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Effects of early home language environment II: Speech comprehension and cognitive functions*

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People who were mostly exposed to English with an accent in the early home environment are more native-like when performing various English tasks, compared to those who were mostly exposed to their non-English heritage language (Tao & Taft, 2016). The present study extends from the work of Tao and Taft (2016), further exploring the effects of early home language environment on linguistic and cognitive outcomes later in life. Three groups of young adult participants who differed in their early home language environment were examined on speech comprehension and executive function tasks. Results showed that people who were exposed mostly to non-English heritage languages have disadvantages relative to native monolingual speakers in the comprehension of certain types of stimuli, but show advantages in their executive functioning. Those exposed mostly to nonstandard English showed a less robust advantage in executive functions over native speakers, and showed no apparent disadvantage in speech comprehension.

Keywords: speech comprehension, accent comprehension, executive functions, heritage language, bilingualism

People who grew up with parents speaking to them in accented versions of the majority language of a country (ML) perform better in that language than people who instead grew up listening predominantly to their parents' heritage language (HL). Tao and Taft (2016) demonstrate this with regard to vocabulary, pronunciation, and processing of certain types of speech stimuli. Early and extended exposure to accented speech, however, does not appear to enhance the ability to understand foreign accents in general, and may in fact produce a disadvantage when listening to unfamiliar accents (Tao & Taft, 2016). Few studies have examined the long-term effects of early and extended exposure to accented speech. Therefore, the present study aims to further investigate the effects of exposure in the early home environment to either foreign-accented English (the "Nonstandard ML" home environment group) or to non-English HL (the "HL" home environment group) in relation to comprehension of accented and standard English, as well as on other cognitive and linguistic measures.

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Studies do exist that have examined the amount of exposure to accented speech in the home environment, but only to regional rather than foreign accents. Floccia, Butler, Girard, and Goslin (2009) observed that children who had been exposed to greater phonological variability due to their parents having different regional accents performed better on an accent categorization task compared to children who were growing up in a "mono-accentual" environment (i.e., one where both parents spoke with the same regional accent as their surroundings). The impact of long-term exposure to pronunciation variability on a child's perceptual representation of accents was further demonstrated by Durrant, Delle Luche, Cattani, and Floccia (2015), who found that infants whose home linguistic environment matched the surroundings did not accept mispronunciations as adequate exemplars of previously familiarized words. In contrast, those exposed to greater accent variability through their parents' speech performed similarly for both correctly pronounced and mispronounced words, showing greater tolerance for mispronunciations. These findings provide support for the notion that continuous exposure to greater accent variability in the home leads to a general broadening of phonemic categories through boundary relaxation. From an early age, then, perceptual representations for pronunciations seem to be modified by experience or

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exposure (Durrant et al., 2015; Floccia et al., 2009; but see Floccia, Delle Luche, Durrant, Butler & Goslin, 2012). However, the results of Tao and Taft (2016) suggest that these adaptation effects either do not extend into adulthood, or do not generalize to unfamiliar foreign accents.

Other studies on the impact of early language experience have mostly investigated the interference arising from early exposure to one language on the acquisition and development of a second language. For example, studies of the bilingual population in the Spanish region of Catalonia, where participants are exposed to both Catalan and Spanish from an early age, have shown that greater amount of exposure to one language over the other produces better perceptual discrimination of speech sounds in that language for both children (Bosch & Sebastián-Gallés, 2003; Sebastián-Gallés & Bosch, 2009) and adults (Sebastián-Gallés, Echeverría & Bosch, 2005), even when participants are matched on lexical knowledge. In addition, there is greater sensitivity to restrictions in a given language on the permissible combinations of phonemes (i.e., phonotactic constraints) for both children and adults (Sebastián-Gallés & Bosch, 2002). These findings indicate an impact of language exposure in the early home environment on aspects of L1 and L2 performance, both during the developmental period and in the longer term. The present study, like that by Tao and Taft (2016), examined participants whose early language experience might have involved more diverse language exposure due to their parents' backgrounds, but extends beyond the previous studies by distinguishing between those who had been mostly exposed to HL and those who had been mostly exposed to foreign-accented versions of ML.

