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ORIGINAL RESEARCH ARTICLE

Multidimensional effects of acculturation at the construct or index level of seven broad neuropsychological skills

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Abstract

This study explored the effects of four sub-domains of acculturation, or degree of alignment with the culture in which one resides, on seven cognitive processes at an index level using the Short Parallel Assessment of Neuropsychological Status (SPANS). Explorations between acculturation and cognitive testing were previously limited to cohorts in the US, and effects for ethnically-diverse groups in the UK has not been explored. The SPANS was selected due to its wide capability to expound cognitive performance across a host of neuropsychological skills, abilities, both at a subtest and an index level of assessment. A total of 231 ethnically-diverse healthy non-White British people participated. Hierarchical regression analyses revealed that self-reported language acculturation significantly predicted a performance-based test of SPANS linguistic ability, and cultural knowledge uniquely associated with tests of orientation. The proportion of UK lifetime residency also predicted SPANS orientation, linguistic ability, and cognitive flexibility at an index level. Subtest-level correlations revealed that aside from all seven subtests that compose the language index, and one that relates to political leadership, four additional subtests significantly correlated with one or more dimensions of acculturation. These subtests could be characterised as having a strong linguistic working memory component or attention. However, extracted in isolation, these subtests alone limit the interpretation of acculturation, as it is unclear if there are any underlying cognitive processes that may be associated with acculturation. Future directions for SPANS research were also discussed.

Keywords Acculturation · Neuropsychology · Cognitive assessment · Neuropsychological domain · Short Parallel Assessment of Neuropsychological Status · SPANS

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Accurately assessing cognitive abilities within diverse cultural populations is challenging. Problems exist with interpretation of test scores in a cultural context, including low or nil validity of particular tests across cultural groups and poor representation of norms for various ethnic groups (Brickman et al. 2006; Puente 2013). Moreover, some studies have shown that healthy ethnic minorities perform below clinical thresholds across many tests, resulting in misclassification of neurological deficits (Gasquoine 2009). In the UK, ethnic diversity proliferated from nine percent to 13% over a ten-year period (Rees et al. 2012) and this is projected to grow to about 30% in the next 50 years (Rees et al. 2012). This is largely attributed to immigration from various countries, but local ethnic groups within the UK also proliferate (Rees et al. 2012). This represents substantial growth of globalisation, and mass movements of people between countries indicate a need for culturally-competent instruments and practices in clinical settings (Puente 2013).

There are a host of variables that can affect neuropsychological testing, and two of the most common variables investigated in the neuropsychological literature, and well-known to have an effect on cognitive test scores, are age and education. Aging is usually deleterious toward cognitive test scores, and it is common for those with higher educational levels to attain higher scores on tests. While these are relatively well established in the literature, the effects of other sociocultural factors, such as the degree of acculturation on cognitive testing have not received as much attention (Acevedo et al. 2007; Arentoft et al. 2012; Arnold et al. 1994; Kemmotsu et al. 2013; Kennepohl et al. 2004; Krch et al. 2015; Manly et al. 1998, 2004; Nielsen et al. 2012a, b; Nielsen and Jørgensen 2013; Nielsen and Waldemar 2016; O'Bryant et al. 2004; Razani et al. 2007a, b; Saez et al. 2014; Simpao et al. 2005).

Acculturation is said to occur when people subsume intrinsic or overt traits of a foreign culture into their own cultural systems, usually a result from prolonged contact with the cultural group that is different from one's own. Acculturation is typically conceptualised as involving two dimensions: 'acculturation' is an individual's degree of immersion or assimilation toward the dominant culture, whereas enculturation involves the degree to which an individual maintains their native culture (Arends-Tóth and Van de Vijver 2006; Celenk and Van de Vijver 2014). Acculturation is also multidimensional, and is typically assessed across several domains (Arends-Tóth and Van de Vijver 2006; Matsudaira 2006). Many measures of acculturation usually include attitudes, behaviours, and the level of socio-cultural competency across 'life' domains such as language, social affiliation, food preference, media, and cultural knowledge. It is for these reasons that acculturation should be assessed across a number of life domains or dimensions (Arends-Tóth and Van de Vijver 2006). A single indicator of acculturation, such as language use, or the length of residency in a host country typically seen in the literature, cannot fully represent the multifaceted nature of acculturation (Arends-Tóth and Van de Vijver 2006; Matsudaira 2006).

