Aging, Culture and Cognitive Training: Exploring the Use of a Novel EEG-Based Brain Computer Interface Intervention in Two Language Groups of an Asian Elderly Population

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Abstract

With the extant greying of the global population, dementia is a pressing issue. Cognitive Training (CT) for the elderly is one promising avenue for delaying or even preventing cognitive decline. However, CT research has been conducted mostly on Western populations even though studies have increasingly highlighted the role of culture in influencing cognitive processes. In exploratory studies, our team developed a novel, personalized Brain-Computer Interface CT intervention which showed preliminary efficacy in improving memory and attention in two pilot samples of healthy Singaporean Chinese elderly—one English-speaking, and the second, Chinese-speaking.

The studies were two-arm, randomized, waitlist-controlled trials. Participants underwent 8 weeks of training (30-minute sessions, thrice a week) and efficacy was measured using the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS).

Pooled data between both arms showed that English-speaking participants improved post-training in the domains of Immediate Memory, Delayed Memory, Attention and Visuospatial/Construction while the Chinese-speaking participants improved only in Delayed Memory and Attention. While the Intervention arms improved in RBANS total scores relative to Waitlist-Control arms in both studies, this was significant only in the Chinese study. Participants from both studies gave positive feedback for usability and acceptability, though Chinese-speaking participants raised more concerns about safety. Our intervention appears to have a stronger and more targeted efficacy signal in the Chinese-speaking sample and a trial on a larger cohort is currently underway. In this paper, we delve further in the findings of these studies and discuss the implications of culture and language on CT research.

ABBREVIATIONS

CT: Cognitive Training; BCI: Brain Computer Interface; SLAS: Singapore Longitudinal Aging Study; MMSE: Mini-Mental State Examination; RBANS: Repeatable Battery for the Assessment of Neuropsychological Status; SD: Standard Deviation; AE: Adverse Events; SAE: Serious Adverse Events

INTRODUCTION

By 2050, the number of individuals aged 60 and above is expected to reach nearly 2 billion, comprising 20% of the world's population [1]. By that year, the number of people with dementia is expected to more than triple from the current estimates of 35.6 million to 115.4 million [2]. With no pharmacological cure for dementia yet available or on the horizon, researchers have increasingly intensified their focus on exploring interventions that can delay or even prevent cognitive decline.

Cognitive Training (CT) is one promising avenue for such exploration. Growing evidence suggests that late-life cognitive...
activities, independent of early life experiences like education, can reduce the risk of dementia by 40-50% [3]. In addition, meta-analyses have demonstrated the beneficial effects of CT for elderly in varying states of cognitive health—the healthy [4-6], individuals with mild cognitive impairment [7,8], and patients with Alzheimer’s disease [9]. There is also evidence that CT can improve functional outcomes, with participants showing less decline in activities of daily living up to five and even ten years after the initial intervention [10,11].

However, the bulk of research has been conducted on Western participants. Although Chinese is the most commonly spoken language in the world [12], a literature review yielded only five independent studies examining the efficacy of CT programs in elderly samples in Shanghai [13], Beijing [1-4] and Hong Kong [15-17]. Yet recent cross-cultural research highlights the pervasive influences that culture has on cognition. Imaging studies have shown significant differences between Westerners and Asians in an array of both low- and high-level cognitive processes. These include perceptual processing, attentional modulation, language and music processing, number representation, mental calculation, emotional processes and attribution—even at the neural level [18]. To ensure that CT benefits the maximum proportion of the world’s aging population in a culturally equivalent manner, it is thus vital to develop CT interventions that are potentially universal, and to examine their efficacy in subjects of different cultural backgrounds.

In 2010, our team developed a novel Brain-Computer Interface (BCI) CT intervention that offered personalized training with real-time feedback, paired with language-independent tasks. BCI is a technology that allows direct communication between a computer and the neural activity of the brain. Our attention-based system consists of a simple headband with two dry electrodes, situated at the FP1, FP2 positions, that record a user’s EEG. The headband communicates with a computer via Bluetooth. Before training, the user undergoes a calibration task that allows the system to build up an individualized model of his/her attentional state. This model is then used to drive subsequent training, in which users have to practice focusing their attention in order to progress through training tasks. In pilot studies, our intervention showed promise in reducing the inattentive symptoms of children with attention deficit hyperactivity disorder [19,20].

