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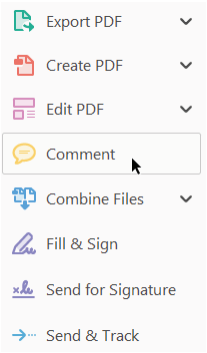

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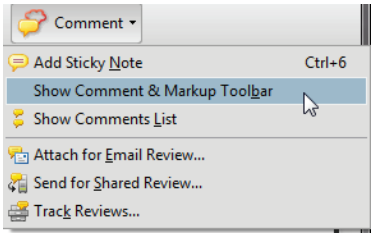

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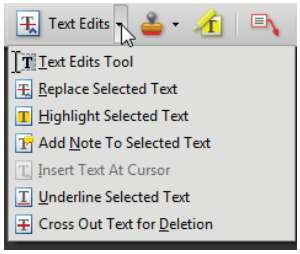

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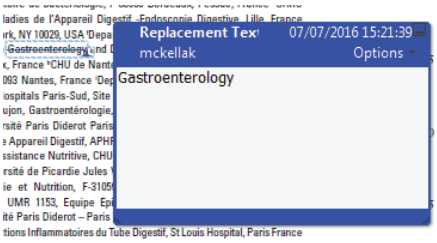

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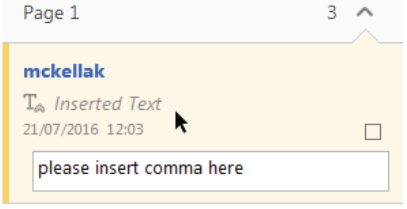

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Role of Native Language in Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) of Youth Athletes

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Abstract

Objective: The aim of this research was to examine the role of native language in the performance of youth athletes on a computerized neuropsychological test battery, the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT).
Method: The study compared the baseline test scores of 5545 participants whose native language was English versus 195 whose native language was not English. The mean age of the participants was 15.06 years.
Results: A multivariate analysis of variance revealed no differences in the five ImPACT Composite scores of the two language groups.
Conclusion: Contrary to prior research, one cannot simply expect that non-native English speakers will do more poorly on ImPACT than native English speakers. Further research on the use of ImPACT with other non-native English-speaking youth athletes is recommended.

Keywords: Native language; ImPACT; Youth athletes

Introduction

An increasing body of medical research and media coverage in the past decade has centered on sports-related concussion, with growing concerns for accurate diagnoses and effective management of sport concussions (Fainaru-Wada & Fainaru, 2013; Lovell, 2009; Moser, 2007). One of the important assessment tools for concussions is neuropsychological testing, which has gained widespread acceptance as a valued approach in the evaluation of the concussed athlete (Echemendia et al., 2013; McCrory et al., 2013). A plethora of studies attests to the usefulness of computer-based neuropsychological test batteries in the sports arena, such as the Automated Neuropsychological Assessment Metrics (ANAM; Reeves, Kane, & Winter, 1995), Cog Sport (Collie et al., 2006), and the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT; Lovell, Collins, Podell, Powell, & Maroon, 2005). Among these test instruments, ImPACT has emerged as one of the most frequently used computerized neuropsychological tools in North America for the assessment of concussion in high school, college and professional sports, with notable advantages, such as ease of administration and cost effectiveness (Lovell, 2006).

Despite its popular usage, ImPACT has been criticized regarding its reliability and validity data (Mayers & Redick, 2012; Randolph, McCrea, & Barr, 2005). Mayers and Redick (2012) expressed their concern that computerized neuropsychological tests, like ImPACT, do not meet the reliability and validity criteria desired for clinical management of concussion, such as return-to-play decisions. On the other hand, Schatz, Kontos, and Elbin (2012) argued that Mayers and Redick presented a limited view of the literature and did not consider reliable change and regression-based measures.

ImPACT was developed and normed in the United States and has been translated into 21 different languages. Nonetheless, reliance on ImPACT norms is compromised by the limited information available as to the potential effect of sociocultural factors, such as socioeconomic levels, ethnicity, and language on ImPACT test scores (Kontos, Elbin, Covassin, & Larson, 2010; Ott, Schatz, Solomon, & Ryan, 2014; Shuttleworth-Edwards, Whitefield-Alexander, Radloff, Taylor, & Lovell, 2009).

