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Influence of Language of Administration on ImPACT Performance by Bilingual Spanish–English College Students

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Abstract

Previous research has suggested that there are performance differences on the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) battery related to language of administration, such that scores are higher with the English than the Spanish version of the battery. This study extended those findings in a within-subjects design, evaluating neurocognitive performance of 58 bilingual English–Spanish-speaking individuals who completed ImPACT in both languages. Results revealed a significant multivariate effect of language of test administration, $p < .01$; partial $\eta^2 = 0.23$, with significantly better English language performance on Verbal Memory and Visual Motor Speed composite scores, but not Visual Memory, Reaction Time, or Total Symptom score. Results are discussed in relation to potential linguistic biases of the ImPACT and functional language dominance that may contribute to the lower scores. These results extend previous findings and suggest a need for separate normative data for Spanish-speaking individuals completing the ImPACT battery if baseline data are not present.

Keywords: Assessment; Cross-cultural; Norms/normative studies

Introduction

The United States has a largely diverse population, with over 60 million people (nearly 19%) who speak a language other than English at home. Of this 60 million, 62% speak Spanish at home. This Spanish-speaking population has grown ~230% from the year 1980 to 2010, increasing by nearly 26 million people (Ryan, 2013). In 2010, it was estimated that 4.2% of Division I NCAA athletes identified as either Hispanic or Latino, increasing from 2.6% in 1990 (Zgonc, 2010). This represents the second largest minority group (to African American, Non-Hispanics) participating in collegiate athletics. However, this number may represent an underestimation of Hispanic athletes in the south and west, as the percentage of Hispanic students attending state universities ranges from 13% (Texas) to as high as 45% (New Mexico) (CollegeBoard, 2014). Given the increasing diversity of both the student and the general U.S. population, neuropsychologists must recognize linguistic and cultural influences that may impact performance on cognitive assessments. Additionally, the limitations of existing measures and norms must be considered when interpreting performance.

The potential for cultural/ethnic and language biases in neuropsychological assessment is well known, although both the sources and solutions remain under debate. In general, results from a variety of studies suggest that group differences between monolinguals and bilinguals appear on language based, but not visuoperceptual or non-verbal tasks (Gasquoine & Gonzalez, 2012; Kranzler, Flores, & Coady, 2010; Mungas, Reed, Haan, & Gonzalez, 2005; Naglieri, Booth, & Winsler, 2004). Studies that fail to replicate this pattern are not difficult to find, however (Kisser, Wendell, Spencer, & Waldstein, 2012; Ott, Schatz, Solomon, & Ryan, 2014).

Bilingualism confers both advantages and disadvantages in cognitive processing. Advantages have been reported for tasks that require response inhibition or similar executive functions. These advantages are generally linked to bilingual individuals' frequent

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need to inhibit responses in one language in favor of the other language. The repeated use of the inhibitory circuits strengthens the efficiency of this process (Adescope, Lavin, Thompson, & Ungerleider, 2010; Gasquoine & Gonzalez, 2012; Mindt et al., 2008).

Disadvantages of bilingualism appear in language-processing tasks, regardless of the language of administration (Festman, Rodriguez-Fornells, & Munte, 2010; Gasquoine & Gonzalez, 2012; Mindt et al., 2008). Even when tested in their dominant language, bilingual individuals tend to perform more poorly on language tasks than monolingual adults. These findings generally persist when educational level and socio-economic status are controlled (Gasquoine & Gonzalez, 2012). Mindt and colleagues (2008) suggest two explanations for this disadvantage. One is competition or interference between languages. While this interference can strengthen the response inhibition processes noted above, it negatively affects performance on language processing. A second explanation is frequency of language use. Individuals who are bilingual must split their language use and processing across two languages, and thus neither one is used as often as the single language of monolinguals. These two phenomena (interference and frequency of use) likely combine to influence performance on any language task, regardless of language of presentation.