In 2013, our team examined the feasibility of pairing this attention-based system with a non-verbal memory game for improving cognition in healthy elderly. Several studies have previously linked attention with memory [21-23]. Awh termed attention the “gatekeeper” of working memory, postulating that attention biases the encoding of information towards items that are most relevant to processing goals [24]. Gazzaley presented evidence that impaired selective attention processes in aging underlie much of the working memory deficits experienced by the elderly [25].

As such, we aimed to determine the usability, acceptability, safety and preliminary efficacy of our intervention in two successive pilot groups of healthy Singaporean Chinese elderly: one predominantly English-speaking, and the other, Chinese-speaking. Singapore is a multicultural and multiethnic city-state of 5.4 million people, though the most common ethnic group is Chinese (74.2%) [26]. English and Chinese are the most commonly used languages, and English is the official language used in government communications. While most citizens are bilingual to a certain extent, many are predominantly proficient in one language, with the younger generation tending to prefer English and the elderly generation, non-English languages [27]. Proficiency in English is also generally associated with higher educational attainment among the Singaporean Chinese, especially for the elderly population [27]. For Chinese-language speakers, Mandarin is the official dialect in Singapore, China and Taiwan and the one used in our study.

While the detailed results of these studies have been separately published [28,29], we intend in the current paper to surface the subtle but prominent role that culture plays in CT research, via an incisive comparison and discussion of our findings.

MATERIALS AND METHODS

Study design

The studies were two-arm, randomized, waitlist-controlled trials, with the two arms being Intervention and Waitlist-Control. Study procedures were identical for the English and Chinese studies except where stated.

Recruitment and randomization

Potential participants were recruited mainly from the Singapore Longitudinal Aging Study (SLAS), a large-scale cohort study of elders in Singapore [30,31], and secondarily by word-of-mouth from recruited subjects, who gave our contact details to interested friends and family members. The inclusion criteria were: Chinese ethnicity, aged 60-70 years, Geriatric Depression Scale (GDS) total score of ≤9, Mini-Mental State Examination (MMSE) total score of ≥26, global Clinical Dementia Rating (CDR) rating score of 0-0.5, able to travel to study site independently, undiagnosed with any neuropsychiatric disorders, and not involved in other clinical research trials at the time of participation (apart from the SLAS). Participants had to be literate in and identify the respective languages as their first language in order to be eligible for the studies.

Participants were randomized into either the Intervention or Waitlist-Control arm via a password-protected internet-based randomization program. Randomization was done in a 1:1 allocation ratio, stratified by education level. Blocking was used in the randomization process. The block length was determined by a biostatistician but was not revealed to the research team as per ICH E9 guidelines.

Calibration

Calibration consists of a series of Stroop tasks, interspersed with rest periods of up to 7 seconds each. Using the EEG recorded during the Stroop tasks and rest periods as representations of a user’s attentive and inattentive states respectively, the system builds up a personalized model of the user’s attentional state. An attention score ranging from 0 (low attention) to 100 (high attention) is then computed and displayed on-screen during training as real-time feedback.

Procedure

Participants underwent 24 sessions of training over 8 weeks (3 times a week), with each session lasting 30 minutes. The Intervention arm underwent training from Weeks 1 to 8, while...
the Waitlist-Control arm did so from Weeks 9 to 16. There were two study sites: Duke-NUS Graduate Medical School, and TaRA@JP (Training and Research Academy at Jurong Point). Participants could choose their preferred study site, and most participants underwent all training and assessment sessions at a single site.

During training, participants played a card-pairing memory game, in which they had to sustain their attention in order to open or close the cards onscreen. Training is graduated, with participants progressing to the next difficulty level (determined by number of cards onscreen) only if they completed their current level within a certain number of attempts. Training difficulty is thus customized to the individual, with users being constantly presented with difficulty levels that are sufficiently challenging and yet not overly insurmountable.

Outcome measures

A usability and acceptability questionnaire [adapted from [32]] was administered to participants after their last training session (Table 1). Participants rated how strongly they agreed with each item on a scale of 1 (Strongly Disagree) to 7 (Strongly Agree).