In the domain of perceptual learning, many studies have shown that listeners can adapt to accented speech, even following only brief training exposures (e.g., Bradlow & Bent, 2008; Clarke & Garrett, 2004; Sidaras, Alexander & Nygaard, 2009; see Cristia, Seidl, Vaughn, Schmale, Bradlow & Floccia, 2012; Samuel & Kraljic, 2009, for reviews). Furthermore, such perceptual learning can generalize to previously untrained stimuli (e.g., Maye, Aslin & Tanenhaus, 2008; Sidaras et al., 2009), and to novel speakers of the same accent (e.g., Bradlow & Bent, 2008; Sidaras et al., 2009). Extended exposure to accented speech, as experienced by those in the Nonstandard ML group, may thus enhance comprehension of accented speech, even for accents with which participants are unfamiliar. However, the results of Tao and Taft (2016) did not show this to be the case. Using a sentence recognition task (where participants transcribed accented nonsense sentences, e.g., "Underneath a highway loses his stated cylinder"), Tao and Taft (2016) found that the Nonstandard ML group, like the HL group, showed a disadvantage on accented speech comprehension, compared to native English monolingual speakers (the "Native ML" group). The present study, therefore, sought to further explore the effects of early and extended exposure to accented speech on the comprehension of unfamiliar foreign accents, using other listening tasks.

In addition to speech comprehension, this study also assessed nonlinguistic cognitive processing, specifically executive functions. The term "executive functions" covers a range of abilities, and there are varying definitions and frameworks of its components. One widely accepted account (Miyake, Friedman, Emerson, Witzki, Howerter & Wager, 2000) identifies three key components, namely inhibitory control, task switching, and updating. The present study focused on the inhibition and switching components. Previous research has shown differences between bilinguals and monolinguals in nonlinguistic cognitive functioning, particularly in the inhibitory control and task switching aspects of executive function (e.g., Bialystok, Craik & Luk, 2008; Carlson & Meltzoff, 2008; Costa, Hernández, Costa-Faidella & Sebastián-Gallés, 2009; Marzecová, Asanowicz, Krivá & Wodniecka, 2012; Tao, Marzecová, Taft, Asanowicz & Wodniecka, 2011; Tao, Taft & Gollan, 2015; see Bialystok, Craik, Green & Gollan, 2009, for a review; but see e.g., Duñabeitia, Hernández, Antón, Macizo, Estévez, Fuentes & Carreiras, 2014; Paap & Greenberg, 2013; Paap, Johnson & Sawi, 2015, for recent counter claims). There is evidence to suggest that the two languages of a bilingual speaker are simultaneously activated when the person uses any one of their languages (e.g., Abutalebi & Green, 2007; Green, 1998; Kroll, Dussias, Bogulski & Valdés Kroff, 2012). Therefore, someone who speaks two languages would constantly need to keep them separate, monitor which is the appropriate language to use, inhibit the other language, and switch when necessary. The argument is then made that enhancement of such processes through continual practice generalizes to other, nonlinguistic, domains of cognitive functioning (Bialystok et al., 2009).

In the present study (as in Tao & Taft, 2016), participants in the HL group were bilingual, which means that they would be expected to show advantages in executive function processes, compared to the Native ML group who were monolingual English speakers. Of most interest is the previously unexamined Nonstandard ML group, who were shown in Tao and Taft (2016) to be mostly monolingual, as they indicated minimal usage of and proficiency in non-English languages. However, although being functionally monolingual, members of the Nonstandard ML group are likely to have been exposed to the non-English languages of their parents and, therefore, have at least some knowledge of a non-English language. As such, they may show differences in cognitive functioning to both the HL and Native ML groups. That is, the Nonstandard ML group may not show the full extent of the bilingual advantage in executive functions as the

HL group, but may still show some advantages over the Native ML group due to their exposure. Some evidence for this possibility comes from Fan, Liberman, Keysar, and Kinzler (2015) who found that children exposed to a multilingual environment, but who were not bilingual, displayed an advantage over monolinguals in perspective taking during communication.