There is no easy solution to the problem of how to validly assess and interpret cognitive function in bilingual or non-native speakers because of the multi-faceted nature of the problem. Focusing only on the Spanish–English bilingual population, one must consider the following: first, the population is heterogeneous, including individuals from multiple countries with differing cultural and linguistic backgrounds (including dialects); second, there is no single accepted definition of "bilingual"; third, there is no single accepted measure of language proficiency or dominance; fourth, for each individual, proficiency varies across modalities (listening, speaking, reading, and writing); and fifth, acculturation—the extent to which an individual adopts or accepts aspects of another culture—is difficult to define and measure. These factors can overlap and intersect so that within any group of bilingual individuals there will be a range of language proficiency, dominance, and acculturation.

One option for assessing bilingual individuals is to use assessments that have been carefully translated (and often back-translated: translated back from the second language to the first, to compare with the original). Input from native language speakers or others with extensive knowledge of the language is necessary to ensure appropriate translation (e.g., Artiola i Fortuny et al., 2005). Awareness of culture must also be considered, as some test items that are appropriate for the original population are not appropriate for individuals with a different cultural background or with different knowledge base. For example, the familiarity (and by extension, difficulty) of picture naming items, such as a pretzel, are based on American culture, and such items may be much less familiar (and thus more difficult) to individuals from non-American cultures.

A second option is to develop norms specific for each language translation. However, this is easier said than done, because of the heterogeneity within any language group (Gasquoine & Gonzalez, 2012). The population of adults in the United States who speak Spanish includes non-Hispanics from a variety of countries with different dialects and forms of the language. Additionally, the term "Hispanic" includes individuals from Mexico, Cuba, Puerto Rico, and the Central or South American countries that speak Spanish (U.S. Census Bureau, 2012, http://www.census.gov/population/hispanic). Members of both the Hispanic and non-Hispanic groups represent a range of acculturation.

With the growing proportion of culturally and linguistically diverse college students and athletes, and the increase in identification of, and concerns about, sports-related concussion, there is a need to explore the intersection of these issues. Clinically, this issue is very important as neuropsychologists and members of concussion management teams are assessing an increasing number of individuals with non-American English cultural and linguistic backgrounds. The decision regarding the most appropriate language of administration for bilingual or multilingual athletes is not straightforward.

There are two recent studies that provide some initial insights based on the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT, 2000) battery (ImPACT Applications, Inc., Pittsburgh, PA). In North America, this tool is widely used to assess cognitive function for identification and management of concussion. The battery has been translated into multiple languages. While this allows athletes to take the test in their preferred language, the norms are based on the English version of the test. The validity of using English norms for other translations of the ImPACT has not yet been examined. Jones and colleagues (2013) appropriately caution that computerized testing makes it easy to interpret performance based on the scores generated, without consideration of language and cultural factors that may influence performance.

Jones and colleagues (2013) conducted a retrospective analysis of ImPACT scores from 405 professional U.S. baseball players, one quarter ($N = 101$) of whom reported Spanish as their first language. Of those 101 players, 86% completed the test in Spanish, while the remainder completed it in English. Language of test administration was not considered further; analyses were conducted to compare performance by those who were native Spanish speakers ($N = 101$) to those who were native English speakers ($N = 304$). The results indicated that the native Spanish-speaking group performed significantly worse on all four ImPACT composite scores (Verbal Memory, Visual Memory, Visual Motor Speed, and Reaction Time) compared with the native English-speaking group. Additionally, the symptom score was significantly higher for those in the native Spanish-speaking group. When education was taken into account, some of the differences became non-significant. The group was divided based on highest level of education completed (9–12 years vs. >12). Native Spanish speakers with no more than a high school degree still showed differences compared with English speakers in Visual Memory, Visual Motor Speed, and reaction time. Only the difference in Visual Motor Speed remained significant in the comparison of those with some college-level education. The results suggest that both level of education and native language may influence performance on the ImPACT. The authors hypothesized that familiarity with computers and computerized testing could be a factor in differences between groups.

Ott and colleagues (2014) retrospectively analyzed performance of a large group ($N = 11{,}820$) of bilingual Spanish–English athletes on baseline ImPACT performance. While all of the bilingual athletes reported Spanish as their first language, 80% opted to complete the test in English. Comparison of the scores of those who took the test in English to scores of monolingual English speakers ($N = 11{,}955$) indicated that the monolingual group outperformed the bilingual group on Verbal and Visual Memory, Visual Motor Speed, and Reaction Time. English only speakers also reported fewer symptoms than the bilingual group. The bilingual group was then subdivided based on language of administration. Results indicated the group that completed the test in Spanish performed more poorly on all four composite scores compared with their bilingual peers who took the test in English. Performance differences on the Visual Motor speed and Reaction Time scores had not been expected, because these scores depend primarily on speed of response and not on language processing. The researchers hypothesized that cultural differences may have played a role. In American culture, fast or speeded responses are valued. If the same value is not present in Hispanic cultures, then those individuals may be at a disadvantage on tasks that require fast responses.

