**Reporting on Diversity in Concussion-Focused Neurocognitive Research: A Demographic Review**

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**Abstract**

Clinical diagnoses of concussions involve a multi-faceted approach, including assessments of symptoms, neurocognitive status, posture, behavior and sleep. The purpose of this literature review was to determine the prevalence of demographic reporting with respect to race, ethnicity/culture, and language in the context of concussion-related neurocognitive testing. Healthy and concussed concussed individuals, from culturally and linguistically diverse populations demonstrate performance at levels lower than similar White, English-speaking cohorts on common neurocognitive tests. A systematic search of the literature yielded 768 unique citations reporting concussion-related neurocognitive outcomes. Of these, 36.07% (n = 277 articles) included at least one participant demographic distribution for race, culture/ethnicity, or language. However, only 1.8% (14 articles) included one or more demographics in the data analyses. These findings indicate limited external generalizability for the majority of the included articles. Additionally, differences between racial, cultural/ethnic, and linguistic groups are not fully explored and caution is warranted for clinical interpretation of neurocognitive test outcomes when used with diverse populations.

**Key points:**

* This review highlights the lack of reporting on potentially key demographic characteristics (race, ethnicity, language) in the area of concussion-related neurocognitive testing. Fewer than 40% of the reviewed articles report the distribution of participants on these characteristics.
* White and English-speaking persons comprised the majority of concussion-related neurocognitive research participants between January 1976 and March 2016.
* Individuals from non-White and non-English backgrounds may have neurocognitive outcomes that differ from White and English-speaking persons. Further research is needed to identify the extent of these differences.

**1 Introduction**

The diagnosis and management of concussion is currently an issue of social and medical emphasis. An estimated 1.7 to 3.8 million mild traumatic brain injuries (mTBI), of which concussions are a subset in the mild end of the spectrum, require hospitalization each year and countless numbers of concussions are managed clinically or go undiagnosed [1–3]. Furthermore, sports related concussion is a cross-sports and a cross-competition level issue. Individuals participating in all sports at all levels of competition are potentially at risk for concussion, with the highest degree of risk found for collision/contact sports (i.e. football, hockey soccer) [4]. The diagnosis and management of both short- and long-term effects of concussion is also a research emphasis for the military, as both blast-related and blunt-trauma related concussions are prevalent for deployed military personnel [5]. Although sports- and military-related concussions receive much of the media coverage, the majority of diagnosed mTBIs are the result of motor vehicle accidents [1,6,7]. Therefore, concussion is not merely a sports and military issue, but one that affects all members of society.

In the current recommendations for the diagnosis and management of concussions, a multidisciplinary team is responsible for evaluating the concussed individual for symptoms and functional deficits [8,9]. Within each of these disciplines, one or multiple measures may be employed to inform this clinical team. These measures may include but are not limited to symptom report, neurocognitive testing, behavioral assessment, postural stability evaluation, and sleep quantification. Given that individuals from all cultural and linguistic backgrounds are at risk for concussion, the need for clinically- and culturally-relevant and valid measures for evaluating the concussed individual is imperative.

This is especially true for neurocognitive testing in light of several facts. First, many commonly utilized neurocognitive tests were developed for, and validated on, White, English-speaking individuals in the United States [10,11]. As such, test performance by other racial, cultural, and ethnic groups may differ from the expected outcomes based on original validation and norms for reasons other than cognitive impairment, such as education, cultural salience, and acculturation [12–14]. Consequently, there is reasonable evidence indicating that neuropsychological tests contain cultural biases [12,13,15,16], resulting in potential misdiagnoses [17–20]. These issues are further exacerbated when considering the difficulties that might also arise when examiners do not share a language with their client [12,14,20–22]. Finally, global immigration trends indicate that, as of 2015, 244 million individuals worldwide reside outside their country of birth. Thus, in both research and clinical practice, the issue of cross-cultural neuropsychological testing is one that potentially affects clinicians, patients, and participants regardless of the country in which testing occurs.

