003) and Moutafi et al. (2005) have found strong negative correlations with general measures of intelligence and measures of fluid intelligence specifically. These authors explain the findings by suggesting that conscientiousness may develop from low fluid reasoning skills as a way to compensate for lower ability. Therefore, high ability results in the strong performance across environments without the need for the development of enhanced conscientiousness. This suggests that, depending on the level of difficulty of the tests and the constructs being measured, conscientiousness may be either positively or negatively correlated to baseline concussion testing.

The final big five trait of agreeableness has been defined as the level of friendly, considerate, and modest behavior by Busato et al. (2000). The review of literature provided by Chamarro-Premuzic and Furnham (2005) suggest that little evidence for association with agreeableness and general intellectual ability exists. This lack of evidence for relationship was also supported by Moutafi et al. (2005). However, Chamarro-Premuzic and

Furnham also provide evidence for agreeableness's relation to social desirability, something which may also be related to both the need to obtain testing profiles consistent with teammates or the "normal" person at baseline as well as, something which may have an impact on symptom report.

Because there has been no research to identify the impact of personality style on the test approach of athletes at baseline, strong conclusions cannot be made regarding the importance of personality assessment in the context of sports-related concussion testing. However, given the similarity between intelligence testing and the cognitive measures used to identify the cognitive impact of concussion, similar patterns of test performance are likely to exist that impact an athlete's motivation and approach toward testing. Future research should be conducted to directly identify whether athletes' baselines are impacted by personality traits such as those outlined above as well as to determine if this impact lessens or increases post-injury due to the effect of RTP.

3.2. Lack of Education

Another important factor that may impact athletes' approach to baseline testing is the amount of education that is associated with their need for testing in the first place. Athletes may feel pressure to ignore the effects of concussion as a normal part of the event in which they are participating. Echemendia and Julian (2001) stated that "Historically, sports-related MTBIs have been dismissed as 'bell ringers' that are simply 'part of the game' with no cause for concern". (p.69). This misunderstanding regarding treatment may be reinforced by the wide range of symptoms associated with concussion and the speed at which they resolve (Barth et al., 1989; Alves, Macchiocchi, & Barth, 1993; Vanderploeg, Curtiss, & Belanger, 2005). Also, the previous lack of empirically supported diagnostic instrumentation and the multiple grading systems and guidelines used by neurologists (Erlanger et al., 1999; Echemendia & Julian, 2001; Echemendia & Cantu, 2004) may add to confusion regarding the impact of sports-related concussion. However, much research has accumulated to show that concussion can be a serious insult that can have long-lasting effects including, on rare occasions, death (Stiller and Weinberger, 1985; Binder, Rohling, & Larrabee, 1997; Cantu & Voy, 1995). These effects are likely not unknown to the athletic trainers and team physicians who work with athletes; however, much of this information may not have been disseminated among the athletes themselves. More recent high profile cases of the long-term effects of sports-related concussion in professional athletes such as Steve Young and Troy Aikman have possibly heightened some coaches' and athletes' awareness to the implications of the insult (Echemendia & Cantu, 2004; Echemendia & Julian, 2001), but the need for further education remains. For example, a recent survey regarding common misconceptions associated with traumatic brain injury by Guilmette and Paglia (2004) showed that approximately 40% of the surveyed individuals endorsed the item "Sometimes a second blow to the head will help a person to remember things that were forgotten," (p. 186) and approximately 60% of the sample endorsed the item "How quickly a person recovers from a head injury depends mainly on how hard they are working at recovering." (p. 186)