Combining findings from these two studies, it appears that there are real performance differences on the ImPACT between groups of athletes based on linguistic background. While the difference in the Verbal Memory composite is consistent with bilingual disadvantages on language tasks, the other differences are more surprising because they appear on tasks that seem to be "culture free:" visual memory, processing speed, and speed of response. Due to the retrospective nature of the studies conducted by Jones and colleagues (2013) and Ott and colleagues (2014), potential influences of acculturation or language proficiency could not be assessed. Additionally, the between-groups design of the studies may have masked important differences in performance.

The current study was designed to extend previous findings by examining performance on English and Spanish versions of the ImPACT using a within-subjects design. An extensive survey was administered to examine the influence of language proficiency and acculturation. College students who were not athletes were recruited for this study in order to obtain information about the language of administration that was not confounded by potential effects of first, past concussions or accumulated sub-concussive blows and second, prior exposure to the ImPACT.

Methods

Participants

Participants were 60 undergraduate students recruited from a university in the southern United States. All participants earned partial credit towards completion of a university class. Demographic, linguistic, and cultural data are provided in Tables 1 and 2. Individuals were excluded from participation if they first, were not bilingual English–Spanish speakers; second, had a

Table 1. Demographic characteristics of the participants

	Number (%)
Age moved to United States	
Born in United States	40 (66%)
0–1 year	2 (3%)
3–5	4 (7%)
6–10	7 (11%)
11–15	7 (11%)
20+	1 (2%)
Region of birth	
South America	5 (8%)
Mexico	15 (25%)
United States/Canada	41 (68%)
Year in school	
Freshman	11 (18%)
Sophomore	13 (21%)
Junior	25 (41%)
Senior	12 (20%)
Self-reported GPA	
Average (*SD*)	3.05 (0.42)
Range	2.0–3.8

Table 2. Language and cultural characteristics of the participants

	English (%)	Spanish (%)	Both (%)
Preferred language spoken at home	26	64	10
Language of instruction			
Elementary school	32	40	27
Middle school	85	7	7
High school	89	2	8
College/university	92	3	5

self-reported history of concussion; or third, had a self-reported history of attention deficit disorder or learning disability. After recruitment and participation, two individuals were excluded from analyses due to obtaining invalid baseline test data (test reports are automatically flagged as "invalid" with the denotation "Baseline ++" using pre-determined validity cut-offs built into the ImPACT test). The resultant sample of 58 individuals was predominantly female (77.6%) and identified Spanish as their first language (70.7%), with an average age of 22 (range 18–34).

Materials

The Internet-based version of the ImPACT battery was used in this study. The ImPACT takes ~25 min to complete and includes a demographic section, symptom inventory, and six subtests measuring attention, memory, processing speed, and reaction time. The demographic section requests information concerning the examinee's age, gender, medical history (e.g., migraines, seizure disorder, psychiatric illness, and substance abuse), educational history (e.g., years of education, presence of learning disability, and diagnosis of attention deficit disorder), and information pertaining to sport (i.e., years played, position). The symptom inventory includes examinee self-report of 22 symptoms using a 7-point Likert-type rating scale (0–6) that when summed, provides an overall symptom score. The six subtests yield composite scores including Verbal Memory, Visual Memory, Visual Motor (processing) Speed, and Reaction Time.

Participants also completed an extensive language questionnaire developed specifically for the purpose of the study. Questions probed age of acquisition of Spanish and English, proficiency in each language (rated on a 1–7 Likert scale) for all modalities (speaking, listening, reading, and writing), number of years of education in each language, and the proportion of English versus Spanish use in their daily life for a variety of activities (overall, at work, at home, watching TV, reading, etc.). Three primary measures were used to characterize proficiency and acculturation: age at which languages were learned, preferred language, and self-rated proficiency in each language.