**1.1 Purpose and Organization**

The purpose of this literature review is, therefore, to determine the extent to which cultural and linguistic demographic data are being reported in concussion-related research, specifically with respect to neurocognitive testing. To do so, first a definition and brief overview of the effects and symptoms of concussions will be provided along with characteristics and features of common testing methods. Second, a brief overview of the evidence for the impact of race, culture/ethnicity, and language in cognitive function will be presented. Third, an overview of the literature regarding racial, cultural, and linguistic differences in neurocognitive testing in the context of concussion diagnosis and management will be given. Finally, conclusions will be offered along with recommendations for future research and considerations in the clinical context.

**1.2 Concussion Overview**

Concussion is a consequence of direct force (applied to the head itself) or indirect force (applied to the body and transferred biomechanically to the head) that result in a disruption of brain function [8,23,24]. Broadly, these disruptions include impairments or changes in cognitive status, behavior, balance, sleep and the presence of somatic symptoms [8,9,23,24]. The most commonly reported symptoms include headache, photo- and phonosensitivity, nausea, and vomiting, confusion or fogginess, and dizziness. These symptoms often present uniquely between individuals, such that the same incident can yield a number of severe symptoms in some and seemingly no symptoms in others [25,26]. Therefore, the diagnosis and management of a concussion is confounded by the multitude of ways in which symptoms may present in the individual.

To further confound this issue, concussion is a clinical diagnosis [8,9,23,24]. For example, brain imaging generally fails to reveal structural insults to the brain in the acute phase, and is therefore not commonly used unless clinical presentation suggests structural damage [8,27]. Accordingly, injury mechanism, clinical presentation and formal testing are the current centerpieces of the concussion diagnosis [8,23,28,29]. Symptom scales, neurocognitive tests, and balance assessments are commonly utilized to provide a comprehensive evaluation of the individual [30–36]. Many of these tools have previously demonstrated validity and reliability in multiple samples in the United States [36–38]. Additionally these tools are proven to have both sensitivity and specificity to deficits related to concussion [36,39,40].

The most common neurocognitive tests for post-concussion assessment are either paper-and-pencil or computerized tests [41–43]. These tests – including ImPACT, CNS Vital Signs, as well as more traditional tests including Trail Making Test and Stroop tests – evaluate the domains of cognition most commonly affected by a concussive event. These domains include memory, concentration, executive function, information processing and reaction speed [30,44,45]. Decrements in these domains are reported in the literature acutely after injury and generally return to pre-injury performance levels within 3 weeks of injury [30,44,46,47]. However, persistent functional deficits have been reported in some individuals long after the clinical resolution of symptoms [48–50].

These tests are often used to measure an athlete’s baseline ability prior to a competitive season or series of seasons. In the event of a concussive injury, data are then used for comparison with post-concussion data collected at specific time points. In the absence of baseline measures, normative values exist for many of these various measures. However, these normative values are generally based on predominantly White, middle-to-upper class English-speaking high school and college students in the United States and may lack sensitivity to racial, cultural/ethnic or linguistic differences when applied to other populations [51–54]. This is undoubtedly problematic when attempting to establish return to “baseline” after injury for individuals not captured in the normative datasets.

**1.3 Racial, Cultural/Ethnic and Linguistic Impacts on Cognitive Tests**

Very few studies have examined the specific effects of race, culture/ethnicity, or language on neurocognitive testing for concussion management. Kontos et al. (2010) compared African American and White athletes’ performance on the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT, [55]) at baseline, two, and seven days post-injury [41]. The authors noted that African Americans were more likely to demonstrate a significant decline in cognitive function at one week post-injury with a similar trend at two days post-injury. Specifically, the authors observed decreased motor processing speed in the African American group and a lack of practice effect from baseline to seven days post-injury. The authors suggest that the lack of differences at baseline between the groups, coupled with the fact that differences were observed in only one measure, does not merit a separate normative baseline for African Americans. However, the participants in this study were all English-speaking high school and college students from similarly performing academic institutions. Consequently, these participants may not represent the breadth of educational, acculturation, linguistic, and socioeconomic conditions, which may impact individuals’ pre- and post-injury performance on this test.