The lack of education and existing misconceptions regarding the impact of head injury on the part of both athletes and coaches can have a strong impact on the athlete's approach to testing. Collegiate athletes typically listen to and admire the coaches for whom they play and they often take seriously those circumstances which might lead to their removal from practice and game play. Therefore, though no research has been conducted to demonstrate this, it would seem likely that had the long-term impact of concussion been explained to them by coaches and staff, along with the fact that they are at a greater risk for concussion than the general population (Erlanger et al., 1999; Echemendia, 1997), then they might approach the baseline testing with a relatively high level of motivation and interest. In fact, the change in test approach has been witnessed across teams whose coaches and staff take an active interest in the safe RTP of their athletes from concussion. However, it seems unusual that the athletes who come to be tested at baseline have been informed even of the purpose of the evaluation, let alone the impact that concussion might have on them or the need for consistent effort throughout evaluation. This is briefly explained to them by test administrators, but an atmosphere of disinterest and unimportance has already been established by the manner in which the testing was approached by the teams initially. This is a problem that could be easily remedied through educational workshops for coaches and staff, physician-led discussions with the team regarding sports-related concussion, and the occasional incentive by coaches for baseline and post-concussive testing to be taken seriously. Concussion is a serious problem with possibly long-lasting symptoms and the assessments associated with it deserve to be taken seriously by both athletes and coaches. Education is likely one way to facilitate this process.

3.3. Active Misrepresentation

The final causative process that will be discussed is the active misrepresentation at baseline. Given the forensic research that has been identified above, many researchers have become highly sensitized to cognitive symptom exaggeration and malingering. Therefore, there are often concerns regarding athletes recognizing that if at baseline they misrepresent themselves as having poor cognitive performance in the domains most often impacted by sports-related concussion, then when tested post-injury, no difference will be observed despite the actual existence of cognitive deficits. Again, there is no empirical evidence to rely on when answering this question. Therefore, only clinical experience and anecdotal evidence can be presented. Since our recognition of the importance of motivation at baseline, we have begun to administer common measures of motivation such as the Computerized Assessment of Response Bias (CARB; Allen, Conder, Green, & Cox, 1997). This is a test which is designed to measure the very misrepresentation and cognitive symptom exaggeration which some have questioned. Though we have not compiled this evidence for statistical analysis as of yet, we have observed that individuals who actually perform below the recommended cut-off for active misrepresentation are few and far between. Nonetheless, we have observed that some athletes perform below levels that are considered optimal on this task. The argument against the possibility that athletes are actively misrepresenting themselves at baseline is probably best made by the preceding section regarding lack of education. Most athletes approach concussion testing without much information regarding what the testing is for and why they need to complete it without having recently experienced a concussion. Since they do not originally understand how the testing is used, it would logically follow that they are not actively attempting to invalidate future testing administrations. The idea that motivation is less active misrepresentation and more disinterest and apathy at baseline fits with our clinical experience and intuition; however, this intuition can be wrong. Though we feel that cases of active misrepresentation are rare, whether or not athletes are actively misrepresenting themselves on testing should be a question for future research.

4. IDENTIFICATION OF POOR MOTIVATION IN SPORT-RELATED CONCUSSION

Given the above empirical evidence for the impact of motivation at baseline and the hypothesized causative factors in that motivation, there are several possible methods by which athletes that did not provide optimal motivation at baseline could be identified. However, it again must be acknowledged that none of the methods below have been adequately empirically validated. They should be thought of as possible or hypothesized methods for identification which may also be clinically useful. The methods to identify motivation in testing which will be addressed will include: objective measures of motivation and unusual patterns on administered testing.