Safety was assessed by querying participants whether they experienced any discomfort after every training session. If participants responded in the affirmative, the research assistant completed a standard Adverse Event (AE) form.

Our primary efficacy outcome measure was the total scale index score of the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). RBANS is a brief clinical neuropsychological testing battery developed specifically for characterizing dementia in the elderly [33]. It assesses five subdomains of cognitive function—Immediate Memory, Language, Attention, Visuospatial/Construction, and Delayed Memory [33]—and comes in four parallel forms.

RBANS was administered at Week 1, Weeks 8/9, and Week 16. To minimize practice effects, forms were counterbalanced.

Table 1: Mean and median responses to items in the usability and acceptability questionnaire.

<table>
<thead>
<tr>
<th>Questionnaire item</th>
<th>English Study</th>
<th>Chinese Study</th>
<th>Combined data from both studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Overall, I am satisfied with how easy it is to use this device</td>
<td>Mean (SD): 6.4 (0.8)</td>
<td>Mean (SD): 6.7 (0.7)</td>
<td>Mean (SD): 6.55 (0.74)</td>
</tr>
<tr>
<td></td>
<td>Median (Range): 7 (4–7)</td>
<td>Median (Range): 7 (4-7)</td>
<td>Median (Range): 7.00 (4-7)</td>
</tr>
<tr>
<td>2. I feel comfortable using this device</td>
<td>Mean (SD): 6.4 (0.7)</td>
<td>Mean (SD): 6.4 (0.7)</td>
<td>Mean (SD): 6.39 (0.69)</td>
</tr>
<tr>
<td></td>
<td>Median (Range): 6 (5-7)</td>
<td>Median (Range): 7 (5-7)</td>
<td>Median (Range): 6.50 (5-7)</td>
</tr>
<tr>
<td>3. I enjoyed playing the game</td>
<td>Mean (SD): 6.8 (0.5)</td>
<td>Mean (SD): 6.7 (0.7)</td>
<td>Mean (SD): 6.74 (0.60)</td>
</tr>
<tr>
<td></td>
<td>Median (Range): 7 (5-7)</td>
<td>Median (Range): 7 (4-7)</td>
<td>Median (Range): 7.00 (4-7)</td>
</tr>
<tr>
<td>4. I think the device is useful in training my memory and attention</td>
<td>Mean (SD): 6.6 (0.8)</td>
<td>Mean (SD): 6.6 (0.8)</td>
<td>Mean (SD): 6.60 (0.76)</td>
</tr>
<tr>
<td></td>
<td>Median (Range): 7 (4-7)</td>
<td>Median (Range): 7(4-7)</td>
<td>Median (Range): 7.00 (4-7)</td>
</tr>
<tr>
<td>5. I will recommend this device to my friends and family</td>
<td>Mean (SD): 6.5 (0.8)</td>
<td>Mean (SD): 6.5 (0.8)</td>
<td>Mean (SD): 6.55 (0.78)</td>
</tr>
<tr>
<td></td>
<td>Median (Range): 7 (4-7)</td>
<td>Median (Range): 7(4-7)</td>
<td>Median (Range): 7.00 (4-7)</td>
</tr>
<tr>
<td>6. Overall, I am satisfied with the interface of the game</td>
<td>Mean (SD): 6.5 (0.6)</td>
<td>Mean (SD): 6.6 (0.8)</td>
<td>Mean (SD): 6.58 (0.71)</td>
</tr>
<tr>
<td></td>
<td>Median (Range): 7 (5-7)</td>
<td>Median (Range): 7(3-7)</td>
<td>Median (Range): 7.00 (3-7)</td>
</tr>
<tr>
<td>7. Overall I am satisfied with the whole system</td>
<td>Mean (SD): 6.5 (0.7)</td>
<td>Mean (SD): 6.6 (0.7)</td>
<td>Mean (SD): 6.58 (0.69)</td>
</tr>
<tr>
<td></td>
<td>Median (Range): 7 (5-7)</td>
<td>Median (Range): 7(4-7)</td>
<td>Median (Range): 7.00 (4-7)</td>
</tr>
</tbody>
</table>

Abbreviation: SD: Standard deviation

RESULTS AND DISCUSSION

Participants

For the English study, 35 participants were randomized, and 31 (15 in Intervention, 16 in Waitlist-Control) contributed information to the primary efficacy and acceptability analysis. For the Chinese study, 39 participants were randomized, and 36 (20 in Intervention, 16 in Waitlist-Control) contributed information to the primary efficacy and acceptability analysis (see CONSORT flow-charts, Figures 1 and 2).