Likewise, Shuttleworth-Edwards et al. (2009) compared white, English-speaking football players in the US to predominantly white English-speaking rugby players in South Africa on the ImPACT [54]. The authors showed that while the South African players tended to report higher symptom scores, the cognitive task outcomes were similar. However, the authors acknowledge that the athletes in both groups were predominantly White and well-educated [54]. The similarity of these results may not persist outside of this narrow scope.

Some cross-lingual comparisons have additionally been conducted. Ott et al. (2014) compared English-speaking athletes to Spanish-English (native Spanish speakers with English as a second language) bilingual athletes taking the ImPACT in either Spanish or English [53]. They demonstrated that these bilingual athletes completing the ImPACT in Spanish performed more poorly than both bilingual and English-speaking individuals taking the test in English. Furthermore, bilingual athletes administered the test in English performed more poorly than English-speaking athletes. The authors note that this study highlights the need for caution when administering the ImPACT to Spanish- and English-speaking Hispanics [53].

In short, racial and ethnic background, cultural heritage, and primary language likely influence neurocognitive testing outcomes following concussion [12–20,22,41,53,54]. The purpose of this review is therefore to determine whether these important demographic features (e.g. race, culture/ethnicity, and language) are being reported in conjunction with concussion-related neurocognitive testing, and then identify to what extent they are factored into the analysis and interpretation of concussion-related neurocognitive outcomes.

**2 Methods**

**2.1 Search strategy**

Literature reporting neurocognitive outcomes related to concussion diagnosis and management procedures was identified in the following manner. A multiple database search was conducted on the following databases: Academic Search Premier, PsycInfo, CINAHL, MEDLINE, SportDiscus, and Psychology and Behavioral Science Collection (all available through EBSCOHost at Utah State University) in March, 2016. Search terms for all databases included terms related to concussion (“concuss\*” OR “mTBI” OR “mild traumatic brain injury” OR “closed head injury”) and terms related to neurocognitive testing (“\*cognitive” OR “\*cognitive test”). Only articles published in English were considered. No restrictions on year of publication were imposed.

These search procedures yielded 4961 citations, of which there were 2541 unique citations. Titles and abstracts were then screened for inclusion based on the following guidelines:

1. Articles reported on original (no systematic reviews, meta-analyses, book chapters, or consensus statements), peer-reviewed (no dissertations or theses) manuscripts. Articles published ahead of print were included.
2. Articles reported on human participants.
3. Articles reported on specific neurocognitive or neuropsychological tests. Articles were included if specific test outcomes were reported, if test scores were used to stratify individuals into groups (e.g., post-concussion syndrome (PCS) or no PCS), or if test scores were entered into a model and reported as coefficients rather than specific values.
4. Articles reported on participants in a concussion context. Concussion context included studies reporting on not only acutely concussed individuals, but also the long-term effects of previous concussions, as well as test-retest reliability for concussion-specific cognitive tests (e.g., one-year test-retest reliability, repeat baseline assessment) within non-concussed populations, and subconcussive effects (e.g., repetitive head impacts from boxing or soccer without formal concussion diagnosis). This wide range of contexts was chosen to ensure a broad range of cognitive testing applications within the typical applications for concussion.
5. Articles were excluded if individuals were only diagnosed with moderate, severe, or moderate-to-severe traumatic brain injuries.

After applying inclusion criteria, 1254 articles remained and full texts were available for 1253 of these. The same inclusion criteria were applied to the available full texts. Additionally, however, articles were excluded if, in the presence of traumatic brain injury, there was not a clearly defined mild TBI or concussion group (e.g., articles were excluded when the sample included individuals with varying degrees of severity who were not separated into distinct groups). A total of 768 articles met the guidelines for inclusion. Please see Figure 1 for a flowsheet of the inclusion/exclusion process.

The methods and results sections of each included article were coded by two independent coders. Variables coded included 1) tests used, 2) whether or not the authors reported racial, ethnic, country of origin, or 3) primary language distribution for the participants, and 4) whether or not racial, cultural/ethnic, country of origin, or linguistic characteristics were considered in the analyses, and 5) the reported number of individuals identifying with various racial, ethnic, or linguistic groups. Race and culture/ethnicity were defined as any explicit indication of the distribution of racial or cultural/ethnic background. When this information was not provided in the manuscript, country of recruitment was not taken as an implicit identification (e.g., participants recruited in South Korea were not assumed to be South Korean). Primary language was defined as any explicit indication of the languages spoken by the participants. Again, country of recruitment was not taken as implicit identification of the primary language of the participants.