In relation to cognitive testing, Helms (1992) proposed a cultural perspective that hypothesised an association between higher levels of acculturation with higher scores on cognitive assessment. Helms (1992) described tests as being implicitly biased toward Western cultures, and therefore to inadvertently measure this acculturative process, which is the degree one has acculturated to Western cultures. For example, people from different cultures might not necessarily find that test-based constructs like 'processing speed' hold relevance in their indigenous culture, and differences in emphasis on speed and time vigilance may directly or indirectly affect test performances (Ardila 2005). Studies have found that higher levels of acculturation were associated with better performance on timed procedures, as purported by many tests of processing speed. These include the Trail Making Test (TMT), Symbol Digit Modalities Test (SDMT), Wechsler Assessment of Intelligence Scale-III (WAIS-III) Digit Symbol Coding, WAIS-III Letter Number Sequencing, and WAIS-III Symbol Search (Arentoft et al. 2012; Razani et al. 2007a; Kennepohl et al. 2004). Acculturation also positively associated with other types of tests, especially measures that involve semantic knowledge and verbal expression. These include the Wechsler Abbreviated Scale of Intelligence-Revised (WASI-R) Verbal Comprehension Index (VCI), WASI-R Vocabulary subtest, WAIS-III Digit Span, and Controlled Word Association Test (COWAT) (Acevedo et al. 2007; Arentoft et al. 2012; Razani et al. 2007b; Nielsen et al. 2012a, b). Similar results were also observed for some nonverbal tests like the Wisconsin Card Sorting Task (WCST), and WAIS-III Block Design (Kennepohl et al. 2004; Krch et al. 2015). It is common for many of these studies to use hierarchical methods to evaluate the unique contribution of acculturation. Age and education are usually treated as covariates, and these are known to simultaneously affect cognitive performance, as well as acculturation (Cheung et al. 2011; Khawaja et al. 2016). These evidences seem to suggest that higher levels of acculturation uniquely account for better performance across a host of neuropsychological measures.

Acculturation as a construct is also not confined to theoretical interest, but can have real-life practical implications. It has been suggested that acculturative levels should be routinely assessed to reduce extraneous confounds and account for systematic or chance differences when testing ethnic minorities, and that these need to be a known quantity (Acevedo et al. 2007; Arentoft et al. 2012; Razani et al. 2007a). Still others consider acculturation should be used as a normative variable, worthy of a place in test manuals, equal in relevance to norming variables such as age and education (Harris et al. 2013; Razani et al. 2007a). Support for this position is evident in studies like Manly et al. (1998), who found performance differences between HIV + Black and White Americans across multiple tests were eliminated when acculturation was controlled for as a covariate. This illustrates the practical value of acculturation, which can be used to improve the vital sensitivity and accuracy of tests to detect abnormal functioning when it indeed exists.

Studies of acculturation are most prolific with South American and African American samples, but other ethnic groups, especially ethnically-diverse populations, have received much less attention. Only two studies reported that a modified version of the Acculturation Rating Scale for Mexican Americans (ARSMA) was associated with several tests of attention, and WASI-R VCI subtests for a multi-ethnic group in America (Razani et al. 2007a, b). Beyond the US, only a handful of studies were found to investigate the effects of acculturation on test performance. Nielsen and colleagues have conducted several studies with Turkish immigrants in Denmark; acculturation positively correlated with the Mini-Mental Status Exam (MMSE), semantic fluency, and a clock reading tests (Nielsen et al. 2012a, b;

Nielsen and Waldemar 2016). Nonetheless, the effects of acculturation on test performances, beyond ethnic minorities in the US, have not been sufficiently explored. To our knowledge, there has not been any published study investigating the effects of acculturation on cognitive testing for ethnically diverse samples in the UK.

Most studies of acculturation also adopt a flexible battery approach, limiting their analysis to a subtest level, rather than using more reliable and valid co-normed fixed batteries (Russell 2012). As a result, the Short Parallel Assessment of Neuropsychological Status (SPANS) (Burgess 2014) was selected as a suitable instrument for purposes of this study. Furthermore, due to an absence of acculturative studies on cognitive measures in the UK, the SPANS provides a wide coverage of neuropsychological skills which can reveal which aspects of neuropsychological skill or function are most affected by various elements of acculturation in the UK. Acculturation can be further evaluated at a subtest level, as well as a domain level of assessment, as the SPANS it consists of 33 co-normed subtests, divided into seven cognitive indexes. These include various assessments of memory, visuospatial-motor processing, cognitive flexibility, and attention, which were co-normed to assess for a broad observation of skills simultaneously. In summary, this study is aimed to explore the multifaceted effects of UK acculturation, across a broad spectrum of neuropsychological skills, on an ethnically-diverse group of individuals with varying sociocultural backgrounds.

Method

Participants

This study adopted the following inclusion criteria: (a) currently residing in the UK, (b) sufficient mastery of English language to understand test instructions and give consent, (c) above 18 years of age, (d) any level of education, and (e) any ethnic minority that were non-White/Caucasian-British European ethnicity. Exclusion criteria included: (a) neurological or health conditions (head injury, disability, psychiatric illness, etc.) that may affect cognitive functioning or ability to manipulate test materials, (b) anyone who only ethnically identified as belonging to a UK majority group (i.e., European British, White English), or native English speaking Caucasians from Western countries (i.e. Australia, US, New Zealand). A total of 231 participants satisfied the inclusion and exclusion criteria, and a majority resided in the East Midlands area. These included a mixture of international students, foreign or immigrant workers, and local British nationals.