In short, the present study extends from that by Tao and Taft (2016), further exploring the effects of early home language environment on linguistic and cognitive outcomes later in life. Participants in the HL group, due to their experience with a non-English language (i.e., being bilingual), may show disadvantages relative to native monolingual speakers in the comprehension of certain types of English speech stimuli, but show advantages in their executive functioning. Specifically, advantages may be shown in inhibitory control and task switching (as assessed by a variant of the Stroop paradigm), despite possible disadvantages in baseline performance (i.e., baseline color naming and word reading without inhibition or switching). Those in the Nonstandard ML group, on the other hand, being functionally monolingual speakers, but still having had some exposure or experience with a non-English language, may display a less robust advantage in executive functions over native speakers, and less disadvantage in speech comprehension.

Method

Participants

As in the study by Tao and Taft (2016), a language background questionnaire was used to classify participants whose parents were from non-English-speaking backgrounds into two groups based on the nature of their early language exposure. The participants could only be classified using retrospective self-report, whereby they were asked to estimate the average percentage of time they were exposed to non-English HL (as opposed to English) from people at home during the time period from birth to before starting school (i.e., around age 5 or 6). Those who indicated greater than 50% exposure to HL were classified as belonging to the HL home environment group, while those who indicated less than 50% exposure to non-English speech (i.e., greater than 50% exposure to accented English) were classified as belonging to the Nonstandard ML home environment group. Those who reported approximately equal amounts of exposure were excluded (see subsections below for the average and range of exposure percentages for each group).

The background questionnaire further collected information from the HL and Nonstandard ML groups relating to their language experience, so that differences in factors such as age of acquisition, proficiency, and usage could be examined. Participants in these two groups rated their proficiency in English and any other languages that they knew using a 7-point scale (1 = Not at all, 4 = Functional, 7 = Native-like), separately for speaking, understanding speech, reading, and writing. Estimates were also provided for the age of first learning to speak in English, and the amount of daily use of non-English HL (expressed in percentages), if any. Demographic details were collected from all participants to allow any major differences between groups, such as age, gender, and socioeconomic background, to be identified and controlled for. For example, females have been found to outperform males on language tasks such as verbal fluency, verbal learning, and reading comprehension, particularly during childhood, but also to a lesser degree through adulthood (e.g., Burman, Bitan & Booth, 2008; Chiu & McBride-Chang, 2006; Wallentin, 2009). In addition, socioeconomic status has been shown to be positively associated with academic outcomes, including graduation rates and standardized test scores, as well as with aspects of language performance (e.g., Sirin, 2005; Stevens, Lauinger & Neville, 2009).

There were 134 participants, divided into the three groups: HL (n = 55), Nonstandard ML (n = 24)[1], and Native ML (n = 55). Table 1 presents the demographic and language characteristics for each of the three groups. All participants were either born in Australia (where English is the ML) or had arrived at or before the age of 1, and were raised and educated in Australia (i.e., had not spent a total of 1 year or more in another country). None reported having any hearing or speech impairments. The participants were all students undertaking a first-year undergraduate psychology course, recruited via the online participant recruitment system provided by the School of Psychology at the University of New South Wales (UNSW). They received course credit in exchange for participation. As was the case in Tao and Taft (2016), all participants in the HL and Nonstandard ML groups had parents who came from a non-English-speaking background, with each group having a wide range of HLs.

HL group

The HL group consisted of 55 participants who indicated that they had greater than 50% exposure to non-English speech from people at home during the period from birth to before starting school. The average exposure to the HL was 83.7%, ranging from 60% to 100%. Participants in this group were either simultaneous bilinguals or early sequential bilinguals, who had learned to speak the HL first (or at the same time as the ML), but who had become dominant in the ML, with moderate levels of current usage and proficiency in the HL. The language backgrounds included Arabic (n = 2), Bulgarian (1), Chinese languages

[1] Note that participants belonging in the Nonstandard ML group are more difficult to find. The number of Nonstandard ML participants is similar to that of Tao and Taft (2016).