4.1. Objective Tests of Motivation

As noted above, there has been much attention paid to the forensic application of neuropsychological evaluations. Given the nature of such evaluations and the secondary gain often associated with them, the need to measure the client's tendency to exaggerate symptoms or actively misrepresent the level of cognitive repercussion experienced is paramount (Larrabee, 2005). Several measures have been validated for use as measures of motivation including the Word Memory Test (WMT; Green, Iverson, & Allen, 1999), the Test of Memory Malingering (TOMM; Rees, Tombaugh, Gansler, & Moczynski, 1998), and the Computerized Assessment of Response Bias (CARB; Allen et al., 1997). These tests each are forced-choice tasks that provide examinees with simple memory tasks and require them to choose one from two choices. There are two ways by which such tasks are used (Larrabee, 2005). First, active misrepresentation of cognitive performance can be identified through the performance on these tests that are below chance levels. By chance alone, an individual should score correctly on 50% of the memory items provided given that there are only two choices. If a subject scores below chance (i.e. 20 correct out of 50 items), then it suggests that the individual is knowingly selecting incorrect items given that, had the subject selected an answer at random without having been presented with the stimuli at all, they would have likely performed better. The second method of scoring objective measures of motivation is by comparison of the subject's performance to that of severely injured and organically compromised patients. Typically, this comparison provides a cut-off of performance that, though greater than chance, suggests poor motivation given significantly worse performance than the severely injured group.

As noted above, measures such as these have demonstrated strong validity in their ability to identify individuals who are actively misrepresenting themselves on cognitive testing (Larrabee, 2005). Unfortunately, as identified in the previous section on causative factors, the use of objective motivation measures for baseline sports-related concussion performance is not appropriate because the athletes are not likely malingering or actively misrepresenting themselves. Measures of motivation such as the WMT, TOMM, and CARB were designed to identify extreme levels of poor motivation not the apathy and disinterest which is likely to exist in athletes at baseline. As noted above, very little variability has been identified on measures such as the CARB when administered to our own clinical population. This presents a problem for the objective measure of motivation and suggests the need for a continuous measure of motivation for sports-related concussion, as opposed to the binary (malingering or not malingering) instruments commonly used. The Validity Indicator Profile

(VIP; Frederick, 1997) is a motivation measure that provides such a continuous measure; however, the VIP takes approximately 25-30 minutes to administer which may not be feasible for most sports-related concussion evaluations. Some studies (Dunn, Shear, Howe, & Ris, 2003) have also identified that response speed on motivation measures such as the CARB may also be an indicator of motivation in college simulators of malingering. This measure was highly correlated with more commonly used indices (number of correct responses) and suggested that the longer the response time on the CARB, the lower the motivation in the simulating sample. Such indices could possibly provide a useful continuous measure of motivation for identifying athletes who are not providing optimal motivation as well. We have found this measure to be useful; however, more research is necessary. Ultimately, a direct, continuous measure of motivation which can be feasibly administered to athletes at baseline will be necessary for the objective identification of poor motivation. Until then, patterns in performance on regular cognitive tests that suggest poor motivation must be relied upon.

4.2. Patterns of Performance Suggestive of Poor Motivation

Given the reviewed empirical evidence of poor performance provided by Bailey, Echemendia, and Arnett (under submission) and Bailey, Echemendia, and Arnett (under review), there are two patterns of performance on cognitive testing that might be suggestive of poor motivation specifically for the population of college athletes undergoing baseline MTBI testing. First, and rather intuitively, is extremely poor performance. It stands to reason that when there has been no identified reason for cognitive problems and an athlete demonstrates consistently poor performance at baseline, then motivation may be suspect. This was the methodology used by Bailey, Echemendia, and Arnett (under review) and significant effects for motivation were identified on several of the measures used, including the Trail Making Test and the Stroop Color-Word trial. Also, Bailey, Echemendia, and Arnett (under submission) identified that a possible pattern for high motivation post-injury is the use of an accuracy-speed tradeoff where the athlete focuses mainly on providing correct answers and sacrifices speeded measures to do so. It might be reasonable to assume that a speed-accuracy tradeoff where the athlete might sacrifice correct answers for finishing a task quickly could be associated with poor motivation. This also fits with the evidence provided by Chamarro-Premuzic and Furnham (2005) which suggests that speed-accuracy tradeoffs are more associated with extroverts who become disinterested and bored in situations of little arousal. Therefore, the use of speed-accuracy tradeoffs across the testing may be suggestive of less than optimal motivation across all tests (though some tests of purely processing speed, such as the Stroop-Word Only trial, may actually result in improved performance with this approach style).