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It has long been known that ethnic minority individuals in the United States generally perform more poorly on psychological tests as compared to White Americans (Anastasi & Urbina, 1997; Strauss, Sherman, & Spreen, 2006). Researchers have found that African Americans have lower scores in various neuropsychological test measures, evidently due to reading ability, level of acculturation, and use of "black English" (Baird, Ford, & Podell, 2007; Byrd, Miller, Reilly, Weber, Wall, & Heaton, 2006). Similarly, studies of Hispanic/Latino Americans indicate that Hispanic Americans tend to score lower on psychometric instruments than non-Hispanic Caucasian Americans as a function of bilingualism, level of education, and acculturation (Echemendia & Harris, 2004; Llorente, 2008). Reports of Asian Americans provide further evidence of the negative impact of native language, bilingualism and cultural factors on neuropsychological tests (Fujii, 2011; Wong, Strickland, Fletcher-Jansen, Ardila, & Reynolds, 2000).

While the sociocultural influence on neuropsychological tests is multifactorial, a common thread seen in recent studies involving ImPACT appears to be language. In a study that examined the ImPACT performances of bilingual English-Spanish-speaking U.S. professional baseball players, Jones and colleagues (2014) found that native Spanish-speaking players performed worse on five of the six ImPACT Composite scores (Verbal Memory, Visual Memory, Visual Motor Speed, Reaction Time, and Total Symptom) compared with native English-speaking players. However, when education was considered, the differences in Verbal Memory and Total Symptom became non-significant.

The only reported study of the influence of a second language on ImPACT scores of high school athletes revealed small but significant differences in the ImPACT performance of 9,733 bilingual Hispanic high school athletes compared with 11,955 English-speaking high school athletes (Ott et al., 2014). The authors found that English-speaking athletes outperformed their bilingual Hispanic peers on all ImPACT Composite scores and Total Symptom scores, whether the tests were administered to the Hispanic athletes in English or in Spanish. The findings of Jones et al. and Ott et al. highlight the importance of considering language factors when interpreting ImPACT scores of ethnic minority athletes. More specifically, Ott and her associates expressed caution when comparing the test scores of bilingual athletes with ImPACT normative data that could result in false positive misdiagnoses of post-concussion test scores. Except for these pioneering studies of the impact of language on ImPACT testing, the influence of language on ImPACT test scores has not been adequately explored.

In the ImPACT examination, the athlete submits demographic and descriptive information, such as age, sex, and medical history. The subject also reports one's native language, e.g., English, Spanish, etc. The goal of this study was to fill the gap in our knowledge of the possible effect of native language on ImPACT measures by obtaining baseline test scores of a large sample of Hawaii youth athletes, with a significant portion of participants of varied ethnicity and varied language backgrounds. According to the 2012 U.S. Census, the ethnic composition in Hawaii is uniquely diverse compared to the USA in general, with the following breakdown (with U.S. data in parentheses): Asian 38.6% (5%), White 33.6% (72%), Native Hawaiian/Pacific Islander 10% (0.2%), African American 1.6% (13%), Native American/Alaskan 0.3% (0.9%), and multi-ethnic 23.6% (2.9%) (U.S. Census Bureau, 2012).

The aim of the present study was to compare the neuropsychological test performance of Hawaii high school athletes whose native language is English versus their counterparts whose native language is not English. The cultural and linguistic variety in Hawaii is uniquely different from the continental U.S., offering a valuable opportunity to study the role of language in youth athletes' performance on the ImPACT. Test score differences between individuals from different language backgrounds may suggest that separate norms for non-native English speakers be considered (Boone, Victor, Wen, Razani, & Ponton, 2007; Mindt, Byrd, Saez, & Manly, 2010). Evidence regarding the ImPACT scores of athletes whose native language is English or non-English can guide users of this widely used test instrument, including neuropsychologists, team physicians, and athletic trainers.

Methods

Procedure

A retrospective archival search obtained the baseline ImPACT test scores of a large sample of youth athletes in middle and high schools in Hawaii prior to their respective seasons. The test, which takes about 30 min to complete, was administered in English in small groups of about 20, monitored by certified athletic trainers trained in the standardized administration of the examination.

Instrument

ImPACT is a web-based computerized neuropsychological test battery developed for the assessment of sports-related concussion in youth, collegiate, and professional athletes. ImPACT yields five Composite scores, including Verbal Memory,

Visual Memory, Visual Motor Speed, Reaction Time, and Impulse Control, as well as a Total Symptom score. Testing also includes self-reported demographic and health information, such as age, sex, years of education, native language, sport played, prior concussion, and history of seizures, psychiatric illness, learning disability, attention deficit disorder, psychiatric illness or seizures. A more complete description of ImPACT can be found elsewhere (Lovell, 2006).