Table 1 shows the means, median, interquartile range, and standard deviations for all demographic variables of the participants. The age ranged between 18 and 50 years, with an average of 25.77 years (SD = 7.32), with 149 females and 82 males. The total mean years of UK residency was 10.86 years (SD = 9.79). The total years of education had a mean of 16.79 years (SD = 3.03). Non-UK education was on average 8.63 years (SD = 7.36), the mean years of UK based education was 7.85 years (SD = 6.60), and 11 participants had not received any UK education. As many participants reported relatively high levels of education,

Table 1 Mean, median, interquartile range and standard deviations for age, years of residency, and education

	Median	Interquartile range	Mean	SD
Age	24	11	27.89	7.68
Years of residency	6	17	10.30	10.44
Total education	16	3	17.25	3.29
UK education	5	13	6.96	6.39
Non-UK education	10	15	10.16	7.10

educational attainment was also recorded, and these included: secondary education (i.e., GSCE 'A' level or equivalent) (n = 104), graduate degree (n = 59), and post-graduate degree (n = 70). Sixty-eight participants were working adults, while the remainder were still in education. All participants received at least 1 year of formal education taught in English. None of the participants indicated they had difficulty with test instructions, and were able to understand ethical procedures to give consent.

Ethnicity and nationality were assessed by self-identification by the participants. There were a total of 97 local British nationals, covering 11 ethnicities. These were African (n = 14), Afro-Caribbean (n = 8), Arab (n = 1), Bangladeshi (n = 6), Chinese (n = 30), Filipino (n = 3), Indians (n = 15), Pakistani (n = 7), Sri Lankan (n = 1), Turks (n = 2), and 10 who were of mixed ethnicity.

The remaining participants were nationals from 35 different countries. These were Albania (n = 1), Algeria (n = 1), Austria (n = 1, Nigerian), Azerbaijan (n = 1), Bulgaria (n = 1), Canada (Nigerian and Japanese), China (n = 14, Hong Kong, n = 14), Colombia (n = 1), Cyprus (n = 2), Greece (n = 1), India (n = 3), Indonesia (n = 15), Iraq (n = 4), Italy (n = 5), Jamaica (n = 1), Jordan (n = 1), Kazakhstan (n = 1), Korean (n = 2), Libya (n = 4), Malaysia (n = 11), Mexico (n = 2), Nigeria (n = 5), Pakistan (n = 3), Poland (n = 1), Portugal (n = 1, African), Qatar (n = 1), Saudi Arabia (n = 1), Singapore (n = 4), Sudan (n = 1), Syria (n = 2), Taiwan (n = 1), Thailand (n = 11), Turkey (n = 8), United Arab Emirates (n = 2), Zambia (n = 1), and Zimbabwe (n = 1).

Acculturation measure

To our knowledge, there is no acculturation scale developed in the UK with the ability to segregate acculturative sub-domains. In addition, few have been validated against a single multi-ethnic group. However, the Asian American Multidimensional Acculturation Scale (AAMAS) (Chung et al. 2004) seemed a questionnaire consistent with the aims of this study. Where appropriate the term 'British' or 'culture' was added into response items. The total scale consist of 15 items, and used a 7-point Likert scale. Table 2 shows examples comparing the original scale and a modified one for this study. Outlined below are each of these acculturative subscale domains and internal reliabilities for this study.

Table 2 Examples below compare one item per domain of the adapted and original versions of the AAMAS

Adapted for this study	Original AAMAS
1. How well do you speak the language of	1. How well do you speak the language of
a. Your own cultural origin?	a. Your own Asian cultural origin?
b. English?	b. English?
5. How much do you like the food of	5. How much do you like the food of
a. Your own cultural origin?	a. Your own Asian cultural origin?
b. White mainstream British groups?	b. White mainstream groups?
7. How knowledgeable are you about the history of	7. How knowledgeable are you about the history of
a. Your own cultural origin?	a. Your own Asian cultural origin?
b. White British mainstream culture?	b. White mainstream groups?
10. How much do you identify with	10. How much do you identify with
a. Your own cultural origin?	a. Your own Asian cultural origin?
b. White British mainstream groups?	b. White mainstream groups?

Language acculturation

Three items on this subscale ask participants how well they perceive they speak, understand, read, and write English. The internal reliability of this subscale was high ($\alpha = 0.95$).

Food consumption

Two items ask how often they eat, and how much they like food from the mainstream White British culture. The reliability of this subscale was high for acculturation ($\alpha = 0.82$).