Because no other research regarding motivation in athletes is available, other indicators of poor performance can be identified from forensic applications. Again, it must be acknowledged that these patterns of performance are likely to be more exaggerated in the populations from which they have been identified (active litigants) than they would likely be in athletes at baseline. However, these methods may provide guidelines for identification of poor motivation. Larrabee (2005) reviews the recent literature associated with the detection of malingering in forensic evaluations. Among the methods Larrabee identified are the following patterns in testing which may be useful in identifying poor motivation in the baseline testing of athletes: inconsistent performance across related tests, poor Digit Span performance, and poor recognition performance. First, Larrabee indicates that neuropsychological testing should, for the most part, make what he describes as "neuropsychological sense." For instance, if memory performance on one test suggests that and individual is at dementia levels, then he or she should not be scoring above average on other related tests of memory. Also, some cognitive abilities should be observable clinically and considered in light of test results. For instance, if an individual's score on tasks of verbal fluency or confrontation naming falls in the Borderline or below range, then the individual's casual conversation with the test administrator should also be suggestive of word-finding and naming difficulties. Another method for identifying poor motivation outlined by Larrabee (2005) is performance on a specific working memory test: The Digit Span Test (DST) from the Wechsler Adult Intelligence Scale, 3rd Edition (Wechsler, 1997a) and the Wechsler Memory Scale, 3rd Edition (Wechsler, 1997b). This is a common task that is often used for the identification of working memory ability and attention. However, Larrabee reviews research which suggests that unreliable performance on the DST may be suggestive of poor motivation. Greiffensten et al. (1994) suggest scoring the DST by only providing credit for the strings of numbers where both trials were repeated correctly (for both the forward and backward section). Finally, Larrabee (2005) also suggested that MTBI or concussion litigants who perform poorly on measures of recognition are likely exhibiting poor motivation as well. Recognition tasks are designed to identify whether the originally presented stimuli were even encoded. Such difficulties are typically only consistent with dementias and severe brain injury and Larrabee reviews research that suggests that litigants often perform worse on such tasks than non-litigants with mild head injury.

There are several important points to keep in mind when identifying patterns in testing that are not consistent with optimal motivation. First, as noted above, the majority of the patterns for poor motivation have been identified within a litigating population which suggests that performance at baseline would not be as extreme as those indicators described above. It may not be likely that any athlete would perform at levels consistent with dementia on memory testing; however, inconsistent performance across memory tests suggests that suspect effort may be present. This is especially true given that, during baseline testing, athletes should not be influenced by the impact of a true neurologic insult or condition. However, this leads us to the next important point to keep in mind: There may be more than one factor responsible for unusual test patterns at baseline. Though suspect motivation may be associated with poor performance, inconsistent performance, and poor recognition among other things, there are several other conditions that may be present in the athlete at baseline which could also account for these patterns. For instance, attention deficit hyperactivity disorder, learning disability, depression, and anxiety could each be associated with variable and poor performance. Therefore, it is important to keep in mind that these patterns are signals that factors other than true cognitive ability may driving the performance, one of which could be sub-optimal motivation.

CONCLUSION

It is likely that this chapter raised more questions than it answered. This was the intent of the authors given that there is such a limited base of research regarding the impact of motivation on sports-related concussion. However, there are two solidly supported pieces of information that can be taken from this review. First, there seems to be clear evidence that motivation has at least some impact on the performance of some athletes at baseline. As noted above, this means that inaccurate reference points are being obtained on those athletes who did not provide optimal effort and this places them at greater risk for RTP before the cognitive repercussions and symptoms of concussion have resolved. The second firmly supported claim associated with motivation in sports-related concussion is the need for further empirical research that directly addresses aspects such as the identification of athletes with sub-optimal motivation, the causative factors of motivation, and the degree to which sports-related concussion testing is affected by differential motivation at baseline and post-concussion evaluations. There is much to be done; however, the information provided in this chapter highlights the areas where future research is most needed and identifies what likely roads that research might take us down.

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