Table 1. *Characteristics of Participant Groups (Standard Deviation in Parentheses)*

	HL	Nonstandard ML	Native ML
Mean age	19.2 (2.7)	20.2 (5.9)	20.1 (3.8)
Age range	17-33	17-47	18-39
Gender (F:M)	41:14	13:11	33:22
Mean age of arrival in Australia	0.03 (0.1)	0.1 (0.2)	0.0 (0.0)
Mean estimated age of learning ML	2.6 (1.6)[#]	1.6 (1.3)	N/A
Mean self-rated spoken ML proficiency[a]	6.8 (0.6)	6.9 (0.3)	N/A
Mean self-rated spoken HL proficiency[a]	4.6 (1.2)[##]	3.1 (1.1)	N/A
Mean estimated % daily use of HL	25.8 (20.4)[##]	5.4 (11.1)	N/A

Note. HL = heritage language. ML = majority language.
[a]1 = Not at all, 2 = Very poor, 3 = Poor, 4 = Functional, 5 = Good, 6 = Very good, 7 = Native-like.
[#]Significant difference between HL and Nonstandard ML groups, $p<.05$.
[##]Significant difference between HL and Nonstandard ML groups, $p<.01$.

(9), Farsi (2), Filipino (3), Greek (3), Indian languages (8), Indigenous Australian languages (1), Indonesian (3), Italian (2), Korean (1), Polish (1), Serbian (1), Spanish (1), Turkish (2), Vietnamese (3), Chinese and Malay (1), and Chinese and Vietnamese (11).

Nonstandard ML group

The Nonstandard ML group consisted of 24 participants who indicated that they had less than 50% exposure to non-English speech from people at home during the period from birth to before starting school, with an average exposure to the HL of 24.3% (i.e., 75.7% exposure to nonstandard English), ranging from 0% to 45%. Anyone who indicated exactly 50% exposure was excluded from this study, as were those in the Nonstandard ML group who reported that the family members they interacted with most during childhood did not have a foreign accent. Participants in the Nonstandard ML group reported minimal usage of the HL, though all but six of the 24 participants in this group (i.e., 75%) reported at least some level of proficiency (i.e., above 1 on the 7-point scale). Nevertheless, the majority of participants (i.e., 75%) indicated a proficiency level of below “functional” (i.e., less than 4 on the 7-point scale) in speaking the HL. Thus, this group as a whole would be at a level below that required for daily functioning or day-to-day communication in an HL, and may therefore be considered functionally monolingual. Language backgrounds in this group included Arabic (n = 2), Chinese languages (3), Finnish (1), Filipino (2), Ghanaian (1), Indian languages (4), Indonesian (1), Italian (2), Japanese (1), New Zealand Maori (1), Serbian (1), Spanish (1), Vietnamese (2), Chinese and Malay (1), and Chinese and Vietnamese (1).

Native ML group

The Native ML group consisted of 55 native monolingual English speakers, whose parents were also native speakers of English. People who had grown up in English-speaking countries other than Australia (i.e., had spent a total of 1 year or more in another country) were not included (as was the case for the other two groups). This is to ensure that participants in this group did not have extended exposure to different types of accents, but instead had relatively uniform experience with one type of English (i.e., Australian English).

Stimuli/materials

Nonverbal Intelligence

In order to compare and control for differences across the three groups on general nonverbal intelligence, participants completed a shortened version of Raven’s Advanced Progressive Matrices Set II (Raven, Raven & Court, 1998) containing 12 items (as was administered in Tao & Taft, 2016). Each item consisted of a 3×3 matrix pattern, with the last figure blank, and with eight possible options to logically complete the pattern. Previous studies have shown differences between bilinguals and monolinguals in nonverbal intelligence, where bilinguals have obtained significantly higher scores (e.g., Marzecová et al., 2012; Tao et al., 2011). Thus, if the bilinguals showed a poorer performance on the language tasks than did the monolinguals, it would be unlikely to be accounted for by nonverbal intelligence. Nevertheless, it is necessary to ensure that differences in language task performance cannot be merely attributed to differences in general intelligence. So, if the groups did differ in performance on the nonverbal intelligence test, the scores could be entered into the analyses as a covariate and, hence, held constant.