Cultural knowledge

These items ask how knowledgeable they are with the traditions, history, and their level of involvement with practices of mainstream White British groups. It also assesses preferences for the local media, such as movies and music. The internal reliability for this subscale was satisfactory ($\alpha = 0.76$).

Cultural identity

A total of six items ask participants how much they identify, associate, and feel proud being part of mainstream White British group. Internal reliabilities for cultural identity was also satisfactory ($\alpha = 0.80$).

Cognitive measure

The SPANS has seven cognitive indexes or constructs including, the Orientation index (ORI), Attention concentration index (ACI), Language index (LAI), Memory and learning index (MLI), Visuo-motor performance index (VPI), Cognitive flexibility index (CFI), and Efficiency index (ECI). These indexes show good convergent validity in accordance with theoretical expectations when compared with the TMT, WAIS-III VIQ, WAIS-III PIQ, Wechsler Memory Scale-III Immediate and Delayed Auditory Indexes, and the Rey-Osterrieth Complex Figure Test (ROCFT) (Burgess 2014). Reliability and validity coefficients for individual SPANS index scores below are those reported in the manual based on English-speaking, Western samples (Burgess 2014).

ORI

Items regarding time and place orientation were not used, as there was little chance participants would be disoriented to these facts. Items about injury conditions were also not used, as all participants were healthy. Two questions about political leadership and one about time estimation were used, as the former were previously assessed to be culturally loaded. Therefore the ORI in this study comprised only these three questions. Internal reliability was high for this index, $\alpha = 0.80$.

ACI

This index consists of multiple aspects of attention, including working memory, sustained attention, divided attention, and inhibition. Tests include digit span, monetary calculations, and counting backwards. Sustained attention is measured by asking individuals to respond to a target letter while ignoring distractors. Divided attention requires participants to ignore distractors and the previous rule on the sustained attention subtest. The reported internal reliability was high, $\alpha = 0.82$.

LAI

This assesses both verbal and written expressions of language, and these are of course written in the English language. Tests include a naming task, repeating sentences, reading, and writing sentences. One subtest requires individuals to explain how two items are similar to one another, and another asked them to follow spoken instructions and point to pictures of common shapes. Finally, one subtest required them to respond to questions in a yes/no dichotomy. Internal consistency for the LAI was also high, $\alpha = 0.84$.

MLI

This measures verbal and visual aspects of encoding, retrieval, and consolidation. There are a total of six subtests, where participants are asked to recall words or figures that were previously learnt. The MLI also has high internal reliability, $\alpha = 0.89$.

VPI

There are eight subtests in this index which combines visuospatial and motor functioning. Tests include copying figures, recognising emotions on facial expression, letter number coding, object and figure recognition. Other tests involve spatial location decisions, and a three-and-one subtest involving simultaneous formation of multiple concepts based on visual stimuli. Internal reliability was reported at $\alpha = 0.85$.

ECI

All subtests on this index are timed or rely on quick reaction time, therefore measures visual, auditory, numerical, and motor processing speeds. Tests from previous indexes are used for this construct, and this includes divided attention, counting backwards, monetary calculations, spatial decisions, and letter number coding. This index achieved a high internal consistency, $\alpha = 0.83$.

CFI

There are only two subtests on this index, which are the three-and-one concept and word similarities. This assesses concept formation, and conceptual flexibility of both visual and verbal material. This index also had satisfactory internal reliability, $\alpha = 0.70$.

Procedure

All procedures and protocols were approved by the ethics committee from the University of Leicester. Personal identifiers were not used or published, thus ensuring anonymity and privacy for all participants. Data were kept securely under lock and key, or stored in encrypted terminals within the University. Recruitment was undertaken by circulating posters, emails, and face-to-face advertisement of the study. This was conducted both within the University, and other social organizations such as local churches around Leicestershire. These attempts were made in order to achieve larger variance in the data, and to enable the result to be generalizable to a wider population. After written informed consent was given to partake in the study, the SPANS was administered, and participants were asked to fill in all self-report questionnaires afterwards. The total time spent was roughly an hour long, and participants were compensated for their involvement.

Analysis

All analyses were conducted using SPSS v24. All SPANS data were assessed for skewness and outliers, but raw scores were used for all regressive models, as this form of analysis is relatively tolerant of violations such as normality. Assumptions for regression analysis, such as VIF tolerances, normality of the error distribution, and leverage points were scrutinized post hoc. To further prevent issues of multicollinearity, inter-correlations between all variables were inspected. Years of non-UK and UK education were highly correlated ($r = 0.85$, $p < 0.01$), and years of UK residency were also highly correlated with UK education ($r = 0.87$, $p < 0.01$). Therefore, a proportion of UK lifetime residency was calculated, by dividing total years of UK residency with age. This would represent total years of residency, as well as years of UK education.