The mean age of participants was 65.1 (SD=2.9) years for the English study (60% female) and 65.2 (SD=2.8) for the Chinese study (69% female). The mean MMSE total scores were 28.3 (SD=1.3) and 27.6 (SD=1.6) for the English and Chinese studies, respectively.
respectively, with mean scores similar across arms.

While 57.1% of participants had an educational attainment of twelfth grade or below for the English study, the corresponding percentage was 84.6% for the Chinese study. Though 80.0% of participants self-reported to be familiar with computers in the English study, only 51.3% of participants in the Chinese self-reported the same.

**PRIMARY OUTCOME MEASURES**

**Usability and acceptability**

The mean and median responses of participants to the usability and acceptability questionnaire are presented in Table 1.

**Safety**

No AEs or SAEs were reported by participants in the English study. No SAE was reported for the Chinese study. However, 10 out of 33 (30.3%) participants reported a total of 16 AEs over the course of the study (Table 2). All AEs were given the lowest severity grading of 1 (Mild), except for one of “Others—Eye strain, tearing”, which was given a severity grading of 2 (Moderate) by trained research assistants.

**RBANS total scale index score**

In both studies, the Intervention arm showed higher change scores between Weeks 1 and 8, relative to their corresponding Waitlist-Control group (Table 3), though this was statistically significant only for the Chinese study. The Hodges-Lehmann estimate of the median difference in the change scores between arms was 7.0 (95% CI: -4.0 to 15.0; p=0.332) for the English study, and 8.0 (95% CI: 0.0 to 16.0, p=0.042) for the Chinese study.

**SECONDARY OUTCOME MEASURES**

**Change in RBANS subdomain scores**

For the English study, the Hodges-Lehmann estimate of the

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**Figure 1** CONSORT Flow chart for English Study.
Table 2: Summary of Adverse Events for the Chinese study.

<table>
<thead>
<tr>
<th>Type of AE reported</th>
<th>Number of subjects (%)</th>
<th>Number of events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue</td>
<td>3 (9.1)</td>
<td>3</td>
</tr>
<tr>
<td>Headache</td>
<td>4 (12.1)</td>
<td>5</td>
</tr>
<tr>
<td>Others</td>
<td>2 (6.1)</td>
<td>3*</td>
</tr>
<tr>
<td>Syncope/Dizziness</td>
<td>4 (12.1)</td>
<td>5</td>
</tr>
</tbody>
</table>

*The 3 events reported were: “discomfort in the head but not headache” from 1 subject, and 2 reports of “eye pain, tearing” from another subject. Abbreviation: AE: Adverse event

The median differences between arms in the change scores (from Weeks 1 to 8) for the five subdomains ranged from 0.5 to 9.5, suggesting an improvement in each of the subdomains for the Intervention group. However, none of the differences were statistically significant.

For the Chinese study, the intervention arm showed improvements in the Immediate Memory, Visuospatial/Constructional, Attention and Delayed Memory subdomains of the modified RBANS as reported by the Hodges-Lehmann estimate of median differences of pre- and post-training score changes between arms. However, the difference in the Delayed Memory subdomain was the only one to reach statistical significance, with the associated Hodges-Lehmann estimate of the median difference being 8.0 (95% CI: 0.0 to 17.0, p=0.042).

**Pooled analysis**

When data was pooled from both arms, the median of the changes in total RBANS index score pre- and post-training was 4.0 (95% CI: -9.0 to 28.0; p<0.001) for the English study and 8.0 (95% CI: 0.0 to 16.0, p=0.042) for the Chinese study, which were both statistically significant. For the English study, pre- and post-training improvements in all five subdomains, except for Language, were statistically significant. For the Chinese study, only the subdomain scores of Delayed Memory (Mdn=1.5, (-12 to 34) (p=0.008)) and Attention (Mdn=0.0 (-19 to 24) (p=0.039)) showed statistically significant improvement.
Table 3: A comparison of change in RBANS Domain and Total Scale Index Scores between Week 1 and Week 8 for Intervention and Waitlist-Control arms for both studies.