Procedures

The language questionnaire, initial instructions, and consent forms were presented in English. All participants completed the ImPACT test twice, once in each language (English and Spanish) in back-to-back assessments. The first administration was identified as a "baseline" test, which utilized a pre-determined set of stimuli, whereas the second administration was identified as a "post-concussion" test, utilizing a different set of stimuli. Language of ImPACT presentation was counterbalanced, with half the participants completing the test in English then Spanish, and the other half in Spanish then English. Participants were tested in small groups of up to five individuals at a time, and per recommendations for ImPACT group administration, there was at least one vacant space in between participants. All participants were given a 5 min break between assessments. After the second administration was completed, participants were asked if they noticed any differences between the two versions, and which language version they preferred to complete the test (these questions were added after the study was underway, so responses from only 41 participants were obtained).

Results

The independent variables included language of test administration, order of language presentation, and language use/proficiency in English and Spanish. The ImPACT composite scores (Verbal Memory, Visual Memory, Visual Motor Speed, and Reaction Time) and Total Symptom Scores were the dependent variables.

While 70.7% of participants reported Spanish as their first language, between-groups analyses revealed no significant effect of first language (i.e., English vs. Spanish; $F(5,52) = 0.75$, $p = .59$) on any of the ImPACT composite scores.

Order of administration multivariate analysis of variance (MANOVA) (i.e., English first vs. English second) yielded no statistically significant differences on any of the four English composite scores [$F(4,53) = 0.56, p = .69$] or Spanish composite scores [$F(4,53) = 1.73, p = .16$], and was not considered in further analyses.

A repeated measures MANOVA was performed with language of test administration as the independent variable and the four ImPACT composite scores and the total Symptom Scale scores as the dependent variables. Hotelling's Trace demonstrated a significant effect of language of administration on test performance, $F(5, 52) = 3.05, p = .01, \eta^2 = 0.23$. These multivariate effects were explained by univariate effects of language of test administration on Verbal Memory, $F(1, 57) = 6.64, p = .013, \eta^2 = 0.10$, and Visual Motor Speed, $F(1, 57) = 6.01$ $p = .017$, $\eta^2 = 0.10$, but not Visual Memory, $F(1, 57) = 0.46$, $p = .50$, $\eta^2 = 0.01$, Reaction Time, $F(1, 57) = 0.47$, $p = .50$, $\eta^2 = 0.01$, or Total Symptom Scores, $F(1, 57) = 3.78$, $p = .057$, $\eta^2 = 0.06$. Means and *SDs* are provided in Table 3.

On the language questionnaire, participants rated themselves as quite proficient in both English ($M = 6.43$, $SD = 0.8$, median = 7) and Spanish ($M = 5.95$, $SD = 0.9$, median = 6). Most participants were exposed to Spanish at birth (mean age of exposure = 1.8 years, $SD = 2.2$) and began speaking English around age 5 ($M = 5.5$ years, $SD = 3.4$). With respect to which language was used more often, ~40% of participants reported speaking English more, 8% reported speaking Spanish more, and 52% reported equal use of the two languages. Summarizing the results from the questionnaire, the majority of participants were born in the United States and rated themselves proficient in both languages. Few spoke Spanish more than English in their daily activities. This homogeneity precluded separation into theoretically interesting groups (e.g., those that learned English before age 5 or after age 10) that could be examined in relation to ImPACT performance. On the post-assessment questions, few participants reported any noticeable differences between the two versions. The majority (70%) of the 41 participants who were questioned reported that they preferred taking it in English (25% preferred Spanish, and 5% had no preference).

Discussion

Results from the current study are consistent with the literature on cognitive performance by bilingual adults. Spanish–English bilingual university students achieved higher Verbal Memory and Visual Motor Speed composite scores when they completed the test in English than in Spanish. These performance differences were obtained despite the fact that the majority of the participants reported Spanish as their first language.

Importantly, the recommended use of the ImPACT involves a baseline test, against which post-concussion assessments are compared. When this practice is used, then the practitioner only needs to ensure that the post-test is conducted in the same language as the baseline assessment. However, in those cases when a baseline is not available, then standard practice is to compare an individual's performance with the norms, which are available only for the English version of the test. In this regard, valid interpretations are unlikely when comparing performance on the Spanish language version to English norms.