Educational attainment was used instead due to the highly skewed reporting of years of education in our sample. However, educational attainment correlated strongly with age ($rho = 0.85$, $p < 0.01$), and previous normative studies on the SPANS reveal that age has an overall higher level of correlation compared to education (Burgess 2014). Nonetheless, to prevent multicollinearity age was retained for the model instead of educational attainment. All analyses adopted alpha levels of 0.01 instead of the usual 0.05, to correct for multiple comparisons to balance between the risks of Type 1 or Type 2 errors. A priori analysis using G-power estimated that a sample size of 148 was required to detect a medium effect size with 80% power, for eight predictor variables with a p value of 0.01.

Results

Acculturation and demographic variables

Table 3 indicates that proportion of UK lifetime residency positively correlated with all aspects of acculturation. Cultural knowledge ($r = 0.57$, $p > 0.01$) and language acculturation ($r = 0.62$, $p < 0.01$) received the highest correlation with UK lifetime residency. These two acculturative dimensions also exhibited a strong correlation ($r = 0.62$, $p > 0.01$) with each other.

Table 3 Correlations between domains of acculturation and age, education, and residency

	1	2	3	4	5	6
1. Age	–					
2. UK lifetime residency	−0.32**	–				
3. Language Acculturation	−0.45**	0.62**	–			
4. Food Acculturation	−0.13*	0.34**	0.32**	–		
5. Cultural knowledge	−0.24**	0.57**	0.62**	0.49**	–	
6. Cultural identity	−0.20**	0.39**	0.42**	0.58**	0.52**	–

*$p < 0.05$; **$p < 0.01$

Table 4 Descriptive statistics of all SPANS indexes and their distributions

	Mean	SD	Skewness	Kurtosis
ORI[a]	3.44	0.78	−1.16	0.3
ACI	41.88	2.92	−0.68	0.14
LAI	45.97	4.75	−0.62	−0.39
MLI	61.57	3.01	−0.70	0.67
VPI	64.19	2.63	−1.26	2.96
ECI	45.12	2.68	−1.25	1.70
CFI	25.60	2.03	−0.74	−0.19

[a]The Orientation index (ORI) for this study consists of 2 items index. The maximum scores for each index are as follows, *ACI* Attention concentration index, 46, *LAI* Language index, 53, *MLI* Memory and learning index, 67, *VPI* Visuo-motor index, 70, *ECI* Efficiency index, 48, *CFI* Cognitive flexibility index, 28

Table 5 A summary of the two-staged hierarchical analysis and coefficients of demographic variables and domains of acculturation on the SPANS

	SPANS							
	ORI		ACI		LAI		MLI	
	β	R^2	β	R^2	β	R^2	β	R^2
Stage 1		0.01		0.03		0.14*		0.01
Age	−0.01		−0.19*		−0.38*		−0.12	
Gender	0.11		0.71		0.05		0.01	
Stage 2		0.28*		0.06		0.51*		0.04
Age	−0.16		−0.12		−0.09		−0.08	
UK lifetime residency	0.38*		0.07		0.33*		0.05	
Gender	0.09		−0.08		0.09		0.01	
Language	−0.06		0.16		0.33*		0.03	
Food consumption	0.64		0.03		0.08		0.02	
Cultural knowledge	0.32*		0.02		0.11		0.12	
Cultural identity	−0.14		−0.04		−0.13		−0.15	

ORI Orientation index, *ACI* Attention concentration index, *LAI* Language index, *MLI* Memory and learning index

*$p < 0.01$

Acculturation and SPANS

A two-stage hierarchical regression was conducted for each SPANS index. Demographic variables known to affect cognitive testing were entered at the first stage, and this included age and gender. Language acculturation, cultural knowledge, food preference, ethnic identity, and the proportion of UK residence was entered at the second stage. Table 4 shows the means and distribution of each SPANS index scores, scores for all SPANS indexes were negatively skewed.

Table 6 Continuation for the hierarchical analysis for SPANS and acculturation

	SPANS					
	VPI		ECI		CFI	
	β	R^2	β	R^2	β	R^2
Stage 1		0.05*		0.04*		0.02
Age	−0.20*		−0.18*		−0.13	
Gender	0.05		0.15		−0.02	
Stage 2		0.06		0.12		0.11*
Age	−0.17		−0.16		−0.02	
UK life time residency	0.07		0.06		0.28*	
Gender	0.05		0.16		−0.01	
Language	0.06		0.06		0.09	
Food consumption	0.12		0.07		0.09	
Cultural knowledge	−0.08		0.04		−0.02	
Cultural identity	−0.09		0.01		−0.13	

VPI Visuo-motor performance index, *ECI* Efficiency index, *CFI* Cognitive flexibility index

*$p < 0.01$

Tables 5 and 6 show the unstandardized coefficients and ΔR^2 for both stages of the hierarchical regression. At stage one of the analysis, the model was significant for the LAI (F (2, 228) = 18.04, $p < 0.01$), VPI (F (2, 228) = 5.45, $p = 0.005$), and ECI (F (2228) = 4.97, $p = 0.008$). At this stage, age significantly predicted the LAI (B = −0.25, SE = 0.04, $p < 0.01$), VPI (B = −0.7, SE = 0.02, p = 0.004), and ECI (B = −0.06, SE = 0.03, $p = 0.008$).