Approval for the use of the research data was granted by the State of Hawaii Department of Education. The study was reviewed by the Hawaii Pacific Health Research Institute and was determined to be exempt from institutional review board review.

Participants

An original pool of 6,406 athletes, consisted of 6,194 who indicated in the ImPACT examination that English was their native language, 220 who reported that their native language was other than English, and two who had missing data. From this pool, 486 (7.58%) were excluded from the study because of invalid profiles that were automatically identified by the online ImPACT version that incorporates validity criteria, including the following cut-off scores: Impulse Control > 30, X's and O's-Total Incorrect > 30, Word Memory-Learning Percent Correct < 69, Design Memory-Learning Percent Correct < 50, and Three Letters-Total Letters Correct < 8 (Lovell, 2012). From among the native English speakers, 469 (7.58%) had invalid test profiles, whereas 17 (7.72%) of the non-native English speakers had invalid results. The difference in percent invalid profiles between the two groups was not statistically significant ($\chi^2[1] = 0.006$, $p = .94$). In addition, 114 test profiles were excluded due to athletes who had two ImPACT baseline testings, and 65 were excluded who age-wise were outside the 13–18 year age range of this research. The total number of subjects included in this study was 5,741. Demographic data of the participants are summarized in Table 1.

Statistical Analyses

The age and years of education was analyzed for the two language groups. To assess the role of native language in ImPACT scores, we performed a multivariate analysis of variance (MANOVA) to identify between-group differences, comparing the native English speakers with the non-native English speakers. The dependent variables were the five ImPACT Composite scores (Verbal Memory, Visual Memory, Visual Motor Speed, Reaction Time, and Impulse Control). Of the 5,741 participants, one was excluded due to missing data.

Results

The mean age of the native English speakers was 15.04 ($SD = 1.21$), whereas the mean age of the non-native English speakers was 15.49 ($SD = 1.14$). The difference between the groups was small but statistically significant ($t = 5.06$, $p = .001$).

Table 1. Demographics

All athletes	5,741
Males	3,313
Females	2,428
Mean age	15.06 years (*SD* 1.21)
Race/ethnicity	
Native Hawaiian/Pacific Islander	1,570
Asian American	1,266
Non-Hispanic White American	470
Hispanic American	129
African American	92
Native American/Alaskan	17
Mixed (more than one race)	1,712
English native language	5,545
Non-English native language	195
Filipino	51
Samoan	27
Japanese	23
Spanish	18
Tongan	16
Others	60

The mean years of education for the native English speakers was 9.32 (*SD* =1.43), and the mean years of education for the non-native English speakers was 9.38 (*SD* = 1.81), with an insignificant difference between the two language groups ($t = 0.52$, $p = .60$).

The means and standard deviations of the five ImPACT scores of the native English speakers and non-native English speakers are presented in Table 2. MANOVA results showed no significant effect of native language on any of the ImPACT dependent variables, $V = .002$, F (6, 5733) = 1.47, p = .185. Using Pillai's trace, the effect size was not significant (partial $\eta^2 = .002$). The results indicated that the native English speakers obtained neurocognitive scores that were not statistically different than the scores of the non-native English speakers.

Discussion

This study represents one of the first efforts to examine the baseline test scores of ImPACT of a large ethnically diverse sample of youth athletes whose native language is English and those whose native language is not English. We found no differences in the ImPACT neurocognitive scores (Verbal Memory, Visual Memory, Visual Motor Speed, Reaction Time, and Impulse Control) between athletes in the two language groups. The current findings were similar to those in a prior investigation that focused on the influence of race and ethnicity on ImPACT testing. Kontos and colleagues (2010) compared African American and White high school and collegiate athletes' performance and symptoms on ImPACT, and found that the two groups did not differ on baseline ImPACT Composite scores and Total Symptom scores. They concluded that ImPACT was culturally equivalent for use with these two racial/ethnic groups.

The present findings, however, vary from a recent study by Ott and colleagues (2014) that reported small but significant differences in the ImPACT scores of bilingual Hispanic high school athletes compared with English-speaking high school athletes. Ott et al. noted that, given the large sample size in their study, small between-groups differences can result in statistical significance while reflecting small effect sizes. The disparity between the current results and the Ott et al. study of bilingual Hispanics could be due to differences in language proficiency or reading levels, which are important factors in neuropsychological testing (Echemendia & Harris, 2004), and which were not assessed in either investigation. Our findings suggest that one cannot simply expect, based on prior research, that non-native English speakers will do more poorly on ImPACT than native English speakers. Because the only other studies on this issue are the Ott and colleagues (2014) and Jones et al. (2014) articles, there is a clear need for further research on the language factor in computerized neuropsychological testing of youth athletes.