Speech comprehension

All of the stimuli were recorded using a Redback C0384 microphone onto a desktop personal computer. Each item (sentence or word) then had the beginning and end trimmed at zero crossings (i.e., trimmed on or as closely as possible to the onset and offset of initial and final speech sounds).

An auditory sentence verification task was used to examine comprehension of both foreign accented and non-foreign-accented speech. This task allows for assessment of the understanding of spoken statements, rather than only the recognition of strings of spoken words, as participants need to understand the sentences as a whole in order to make a response. The task involved an equal number of obviously true (e.g., "Birds have feathers.") and obviously false statements (e.g., "Cats can lay eggs."). The stimuli were taken from the "Silly Sentences" task (Baddeley, Gardner & Grantham-McGregor, 1995; May, Alcock, Robinson & Mwita, 2001), which was adapted from the Speed of Comprehension subtest of the Speed and Capacity of Language Processing (SCOLP) test (Baddeley, Emslie & Nimmo-Smith, 1992). Part 1 of the task involved a set of 20 statements (10 true and 10 false), spoken in different foreign accents. Five speakers, each with a different foreign accent, were recruited to record the sentences. An effort was made to select speakers with uncommon accents that the participants were not likely to be familiar with. The accents were Danish (female), Jamaican (female), Mauritian (female), Russian-Hebrew (male), and Swiss German (male). The speakers were recruited through advertisements in UNSW's weekly International Student Forum newsletter, and received $20 for their time. Part 2 of the task involved another set of 20 statements (10 true and 10 false), spoken in standard Australian English by five native monolingual English speakers (also three female and two male) who were recruited from the student pool undertaking a first year undergraduate psychology course at UNSW. The number of statements was evenly distributed among the five speakers in each part (i.e., four statements per speaker, with two true and two false). There were also six accented practice items (three true and three false), spoken by one speaker of Farsi (Persian) from Iran (female) who was not included as a speaker for any of the test items. As in Tao and Taft (2016), multiple accents and multiple speakers were included to help ensure that any observed advantages in accent comprehension were not due to relative familiarity with any particular accent, but to accented speech in general. Also, having multiple speakers helped to reduce speaker-specific perceptual learning effects, as listeners have been found to learn and apply speaker-specific pronunciation differences in real time speech comprehension (Trude & Brown-Schmidt, 2012).

To further examine processing of accented speech, an accented auditory lexical decision task was also used. The task consisted of 40 words and 40 nonwords, plus 20 practice items (10 words and 10 nonwords). There were equal numbers of monosyllabic and polysyllabic words and nonwords (e.g., "score", "discover", "chusk", "omsify"). Processing of accented speech with single-word utterances is likely to be more difficult than with sentence stimuli, because there are fewer contextual cues to help identify the stimulus and fewer points of exposure within each trial for listeners to adapt to (e.g., Gordon-Salant & Fitzgibbons, 1997; Mattys, Davis, Bradlow & Scott, 2012; Zwitserlood, 1989). The same five accented speakers who produced the sentences for the auditory sentence verification task were asked to record the items in this task. The number of items was evenly distributed among the five speakers (i.e., 16 per speaker, with eight words and eight nonwords). The practice items were spoken by the same speaker who produced the practice sentences for the auditory sentence verification task. Note that the present study did not include a "standard" (i.e., non-accented) part for the lexical decision task, as this was assessed in Tao and Taft (2016) among the same three types of participants.

Executive functions

To assess executive functions, the Trail Making Test (TMT; Reitan, 1992) and the Color-Word Interference Test (CWIT) of the Delis-Kaplan Executive Function System battery (D-KEFS; Delis, Kaplan & Kramer, 2001) were administered (the same two executive function tasks as used in Tao et al., 2015). The TMT focuses on the task switching component of executive functions, and was composed of two parts. Part A involved participants connecting numbered circles on a page, beginning with the number 1 and proceeding in numerical sequence up to 25. Part B also involved connecting circles in sequence, but alternated between numbers and letters (i.e., 1 to A, A to 2, 2 to B, and so on).