The model at the second stage of analysis accounted for performance on the ORI (F (7, 223) = 12.27, $p < 0.01$), LAI (F (5, 223) = 37.01, $p < 0.01$), and the CFI (F (7, 223) = 4.09, $p < 0.01$). At this stage, UK residency predicted the ORI (B = 0.07, SE = 0.01, $p < 0.01$), LAI (B = 0.38, SE = 0.24, $p < 0.01$) and the CFI (B = 0.14, SE = 0.04, $p = 0.001$). Cultural knowledge predicted the ORI (B = 0.19, SE = 0.05, $p < 0.01$). Language acculturation predicted performance on the LAI (B = 1.49, SE = 0.21, $p < 0.01$).

SPANS subtests and acculturation

Table 7 shows Spearman's rho correlation table between acculturation and 22 subtests of the SPANS. None of the subtests from the VPI showed any significant relationship with acculturation, this was therefore not further reported upon. All subtests of the LAI showed significant correlations with various domains of acculturation. Aside from LAI subtests, the remainder of the SPANS showed that Political leadership, Digit Span forwards, Counting Backwards, Sustained Attention 1, and List Learning subtests had significant positive correlations with at least one domain of acculturation.

Table 7 Correlations between domains of acculturation and subtests of the SPANS

	Acculturation			
	Language	Food consumption	Cultural knowledge	Cultural identity
ORI				
Political leadership	0.29**	0.21**	0.45**	0.17**
Time estimation	0.07	0.09	0.10	0.04
ACI				
Digit span forward	0.18**	0.06	0.09	0.03
Digit span backward	0.05	0.11	0.05	0.15*
Sustain attention 1	0.25**	0.07	0.11	0.08
Sustain attention 2	0.06	0.13*	0.06	0.05
Counting backward	0.22**	0.13	0.19**	0.16*
Money calculation	0.06	0.13*	0.06	0.05
LAI				
Repetition	0.69**	0.26**	0.51**	0.26**
Naming	0.50**	0.25**	0.41**	0.25**
Yes/no	0.41**	0.14*	0.38**	0.19**
Follow directions	0.21**	0.13	0.20**	0.09
Reading	0.52**	0.28**	0.34**	0.29**
Writing sentences	0.50**	0.19**	0.34**	0.24**
Similarities	0.26**	0.13*	0.21**	0.05
MLI				
Object recall	−0.09	0.00	−0.06	−0.04
Figure recall	−0.04	−0.05	0.05	−0.01
List learning	0.22**	0.11	0.19**	−0.01
List recall	0.08	0.04	0.09	0.06
List recognition	0.08	0.08	0.04	−0.09
Symbol learning	0.08	0.06	0.07	0.03
ECI				
Sustain attention 2	0.06	0.13*	0.06	0.05
Spatial decision	−0.01	−0.04	−0.03	0.01
Letter number coding	0.05	0.1	0.02	−0.01
Counting backwards	0.25**	0.07	0.11	0.08
Money calculations	0.07	−0.01	0.03	0.01
CFI				
Similarities	0.26**	0.13*	0.21**	0.05
3 and 1 concept	0.11	0.06	0.03	0.09

ORI Orientation index, *ACI* Attention concentration index, *LAI* Language index, *MLI* Memory and learning index, *ECI* Efficiency index, *CFI* Cognitive flexibility index

**$p < 0.01$; *$p < 0.05$

Discussion

This study set out to explore the multidimensional effects of acculturation on several neuropsychological domains represented by the SPANS. Language acculturation, cultural knowledge, and the proportion of UK lifetime residency predicted three cognitive performances at an index level of assessment while controlling for the effects of age and gender. In our study, language acculturation was assessed in terms of proficiency (i.e., how well participants spoke, understood, and wrote English), and this being the case, it should not be surprising to find an association between language acculturation and the LAI. Studies have demonstrated how subjective measures of language dominance positively correlated with objective tests of picture naming, fluency, and comprehension (Marian et al. 2007; Sheng et al. 2014). These findings were consistent with this study, supporting the notion that subjective ratings of language proficiency predict performance on a co-normed set of performance-based language subtests. The proportion of UK residency also predicted the LAI, this could be reflective of language competency acquired via everyday exposure to the cultural milieu, or in combination with UK-based education.