<table>
<thead>
<tr>
<th></th>
<th>English Study</th>
<th>Chinese Study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention</td>
<td>Wait-list</td>
</tr>
<tr>
<td><strong>RBANS Domain Index Scores</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate Memory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>8.3 (18.4)</td>
<td>-1.8 (17.2)</td>
</tr>
<tr>
<td>Median (range)</td>
<td>6.0 (-17 - 44)</td>
<td>-3.0 (-33 - 40)</td>
</tr>
<tr>
<td>Visuospatial/Constructional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>4.1 (12.3)</td>
<td>3.5 (15.4)</td>
</tr>
<tr>
<td>Median (range)</td>
<td>4.0 (-13 - 32)</td>
<td>1.5 (-21 - 37)</td>
</tr>
<tr>
<td>Language</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>0.1 (21.6)</td>
<td>-1.4 (20.7)</td>
</tr>
<tr>
<td>Median (range)</td>
<td>-4.0 (-30 - 42)</td>
<td>0.0 (-36 - 38)</td>
</tr>
<tr>
<td>Attention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>4.1 (12.2)</td>
<td>3.0 (13.5)</td>
</tr>
<tr>
<td>Median (range)</td>
<td>6.0 (-27 - 25)</td>
<td>1.5 (-29 - 31)</td>
</tr>
<tr>
<td>Delayed Memory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>6.5 (11.2)</td>
<td>2.1 (11.3)</td>
</tr>
<tr>
<td>Median (range)</td>
<td>4.0 (-7 - 37)</td>
<td>0.0 (-24 - 22)</td>
</tr>
<tr>
<td>RBANS Total Scale Index Score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>7.6 (11.4)</td>
<td>1.2 (11.3)</td>
</tr>
<tr>
<td>Median (range)</td>
<td>3.00 (-6 – 28)</td>
<td>2.0 (-18 - 19)</td>
</tr>
</tbody>
</table>

<sup>1</sup> P-value from the Mann-Whitney U test
<sup>2</sup> Hodges-Lehmann estimation and its associated 95% confidence interval

Abbreviations: RBANS: Repeatable Battery for the Assessment of Neuropsychological Status; SD: Standard Deviation; CI: Confidence Interval

**DISCUSSION**

The demographics of our participants yielded two notable contrasts: firstly, the Chinese-speaking participants were generally less well-educated than the English-speaking participants, and secondly, fewer of them self-reported to be familiar with computers. This underscores the inherent difficulty in teasing apart the influence of culture, language and education, with the usage of a non-English language at home often strongly associated with poorer educational attainment in certain populations. According to Singapore’s 2010 population census [27], 96% of individuals who attained an educational level of twelfth grade and below spoke a non-English language at home, as compared to 51% of individuals who attained a Bachelor’s degree or higher. This relationship between linguistic preference and education likely arose because English is the medium of instruction in schools, with proficiency in the language linked to the length of time spent in the education system. The 2011 U.S. Census Bureau painted a similar picture: 43% of individuals who spoke a non-English language at home attained an educational level of twelfth grade and below, as compared to 18.0% who attained a Bachelor’s degree or higher [35]. This interplay between culture, language and education may underlie many of the differences in our findings for the two studies.

For a start, it could underlie the noticeable difference in the number of AEs reported. While no AEs were reported by the English-speaking participants, 30.3% of the Chinese-speaking participants reported at least 1 AE. Notably, the most frequent AEs reported in the Chinese study were “headache”, “syncope/dizziness” and “fatigue”, symptoms which could reasonably result from a period of sustained attention in front of a computer. We postulate that while the more technology-savvy English-speaking participants may not think these experiences worth flagging, these experiences may be more novel and thus more of a concern to our Chinese-speaking participants, some of whom have, anecdotally, never used a computer prior to the study. Nevertheless, it is encouraging that by the last training
session, feedback from participants on the usability and acceptability questionnaire was generally positive regardless of linguistic group. This suggests that while non-English-speaking participants may eventually grow accustomed to and see benefit in using novel technology-based CT interventions, more time and effort may be required initially to familiarize them and assuage any safety concerns that they might have.