Coded articles were then sorted to determine the frequency of reporting various racial, ethnic and linguistic participant characteristics. Due to the varied ways that authors reported race and cultural/ethnic distributions, these two categories are combined into a single category. For example, Macciochi et al. (2013) reported African American as “race” [56] whereas Cole et al. (2013) reported African American as “ethnicity” [57]. Data are presented as percentages of the total sample of included articles.

**3 Results**

**3.1 Article characteristics**

On the basis of this systematic search, 768 group-design articles published between January 1976 and March, 2016 were identified that used neurocognitive tests within a concussion context (baseline testing, test-retest reliability, or post-injury follow up). Of these articles, the majority (n = 489, 63.67%) were published by researchers or groups recruiting participants in the United States. See Figure 2 for a more detailed view of articles by country.

**3.2 Reporting demographics**

Demographic variables of interest were reported in 36.07% (n = 277 articles) of the included articles. Race, culture, ethnicity, or country of origin were reported in 20.01% (n = 164 articles) of these articles (Supplementary Table 1). Participants’ preferred or spoken language was reported in 21.88% (n = 168 articles; Supplementary Table 2). Furthermore, of the 277 reporting any of these distributions, 55 articles (19.86%; 7.16% of all included articles) reported both language and race, culture/ethnicity, or country of origin. Finally, 14 articles (5.05%; 1.82% of all included articles) included these categories in the data analyses or stratified outcomes based on these demographic characteristics [41,53,54,56,58–67].

<Insert Supplementary Table 1 approximately here>

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**3.3 Articles reporting race, culture, ethnicity, or country of origin.**

Of the 164 articles reporting demographic distributions related to race, culture, ethnicity, or country of origin, 150 reported participants in terms related to race, culture, or ethnicity and six reported participants in terms of their country of origin, with four articles reporting participants in terms of both race, culture or ethnicity and in terms of country of origin. Two articles referred to the majority of the participants being Caucasian or White without reporting actual values [301,323], while one simply noted “comparable… ethnic backgrounds” between groups [324]. One further article reported individuals in terms of race, culture, or ethnicity, however it was unclear in the text whether the distributional percentages reflected the entire sample including control participants, the entire sample prior to exclusionary criteria being applied, or only those individuals with mTBI [262]. Therefore, for the purposes of this review, the distributions of participants in these four studies will not be included in subsequent descriptions (*n* = 160 articles).

Among those articles reporting race, culture, or ethnicity demographics, a total of 73 descriptors are used, many of which overlap each other but are not reported consistently. For example, there are seven different descriptors applied to individuals traditionally described as “White,” including: White, Caucasian, Caucasian/White, White (non-Hispanic), White or European-American, White (non-Latino), and White Latino. See Table 1 for frequencies of these descriptors. Of the 10 articles reporting country of origin, 24 different descriptors are used. See Table 2 for frequencies of these descriptors.

<Insert Table 1 approximately here>

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Across all of the studies reporting race, or ethnicity demographics, individuals identified as “White” (n = 26037, 35.00%) or “Caucasian” (n = 8816, 11.85%) accounted for 46.53% of all participants, with individuals identified as “Hispanic” (n = 12903, 17.34%) or African-American (n = 3772, 5.07%) accounting for the next largest proportions of the participants (Table 1). Furthermore individuals identified as “White” or “Caucasian” accounted for more than 50% of the participants in 66.25% (n = 106) of the 160 articles (Table 1).Participants specifically identified as being from the United States were the majority of all participants across the 10 articles reporting country of origin (n = 31793, 92.04%; Table 2).

Authors made direct comparisons between racial/cultural groups in six of the 160 articles. These articles produced mixed results. No cognitive differences were observed between White, English-speaking South African rugby players and English-speaking American football players [54] or between multiple groups (Caucasian, African American, Other) [61]. Furthermore, while White individuals were more likely to report amnesia than individuals identified as “other”, there were no difference between amnesia and non-amnesia groups on ImPACT subscales [66].