What was more interesting was the lack of an association between language acculturation with the remainder of the SPANS indexes. Some participants in this study were non-native English speakers, and all with varying levels of English proficiencies. It might be reasonable to suspect that those with lower levels of English ability may find it more difficult to be tested in their non-native language. Native English speakers have been found to outperform non-native English speakers and bilinguals on a variety of tests of attention (Boone et al. 2007; Razani et al. 2007a; Lu and Bigler 2000). However, the current findings seem to be in conjunction with previous works on the SPANS, where general English competency measured by historical factors, only had bearing on a co-normed index level of language assessment (Burgess 2014; Haddesley 2016).

For the ORI, it is reasonable to expect that those who have lived in the UK for longer periods may experience a larger exposure to the local media and eventually become more interested in, or aware at least, of that country's political situation. These can also be considered as culturally specific pieces of information (i.e. knowing names of UK prime ministers), which might explain how cultural knowledge on the AAMAS is associated with the ORI. The proportion of UK residency also predicted the CFI. Those with more years of UK residency were more likely to have better English proficiency, either through UK based education or general cultural exposure; and this could have provided an advantage on the verbal component of the CFI. Experimental studies have also shown how different cultures adopt different strategies when categorising objects (Nisbett and Masuda 2003; Nisbett et al. 2001). Perhaps those with more years of UK residency learnt new skills or strategies which benefited test performances of cognitive flexibility. Although years of residency correlated with many aspects of acculturation, only this variable survived the regression analyses for the CFI. It appears that time spent in the UK is more salient influencing style or levels of cognitive flexibility than any component part of acculturation. Alternatively, there could be some other cultural elements captured by years of UK residency that is not reflected on the AAMAS.

At a sub-test level, language acculturation and cultural knowledge generally had a slightly stronger correlation with the SPANS compared to other domains of acculturation. Our analysis also revealed that these two domains were quite strongly correlated with each other. It is reasonable to suspect that higher levels of language proficiency may facilitate the acquisition of culturally specific knowledge (Khawaja et al. 2016). In any case, these acculturative domains appear to be more salient for cognitive testing at a subtest level. Aside from the LAI, five subtests were found to be related to at least one sub-domain of acculturation. These subtests relate to knowing the current and past history of political leadership in the UK, or are associated with high linguistic demands in working memory, attention, and immediate recall.

Both SPANS subtests, Sustained Attention 1 and 2, were similar in construction, both require familiarity with the English alphabet. However, only Sustained Attention 1 correlated with language acculturation. As for Digit Span, studies have found an association between language and acculturation on this test (Acevedo et al. 2007; Razani et al. 2007a; Mattys et al. 2017). Native English speakers are known to outperform non-native speakers on these tests (Boone et al. 2007; Razani et al. 2007a); participants here could have mentally translated these digits into their native language before verbally translating them into English. This process of covert translation added working memory load, which could have impacted test performance (Elliott 1991; Haddesley 2016). These associations however did not occur for subtests that immediately followed (i.e., Digit Span Backwards, and Monetary Calculations). Participants may have adopted a more optimal strategy for these subsequent tests, perhaps discontinuing covert translations, thus attenuating the relationship with acculturation. Alternatively, learning maths can also be conceptualised as a culturally bound phenomenon related to education (Frade and Faria 2008; Woodrow 1984), which might explain the relationship between acculturation and the Counting Backwards subtest. The lack of association between the Monetary Calculation subtest and acculturation however, could be due to how money has been described as a relatively universal concept (Frade and Faria 2008).

Many verbal and visual memory tasks, such as the Brief Memory Visuospatial Test, and the California Verbal Learning Test have not shown any association with acculturative measures (Kemmotsu et al. 2013; Manly et al. 2004; Saez et al. 2014). To date, no study has shown any significant effects for acculturation on delayed recall. This suggests that recalling previously learnt information is unlikely to be a culturally-bound process, but a neuroanatomically universal one. Kennepohl et al. (2004) demonstrated that acculturation predicted immediate recall on the Rey Auditory Verbal Learning Test (RAVLT). Such results were somewhat consistent with the results of this study, where correlations were limited to SPANS grocery list learning and language acculturation. Participants may know what the items are on the list, but those with better language proficiency may be more familiar with the English names for those items, resulting in a quicker rate of learning. Components involved in learning new information could be affected by aspects of language, familiarity, or culture. Despite this, acculturation does not have any bearing on a single index score of co-normed tests of visual and verbal memory, suggesting the memory items of the SPANS are not overly culturally-loaded for our participants.

One caveat of these interpretations, is that when these subtests were extracted from their index score, it became less clear exactly what about these subtests related to acculturation, whether it be random error, a non-cognitive third variable, or a cognitive skill that none of the SPANS domains adequately assess. For example Counting Backwards on the SPANS can be conceptualised as an attention index (ACI), or a speed processing index (ECI).