The CWIT assesses both inhibition and switching, using the Stroop paradigm originally developed by Stroop (1935), where there is difficulty in naming the color in which a word is printed when that word refers to a color that is incongruent with the color of the print (e.g., participants have difficulty saying "red" in response to the word *blue* printed in red ink). This task consisted of four conditions. The two baseline conditions were Color Naming and Word Reading, which assessed key component skills of the other two higher level tasks, namely basic naming of color patches and basic reading of color words printed in black ink. The third condition, Inhibition, was the traditional Stroop task, in which participants needed to inhibit reading the words in order to name the incongruent ink colors. The final condition was Inhibition/Switching, which required participants to switch unpredictably between naming the incongruent ink colors and reading the words, as indicated by a cue (a box surrounding the word). It has been shown that, by simultaneously requiring both inhibition and cognitive switching, the demands on executive functioning are greater in this condition than in the traditional Stroop Inhibition condition (Fine, Delis, Wetter, Jacobson, Jak, McDonald, Braga, Thal, Salmon & Bondi, 2008).

Procedure

After providing informed consent, participants first completed the language history questionnaire, followed by the nonverbal intelligence test. The two speech comprehension tasks were then administered, following which the participants completed the two executive function tasks[2]. All participants were tested individually in the same sound-attenuated testing room. The study was approved by the UNSW Human Research Ethics Advisory Panel (Psychology).

Nonverbal Intelligence

The nonverbal intelligence test was presented to participants via an online quiz platform, SurveyGizmo. Images from the original paper version were uploaded to SurveyGizmo and set up to have the same layout as the original paper format. Participants indicated their answers by clicking on one of the eight options that appeared below the matrix. A time limit of 10 minutes was imposed to ensure that participants took a standardized amount of time on the task. One point was given for each correct answer, with a maximum total of 12. The total score was used as an index of the person's general nonverbal intelligence.

Speech comprehension

For both tasks, stimuli were presented and responses recorded using DMDX (Forster & Forster, 2003), a Windows-based display program with millisecond timer, on a desktop personal computer. Auditory stimuli were delivered to participants through Sennheiser HD 202 headphones.

When performing the auditory sentence verification task, all participants heard the foreign-accented items first, and then items spoken in Standard Australian English. The order of presentation of the two parts was not counterbalanced in order to prevent any potential practice effects or familiarity with performing this type of listening task impacting accented speech comprehension, which might happen if the standard part was performed beforehand. In addition, it ensured that all participants were equally inexperienced with the task when performing the accented part. Each statement was presented once to participants in a randomized order within each part. The practice items were presented prior to the foreign-accented part. Each item was presented as soon as the participant had responded to the previous one, or after 5 seconds had elapsed with no response. Participants were instructed to respond as quickly but as accurately as they could, by pressing the right Shift key labelled "Yes" for true, and the left Shift key labelled "No" for false. Response times (RTs) and error rates (ERs) of decisions were recorded.

In the accented lexical decision task, all items were presented to participants in a randomized order, preceded by the practice items. Each item was presented once the participant had responded to the previous one or after 3 seconds had elapsed with no response. Participants were instructed to respond as quickly but as accurately as they could, by pressing the right Shift key labelled "Yes" for words, and the left Shift key labelled "No" for nonwords. RTs and ERs of decisions were recorded.

Executive functions

For the TMT, participants were instructed to connect the circles as quickly as possible without making mistakes, while being timed for completion of each part. Mistakes were immediately corrected by the experimenter while the stopwatch was kept running. Completion time in seconds for each part was recorded. A ratio score (TMT-B/TMT-A) was calculated for each participant. The ratio score takes into account the baseline speed of performance in Part A (i.e., without task switching).