By contrast, concussed African Americans had lower visual motor processing speed as well as a greater likelihood to demonstrate at least one cognitive impairment on ImPACT at seven days post injury [41]. Additionally, boxers were shown to have a significant decrease in processing speed with increasing fight exposure, used as a proxy for concussion risk, after adjusting for age, race, and education [59]. Furthermore, non-European New Zealanders tended to perform less well on CNS Vital Signs at 12-months post injury than European New Zealanders [58]. However, the authors are careful to note that there is some evidence of poorer neuropsychological test performance by New Zealanders in comparison to European New Zealanders on traditional neuropsychological testing and therefore cultural bias, rather than true differences in test outcomes, may be partially explanatory in this case as well.

Lower test-retest reliability on ImPACT for American college students compared to Irish students was reported in one article [67]. However, the groups did not complete the second and third administrations on the same time scale. The Irish students completed tests on days seven and fourteen from baseline whereas the US students completed them on days 45 and 50 [67]. While these timeframes inform about the long-term stability of the test, the dissimilarity does not permit cross-cultural comparison.

**3.4 Articles reporting language.**

Across the 168 articles reporting participant languages, 27 descriptors were reported. One article specified that most participants spoke French without giving an exact breakdown [323] and is not included in subsequent analyses. Out of 167 articles reporting participant language distributions, a total of 88.62% (n = 148) identified a single language for all participants (see Table 3), with English as the most common language (n = 122). English-only speaking participants were identified in 80.24% (*n* = 134 articles) of these articles, with French-speaking participants being the next most common group (*n* = 8 articles). Additionally, English-only speaking individuals represented the majority of the participants (> 50%) in 79.04% (n = 132) of these articles. Furthermore, English-only speaking individuals accounted for 83.50% (n = 79714) of all participants across the 167 articles.

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Fourteen articles reported participants from two or more language groups. However, only four articles provided comparisons between multiple language groups in the data analyses. These articles identified clear differences on neurocognitive test performance between language groups. Spanish-English bilinguals demonstrated lower performance on ImPACT, when taking the test in their preferred language (either English or Spanish), than monolingual English-speaking individuals [53,60,63]. Additionally, those bilinguals taking the test in English performed better than those taking it in Spanish. Furthermore varying test-retest reliability within language groups (English, French, Czech, and Swedish) on ImPACT composite scores at baseline and a one-year follow up were observed [62]. However, no between-group comparisons were made to determine whether there were systematic differences.

**4 Summary**

Concussion is a public health crisis. The demand for objective, quantifiable measures of impairment and recovery are essential not only to diagnosing the individual but documenting recovery and making return-to-learn, -play, and -work decisions as well as a means to track functioning over time. Among the many documented effects of concussion, impairments in memory, executive function, emotional control, decision-making, concentration and attention, and reaction time are frequently observed. Given global patterns of immigration and the subsequent increase in cultural and linguistic diversity in destination countries, such as the United States [325], there is the reasonable necessity for measures that are sensitive to these neurocognitive deficits while accounting for racial, cultural/ethnic, and linguistic characteristics of the participant or patient.

Despite such diversity, fewer than 40% of the articles identified in this review reported participant characteristics with respect to race, culture/ethnicity, or language. Of these articles, White or English-speaking participants are the majority of, or only, participants in approximately 80%. Furthermore, approximately 2% of all of the articles account for these demographics in the data analyses. Consequently, the external generalizability of the results of the majority of the articles identified here is limited. Furthermore, the effects of concussion on neurocognitive test outcomes in diverse populations is unclear.