Several characteristics of the sample are important to consider. Overall, the sample was quite homogenous in terms language proficiency and specific measures of acculturation. First, although 70% of the group was exposed to Spanish first, they also learned English at a young age (26% before age 3; 88% before age 9). Second, all regarded themselves as being quite proficient in both languages [on the 7-point Likert-type scale, none rated themselves as <4 ("functional") in either language, and 57% rated themselves as a 7 ("native-like") in English]. In contrast, only 36% rated themselves "native like" (e.g., a 7) in Spanish, with an additional 30% selecting "very good" (e.g., a 6). Third, most were being educated primarily in English by the time they were in middle school, all of the participants had been admitted to an English-speaking university, and all were using English as their primary (if not only) academic language on a daily basis. In this respect, the lower scores obtained when completing the ImPACT in Spanish are not surprising. These group characteristics highlight a problem with the use of the labels "primary" or "first" language, as these terms are generally interpreted as the language first learned as a child, and typically assumed to be the stronger or dominant

Table 3. ImPACT composite scores by language of test administration

Variable	English	Spanish	p/η^2*
Verbal Memory	90.8 (7.9)	87.8 (9.2)	.013/0.11
Visual Memory	77.5 (12.9)	73.9 (13.9)	.52/0.007
Visual Motor Speed	39.5 (7.0)	38.2 (6.9)	.011/0.11
Reaction Time	0.63 (0.11)	0.64 (0.12)	.53/0.007
Symptom Scale	10.9 (16.6)	12.1 (17.8)	.06/0.06

Notes: Multivariate: $F(5, 52) = 3.05$; $p = .01$, $\eta^2 = 0.23$.
*p-values and η^2 for language comparisons; $df = (1, 57)$.

language. However, as demonstrated by the current group of participants, the language used for educational purposes, and the preferred language for taking the cognitive test was not their first or primary language.

As noted above, there is no agreed upon definition of language dominance. Factors that are generally considered include age of acquisition, frequency of use, and context of use (e.g., at home, in educational settings, at work). The majority of the participants in the current study reported Spanish as their first or primary language, but reported being exposed to English at an early age (the majority before age 5). The bilingual interference effect has been shown to be greater for those who learn the second language prior to age 5 (Ardila et al., 2000).

The specific composite scores that differed (Verbal Memory and Visual Motor Speed) are worth considering. The lower scores for Spanish Verbal Memory are consistent with findings from a variety of neuropsychological studies and assessment batteries reflecting the bilingual disadvantage for language tasks (Festman et al., 2010; Gasquoine & Gonzalez, 2012; Mindt et al., 2008). Findings from previous studies of bilingual language processing (Costa, Caramazza, & Sebastian-Galles, 2000; Kroll & Stewart, 1994) suggest that interference is greater when the test is presented in the non-dominant language, as the dominant language is more difficult to inhibit. Given the linguistic characteristics of the participants in the current study, the findings likely are a reflection of the participants' preferred and more frequent use of English for academic and testing purposes. Thus, even though Spanish was their first language, they were functionally dominant in English. This could have resulted in the poorer performance on the Spanish language version of the test.

Visual Motor Speed was the one composite score that differed for the college-educated group in the study by Jones and colleagues (2013), and also was the score with the largest effect size obtained by Ott and colleagues (2014). The composite is calculated by combining aspects of performance on interference tasks for the Visual Memory (X's and O's) and the Verbal Memory (three letters) tasks. On the surface the tasks appear to be "culture free" as they do not directly rely on language, but rather reaction time and color and number identification. However, critical to the English–Spanish comparison is the interference task for the verbal memory test: counting backwards from 25. The average number of digits correctly counted is used in the composite. While this task can be done without subvocalization, if the person does say the numbers as s/he checks them off, Spanish speakers are at a distinct disadvantage because the names of the numbers generally have more syllables in Spanish than in English (e.g., 19 = "diez y nueve" [6 syllables] versus "nineteen" [2 syllables]). Results from a variety of studies in the 1980s consistently showed a word-length effect in counting and digit span tasks, in which the length of digit names was negatively correlated with digit spans (see review in Ellis, 1992). In English, the total number of syllables in the digit names 15 through 25 is 25, while in Spanish the digit names add up to 43 syllables. Thus, differential performance on this task may not reflect any cognitive process of interest, but simply may be a result of linguistic bias on the test. A comparison of performance across two languages that had more similar syllabic structure would be one way to test this interpretation. Given this potential bias, performance on the Spanish version cannot validly be compared with English norms; doing so will result in systematic underestimation of performance by Spanish speakers.