Similarly for the CWIT, participants were instructed to complete each condition as quickly but as accurately as possible, with completion time in seconds for each condition being recorded. Three contrast scores were calculated (see Delis et al., 2001): Inhibition Cost (i.e., Inhibition minus Color Naming), combined Inhibition/Switching Cost (i.e., Inhibition/Switching minus the sum of Color Naming and Word Reading), and Switching Cost (i.e., Inhibition/Switching minus Inhibition). The Inhibition Cost reflects the ability to inhibit the automatic tendency to read the written word in order to correctly name incongruent ink colors, while accounting for baseline speed of performance in naming color patches. The combined Inhibition/Switching Cost is a measure of both the ability to inhibit reading the word and to switch between naming colors and reading words, while accounting for baseline speed of performance in both naming color patches and reading words printed in black ink. The Switching Cost measures switching ability between naming incongruent ink colors and reading words, while partialing out inhibition. Differences in performance on the two baseline measures (i.e., Color Naming and Word Reading) were also examined, as these

[2] The participants in this study also completed three additional tasks within the same experimental session, including two that assessed information processing speed and one assessing working memory. Data on these tasks, as well as on the speech processing and executive function tasks, are reported in Tao and Taft (2017), which addressed a research question unrelated to the present study, namely the influence of cognitive processing capacities on speech listening performance. The full lists of stimuli used in the speech processing tasks can be found in the Supplementary Material section of Tao and Taft (2017).

Table 2. *Mean Scores on Outcome Measures for Participant Groups (Standard Deviation in Parentheses)*

	HL	Nonstandard ML	Native ML
Mean parental education (years)	12.8 (3.9)[* * #]	14.8 (3.6)	14.9 (2.5)
Nonverbal intelligence score	7.0 (2.9)	7.5 (2.3)	6.7 (2.2)
Accented sentence verification			
ER true	1.5 (4.1)	1.3 (3.4)	1.1 (3.7)
ER false	2.1 (4.1)	1.8 (4.1)	2.2 (4.2)
RT true	2219.3 (240.9)	2166.0 (129.0)	2170.9 (214.3)
RT false	2194.0 (238.4)	2190.6 (204.5)	2150.2 (230.7)
Standard sentence verification			
ER true	1.2 (3.3)	1.7 (3.8)	1.5 (3.6)
ER false	2.3 (5.1)	1.7 (3.8)	0.9 (3.5)
RT true	1982.0 (242.2)[t]	1916.3 (159.4)	1912.8 (178.5)
RT false	1992.7 (236.5)	1952.7 (153.8)	1948.5 (200.8)
Accented lexical decision			
ER words	8.5 (5.0)[t]	9.2 (6.0)	10.9 (5.2)
ER nonwords	23.3 (15.7)[* ^]	15.7 (11.9)	16.3 (11.7)
RT words	1081.8 (85.8)	1075.4 (89.2)	1080.3 (91.0)
RT nonwords	1327.8 (149.6)[t]	1296.9 (153.0)	1279.2 (138.7)
Trail Making Test			
Ratio score (B/A)	2.6 (0.8)	2.4 (0.8)	2.5 (0.7)
Color-Word Interference Test			
Color Naming	27.1 (5.3)[* * ^]	25.1 (3.6)	25.2 (3.8)
Word Reading	20.5 (3.3)	19.5 (2.7)	20.3 (3.2)
Inhibition Cost	17.1 (7.2)	15.3 (5.2)	16.5 (5.9)
Inhibition/Switching Cost	3.9 (7.5)[*]	3.1 (9.0)[t]	7.1 (8.1)
Switching Cost	7.3 (8.5)[t]	7.2 (10.4)	10.9 (8.9)

[*] Significant difference compared to Native ML group, $p<.05$.
[* *] Significant difference compared to Native ML group, $p<.01$.
[t] Trend compared to Native ML group, $p<.10$.
[#] Significant difference between HL and Nonstandard ML groups, $p<.05$.
[^] Trend between HL and Nonstandard ML groups, $p<.10$.

may reveal differences among the participant groups in naming or word retrieval.