However, on the basis of this review, there is reason for caution when interpreting the results of neurocognitive tests, particularly ImPACT, of individuals from non-English speaking populations as well as individuals who do not identify as “White,” or “Caucasian.” Specifically, there is evidence that Spanish-English bilinguals demonstrate lower performance under non-concussed conditions regardless of the test language (Spanish or English) than their English-only counterparts, though taking the test in English consistently yields higher scores [53,60,63]. This is true even when these bilingual individuals take the test in the language that they prefer [53]. The mechanisms for such differences remain unclear, though education, acculturation, cultural bias, and test translation are all plausible explanations [13,17,22,53,60,63]. There is also an indication that long-term test-retest reliability may vary on the ImPACT between multiple cultural and linguistic groups on the basis of different within-group intraclass correlation coefficients [62,67]. However, no between-group statistics have been calculated to fully explore this. Additionally, there is evidence of increased symptom-reporting [54] and increased likelihood of cognitive impairment [41] in non-American and non-White samples, respectively.

The lack of reporting of race, culture/ethnicity, and languages spoken by the participants is problematic in three ways. First, it does not permit the reader to gauge the representativeness of the samples drawn. Second, it does not permit the reader to judge the populations on whom the results are valid and generalizable. Third, it does not allow for testing and evaluating outcomes for differences across racial, cultural/ethnic, and linguistic populations.

**4.1 Recommendations for Research**

In light of these findings, two recommendations for future research emerge. First, researchers should begin to obtain and document the race, culture/ethnicity, and language (primary, bilingual status) of participants. Doing so, will allow for better external generalizability and facilitate comparisons between articles. Furthermore, reporting these demographic variables may enable researchers to identify correlates and etiology of performance differences on neurocognitive tests when participant outcomes are not homogenous or conflict with reported normative data. Additionally, researchers should endeavor to recruit country-specific representative samples, given the global trend toward immigration [325]. This will help to ensure greater applicability of the findings to the general population.

Second, future research should investigate differences in neurocognitive outcomes of various populations with respect to concussion. There is limited yet emerging evidence, for differences between English-speaking White Americans and those from other backgrounds [53,63]. Thus, it is necessary to more fully explain these differences to determine whether there are in fact systematic differences between various groups. Doing so will allow for the development of racially-, culturally/ethnically-, and linguistically-sensitive interpretations.

**4.2 Recommendations for Practice**

Recent work has highlighted the fact that cross-cultural neurocognitive testing with tests validated for White, English-speaking individuals introduces issues of cultural bias and misdiagnosis, even in healthy populations [11,15,16,20,326]. In light of these concerns and findings here [41,53,54,60,63], clinical interpretation of neurocognitive outcomes with respect to concussion merits caution with diverse populations, particularly when testing is not conducted by trained neuropsychologists. Concussion remains a multi-faceted clinical diagnosis, with neurocognitive testing as only one component. It is important to recognize that neurocognitive outcomes at baseline and post-injury may not reflect the true capacity of the individual if the commonly used tests do indeed contain racial, cultural/ethnic, or linguistic biases. Until further research more clearly identifies the role of these demographic variables, no other specific recommendations can be made for the clinician in this area.

**4.3 Limitations**

The systematic search terms used may have excluded some literature due to the narrow focus of the wording. Additionally, no ancestral or descendent searches were conducted. However, the results from this limited search are striking in the magnitude to which these demographic characteristics are not being reported and not being systematically investigated. While there may be articles not captured by this search, it is reasonable to view the proportions within this sample (n = 768 articles) as representative.

**5 Conclusion**

Current practices for reporting race, culture/ethnicity, and language demographics in concussion-oriented neurocognitive research are inconsistent and insufficient for determining both sample representativeness and generalizability. While some evidence suggests differences between groups, such differences are not fully clarified. Further research and more complete reporting of these demographic variables are required in order to fully evaluate the utility and interpretation of the scores achieved on these tests with diverse populations, particularly when comparing individual performance with normative data. In doing so, both researchers and clinicians can more thoroughly document the magnitude of neurocognitive impairment following concussion and the time-course and trajectory of recovery.

**Compliance with Ethical Standards**

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**Conflict of interest**

Adam Raikes, Lillian Duran, and Sydney Schaefer declare that they have no conflicts of interest relevant to the content of this review.

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**Figure 1.** Study selection PRISMA flowsheet

**Figure 2.** Number of articles by country. Colors are present in a log10 scale. For reference, research groups in the United States contributed 489 articles.