There are several other limitations to consider. First, the decision to recruit non-athletes was intended to minimize possible effects of previous concussions as well as exposure to the ImPACT test. However, this may limit the generalizability of the results to athletes, most of who are involved in team sports. It is possible that membership on a team provides benefits such that multicultural/multilingual team members would be more acculturated to American culture than would college students not associated with a similarly tight-knit group. Greater acculturation may lessen the impact of cultural biases on cognitive testing. Second, the majority of participants were female, which may limit the generalization of results to male athletes, who make up a large proportion of the athletes assessed for sports-related concussions. In the bilingual literature, sex is rarely considered as a variable of interest. In the occasional studies in which it has been examined, there has been no effect on language or cognitive performance (e.g., Gold, Kim, Johnson, Kryscio, & Smith, 2013; Jahn et al., 2013). Thus, differential performance on Spanish versus English versions of the ImPACT should not be substantially different for males versus females. The sample size is a third limitation, although even with the relatively small number of participants, results are in agreement with two similar previous works regarding ImPACT performance and language (Jones et al., 2013; Ott et al., 2014). As well, the within-subjects design likely mitigated the potential loss of power relative to the small sample. Finally, the homogeneity of the group in terms of linguistic background and acculturation, as mentioned above, prevented exploration of the potential effects of these factors on ImPACT performance.

The picture emerging from studies of Spanish–English bilinguals suggests that athletes and college-age students score lower on the Spanish version of the ImPACT than the English version. As noted earlier, if an individual has a baseline test on record, then follow-up tests administered in the same language will not be affected by these cross-translation differences. This practice does not address the question of which language version should be used for baseline testing for a bilingual individual. Given the absence of a definition or measure of language dominance, it might be most prudent to administer the ImPACT in the examinee's preferred language (functionally dominant language) for computerized testing.

More broadly, in clinical use of any translated test, close examination of the translated version of the test, and direct comparisons between the complexity of the tasks across languages are needed to identify potential sources of cultural and linguistic biases. In addition to examination of the interference tasks mentioned above, characteristics of the verbal memory task should be analyzed. Specifically for the ImPACT, the Spanish version is a direct translation from the English version such that the words for the verbal memory measures are the same in both versions. It is not known how well the psychometric properties match across languages. It is possible (and fairly likely) that there is a different range of frequency of use and age of acquisition of the words in each language, as well as a difference in numbers of syllables in the words (perro vs. dog; enfermera vs. hospital; musica vs. music). All of these could influence the number of words that a test-taker would be able to recall in the verbal memory task.

One potential solution is to develop language-specific norms for each translated version of the ImPACT. While language-specific norms would not solve all of the problems, they would be a step in the right direction, and take into account word-length and frequency differences. The current practice of using the English language norms as the basis for comparisons regardless of language of administration is not valid and can lead to false positives and incorrect diagnoses of altered cognitive status in Spanish-speaking athletes. While it is not always possible, the recommended practice of obtaining a measure of baseline performance to use as a comparison is even more important for athletes who are bilingual and specifically those who choose to take the test in another language, to eliminate the biases inherent in using English-based norms.

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Conflict of Interest

a. Summer Ott has received honoraria from ImPACT Applications to conduct educational workshops. However, ImPACT Applications, Inc., had no role in the conceptualization of the study, the collection or analysis of the data, the writing of the article, or the decision to submit it for publication. b. Philip Schatz has served as a consultant to ImPACT Applications, Inc., however, ImPACT Applications, Inc., had no role in the conceptualization of the study, the collection or analysis of the data, the writing of the article, or the decision to submit it for publication. c. Margaret Blake, Elizabeth Villanyi and Katia Kazhuro have no relevant conflicts of interest to disclose.

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