Likewise, the TMT is purported to measure a conglomerate of neuropsychological functions, such as attention, visual scanning, cognitive flexibility, inhibition, psycho-motor processing speed, executive function, and working memory (Spreen and Strauss 1991; Lezak et al. 2004). Therefore, investigating the effects of acculturation at a subtest level limits clarity of which skill or skills accounted for test scores, or whether a non-cognitive third variable influenced the scores, which makes it unclear if there are any underlying cognitive processes that might be related to acculturation. Overall, our study did not find acculturation to be an exclusive predictor of attention, processing speed, memory, or cognitive flexibility at an index level of assessment, which relied on several co-normed subtests reliably measuring the same construct.

Lastly, statistically non-significant results for the VPI with acculturation seemed to be in agreement with the extant literature. Several measures of visuospatial ability, such as the Ruff Figural Fluency test, ROCFT, and visuoconstruction tests showed no associations with acculturation (Acevedo et al. 2007; Nielsen and Jørgensen 2013; Saez et al. 2014). This also extended to abstract visual reasoning tests, like the WASI-R Matrix Reasoning subtest, and visuo-motor coordination such as the Grooved Pegboard Test (Arentoft et al. 2012; Kennepohl et al. Manly et al. 1998; Razani et al. 2007b). Nielsen and Jørgensen (2013) also did not find any correlations between errors on a number of visuoconstruction tasks and acculturation for Turkish immigrants. In our study, acculturation did not bear any relationship across a range of visuo-motor and visuospatial subtests, and its corresponding index level of assessment.

Limitations and future direction

Many participants here were relatively young and highly educated, which might have attenuated some of our results. Despite these limitations, two acculturative dimensions and years of UK residency still predicted three cognitive indexes, suggesting that there is some cultural variability in our sample. Initially, data were collected with the intention to differentiate between education within and outside the UK, as well as the effects of educational attainment on testing. However, due to multicollinearity, these variables could not be assessed independently. Nonetheless, prospective studies should explore the effects of lower levels of education, and more varied age groups on the SPANS. Studies can also employ more complex methods to explore whether the quality of education has any bearing on the SPANS. For instance Lam et al. (2013) formulated a statistical method, using various pathways of education as a means of assessing the quality of education.

The other limitation could be more specific to the construction and foundations of the SPANS itself. As the SPANS was designed to achieved sensitivity and specificity to neurological impairment (Attwood 2013), it provides the function of measuring a crucial level of cognitive skills for clinical purposes, but does not cover the whole range of intellectual ability. Healthy individuals should find the items difficult but not exceptionally so, and expected to achieve near-to-maximum points on most subtests. However, past studies using tests such as the MMSE, with its single composite score of mostly simple and linguistically-loaded items, found sociocultural influence on testing (Nielsen et al. 2012a; Simpao et al. 2005). On non-linguistic items on the SPANS, the current study may be limited by the restrictive variance of scores, a possible explanation for non-significant results. It was possible that ethnically-diverse participants in this study could have performed similarly to normative samples in the SPANS manual. As such, scores were expected to be negatively skewed just like the existing normative sample, which indeed was supported by our study.

It might be possible that the ethnic composition was too heterogeneous in this study. Cognitive performance or acculturative variables may be biased toward a particular ethnic group, and in this case Asians (East, and South East Asians) made up a majority of the sample. Therefore the results of this study may not fully generalise to ethnic groups that are underrepresented in our sample. Future studies on the SPANS may consider the impact of specific ethnic group memberships on the SPANS.

Conclusions

To the authors' knowledge, this is the first study investigating the relationship between acculturation and cognitive performances in the UK. Many past studies limited their analysis of acculturation to a single subtest or test, and only a handful of studies utilised fixed neuropsychological batteries to measure cognitive indexes. These make it difficult to discern which neuropsychological constructs were related to acculturation, or indeed if correlations were related to a wholly non-cognitive or non-neuropsychological variable. This study on the other hand incorporated a test battery that was reliable in assessing cognitive constructs at the index level, using multiple co-normed subtests that each predominantly rely upon the same cognitive skill or ability, or construct, for success or failure on that item. Overall, our results limited acculturation to language proficiency for linguistic ability, and cultural knowledge for tests of orientation, in our sample of educated, ethnically diverse group of healthy individuals. Years of residency also predicted three cognitive indexes, and this variable may be sensitive to cultural aspects pertinent to neuropsychological testing that may not be reflected by measures of acculturation. Although our data suggests that there is some amount of cultural variability, our results could have been skewed by highly educated and majority English-proficient participants. Future studies that recruit ethnic groups with more varied levels of education, age, or language characteristics may find more aspects of cognition being affected by culture. Prospective studies may also explore the effects of other cultural constructs like enculturation, acculturative stress, or language factors (i.e. English as a first language vs. second language, etc.) on cognitive testing or the SPANS.

Compliance with ethical standards

Conflict of interest Gerald H. Burgess is the author and creator of the SPANS. To our knowledge, there are no other conflicts of interests.

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