In terms of efficacy, our intervention appears to have a stronger and more targeted impact in the Chinese sample than in the English sample. For the English study, none of the improvements attained by the Intervention group as compared to the Waitlist-Control group were significant, be it for the RBANS total scale index score or the five sub-domain scores. By contrast, the Chinese-speaking Intervention group showed significant improvement as compared to the Waitlist-Control group, for both the RBANS total scale index score as well as the Delayed Memory sub-domain.

Yet when pre- and post-training data were pooled between arms, participants significantly improved in RBANS total scale index scores for both studies, suggesting that while English-speaking participants do benefit from CT as well, this impact is weakened as compared to the Chinese-speaking participants. Another interesting contrast arises from reviewing the pooled results for the five subdomains. In particular, the English-speaking participants showed a more generalized trend of statistically significant improvements in all domains except Language, while the Chinese-speaking participants showed statistically significant improvements only in the targeted domains of attention and delayed memory.

As no equivalence studies have been done between the English RBANS and our culturally-adapted, Chinese-translated RBANS, the raw RBANS scores cannot be compared directly between studies. Nevertheless, we postulate that our intervention may have a weaker impact on the English-speaking sample, due to their higher educational level and presumed pre-training cognitive abilities, leading to a potential ceiling effect. Yet the improvements that they attain generalize to even non-targeted domains—we hypothesize that this could be because the English-speaking participants harnessed a greater variety of strategies to improve their performance, such as by paying greater attention to certain visual elements in the pictorial stimuli, hence leading to incidental gains in domains such as Visuospatial/Construction. This falls in line with current theories about cognitive reserve—commonly defined to include years of education—as involving the ability and flexibility to recruit alternate cognitive strategies and differential brain networks to maximize performance [36,37].

What implications do these findings hold for future research? Firstly, it is noteworthy that these differences in findings have surfaced even though sample sizes were small, participants were of the same ethnicity and nationality despite having different first languages, and the intervention was designed to be language-independent. This suggests that more drastic differences may emerge if larger samples from more distinct ethnic and cultural backgrounds are compared. In addition, while researchers have traditionally considered non-verbal tasks to be more culturally fair, these results caution researchers against assuming homogeneous effects across cultures simply because non-verbal training tasks were used. In support of this notion, there is evidence that performance on non-verbal neuropsychological tests such as drawing maps, listening to tones or copying figures can be significantly influenced by the individual’s culture [38].

Secondly, while the less well-educated may derive a larger magnitude of benefit from CT, their gains may be confined only to the domains that they received training in. This comes with the worrying possibility that lower educational attainment may impede the generalizability of CT gains to longitudinal functional outcomes. It is also unclear whether the impact of culture, education and language changes at different stages of cognitive decline—it is possible that the impact of education gets attenuated with cognitive deterioration, with both language groups showing increasingly similar patterns of results; but it is equally plausible that the effects of cognitive reserve persists even into the late stage of cognitive decline. All of these issues await future research.

For future studies, a new delayed memory training task will be added to strengthen the robustness of our CT. In addition, genetic analyses and fMRI scanning will also be included to examine if CT can lead to observable biological changes. We also plan to delve into a more in-depth exploration of the roles of culture, language and education in CT.

CONCLUSION

In sum, the impact of culture, language and education on CT interventions should not be underestimated. The effects of these three factors are often intimately intertwined, with the usage of a non-English home language often strongly associated with lower educational attainment and preferential identification with the cultural norms associated with one’s preferred language. These factors may have subtle but wide-ranging influences on various aspects of CT interventions, including perceived safety, acceptability, magnitude of efficacy, as well as patterns of cognitive gain. With the bulk of existing CT literature based on a small Western subset of the global aging population, a deeper appreciation of these influences is timely and warranted.

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Conflict of interest

None of the authors have any conflict of interest to declare.

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REFERENCES