Although non-native English speakers could be at a disadvantage in responding to standard psychological testing, particularly on tests that are substantially verbal in nature, they may not be handicapped when evaluated with ImPACT, perhaps because of its test content. Verbal Memory aside, the computer-based ImPACT consists largely of visual, non-verbal content, with no demand on overt verbal expression. According to the ImPACT technical manual, a sixth grade reading level is sufficient to respond in a valid manner to test items (Lovell, 2012). The relatively low requirement on verbal proficiency in ImPACT may explain the lack of difference between the two language groups in this research.

Limitations

The limitations of the current study are noteworthy. While the primary focus of this research was the native language of the youth athlete undergoing the ImPACT examination, "native language" was self-reported and not independently verified. Moreover, the available data set did not include "second language" information so that those who listed English as their native language probably included some who were bilingual, as were all the athletes in the non-native English group, which could

Table 2. Means and standard deviations of ImPACT Composite scores of athletes with English and non-English native languages

	English native language (n = 5545)		Non-English native language (n = 195)				
	Mean	*SD*	Mean	*SD*	*F*	*p*	Cohen's *d*
Verbal Memory	82.16	9.96	81.73	9.69	0.35	.56	0.04
Visual Memory	71.84	12.98	71.27	12.96	0.36	.55	0.04
Visual Motor Speed	35.26	7.00	34.15	7.27	4.73	.03	0.16
Reaction Time	0.61	0.09	0.61	0.09	0.00	.99	0.00
Impulse Control	7.59	5.15	7.31	5.42	0.53	.47	0.05

have reduced the ImPACT difference between the two language groups in this study. Caution is advised when interpreting neuropsychological test data, such as ImPACT test scores, for bilingual subjects.

Concerns were indicated with (1) the wide differences in the sample sizes of the two language groups, (2) the potential inter-correlations between ImPACT Composite scores, (3) the age differences and (4) sex differences between the two groups. There were 5,545 athletes in the native English group as compared to the 195 in the non-native English group. The inter-correlations between the five ImPACT Composite scores in this study ranged from negligible (e.g., –.01 between Reaction Time and Impulse Control) to moderate (e.g., .46 between Reaction Time and Visual Motor Speed), which were similar to inter-correlations between Composite scores reported in prior studies (e.g., Maerlender et al., 2010). These statistical concerns were addressed with MANOVA that adjusted for the unequal sample sizes by defaulting in statistical power to the smaller group size (195), and also adjusted for the low to moderate inter-correlations between ImPACT measures. The difference in the mean ages of the native English athletes (15.04) and the non-native English athletes (15.49) was statistically significant, but the very small difference is not considered clinically meaningful. The proportion of males and females in the two groups differed significantly, with proportionately more females in the native English group than in the non-native English group. However, past studies comparing the baseline ImPACT scores of male and female athletes revealed no sex differences (Covassin, Elbin, Harris, Parker, & Kongtos, 2012; Covassin, Schatz, & Swanik, 2007); therefore, the imbalance of males and females in the two groups are not of concern.

The participants in this study consisted of a large convenience sample of youth athletes in Hawaii. Thus, while the findings of this research are notable, they may not be generalizable to ethnic minority athletes in other regions of the country. Finally, this retrospective archival investigation did not include specific sociocultural and educational data, such as socioeconomic status, quality of education, reading proficiency, bilingualism, and acculturation, that could have shed more light on its findings on language effects.

Conclusion

In sum, the present results indicated no difference in the ImPACT Composite scores of youth athletes whose native language was English compared to those whose native language was not English. The findings tentatively suggest that native language is not a significant factor in the ImPACT scores of high school athletes. As such, separate ImPACT baseline norms for non-native English speakers do not appear warranted. However, because of the nascent nature of this investigation of language effects on ImPACT scores and its conflict with prior studies of Spanish-speaking athletes (Jones et al., 2014; Ott et al., 2014), the role of native language in ImPACT remains uncertain. As the growth of the cultural and linguistic diversity of the U.S. population continue, further research on the use of ImPACT with youth athletes with other ethnic minority groups and in other areas of the country is recommended.

Conflict of Interest

The authors have no financial interest in ImPACT Applications, Inc., and declare no conflict of interest in this study.

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