Results

Table 2 presents the mean scores for each participant group on each of the outcome measures. Analysis of variance (ANOVA) showed that the groups differed significantly on parental education (SES), $F(2,131) = 5.98$, $p = .003$, with between-group comparisons showing that the HL group had significantly lower SES than both the Nonstandard ML group, $p = .017$, and Native ML group, $p = .002$, while the latter two groups did not differ, $p = .929$. The groups, however, did not differ significantly on nonverbal intelligence, $F<1$. Nevertheless, there may still have been individual differences that contributed to performance on the various outcome measures. In addition, gender was not evenly distributed across the groups (see Table 1), with proportionately more female participants in the HL groups (75% females) than in either the Nonstandard ML (54%) or Native ML groups (60%). Therefore, analyses of covariance (ANCOVAs) were carried out controlling for SES, nonverbal intelligence, and gender (coded as a binomial variable) as three covariates, with post-hoc Tukey tests carried out for pairwise comparisons among the three groups: HL vs. Nonstandard ML, HL vs. Native ML, and Nonstandard ML vs. Native ML.

Controlling for pre-existing differences between groups

Speech comprehension

Data for two participants were excluded from the analyses of the sentence verification task, because they made 100% errors for one type of sentences (e.g., false statements), which led to no RT data for that set, and zero errors for the other type (e.g., true statements), showing that they simply pressed the same key throughout the task. Both participants were in the HL group. The data from these two participants were included in the analyses of the other tasks though, as they were within the normal range, even for the accented lexical decision task which also involved speeded “Yes” or “No” responding.

Prior to analysis of the accented sentence verification data, trials with an RT less than 500 ms or greater than 4500 ms were discarded, and trials with an RT greater than 2 standard deviations from the grand mean were trimmed to those cutoff values (with 0.3% of trials discarded and 4.7% of trials trimmed). Further, the analysis for RT only included correct trials (with 1.6% of trials excluded). Three-way (3×2×2) ANCOVAs were carried out for ER and for RT, controlling for the three covariates. The three factors were group (three levels: HL, Nonstandard ML, Native ML), accent type (two levels: accented, standard), and sentence type (two levels: true, false). In terms of ER, all participants made few errors on this task, with no significant main effect of group, $F<1$, and also no interaction between group and accent type, nor between group and sentence type, F’s<1. This indicates that the participant groups did not differ in performance accuracy on this task, either across the two parts (accented and standard) or across the two types of sentences. There were also no significant main effects of accent type or sentence type, F’s<2. For the RT measure, the group main effect was significant, $F(2,513) = 3.38$, $p = .035$, $\eta^2_p = .013$, with pairwise comparisons showing that the HL group performed significantly more slowly than the Native ML group, $p = .010$. There was no significant difference between HL and Nonstandard ML groups, nor between Nonstandard ML and Native ML groups, p’s>.20. Further, there was a significant main effect of accent type, where RTs for standard items were significantly faster than that for accented items, $F(1,513) = 137.92$, $p<.001$, $\eta^2_p = .212$, indicating that the presence of accent significantly slowed responses. There was no significant main effect of sentence type, $F<1$, and no significant interactions between group and the other factors, F’s<1.

For the auditory lexical decision data, trials with an RT less than 200 ms or greater than 2000 ms were discarded, and trials with an RT greater than 2 standard deviations from the grand mean were trimmed to those cutoff values prior to analysis (with 3.2% of trials discarded and 3.6% of trials trimmed). Again, the analysis for RT only included correct trials (with 14.3% of trials excluded). Two-way (3×2) ANCOVAs were carried out for ER and for RT, controlling for the three covariates. The two factors were group (three levels: HL, Nonstandard ML, Native ML) and word type (two levels: words, nonwords). For the ER measure, there was no significant main effect of group, $F<2$. There was a significant main effect of word type, $F(1,259) = 43.16$, $p<.001$, $\eta^2_p = .143$, where participants made significantly fewer errors on real word items than on nonwords. Moreover, there was a significant interaction between group and word type, $F(2,259) = 6.23$, $p = .002$, $\eta^2_p = .046$, and the pattern of means indicate that the Native ML group made fewer errors on nonwords but more errors on real words than the HL group (see Table 2). In the measure of RT, there was also a significant main effect of word type, $F(1,259) = 195.26$, $p<.001$, $\eta^2_p = .430$, where participants performed significantly more quickly on real words than on nonwords. However, there were no significant effects for group, nor for the interaction between group and word type, F’s<2.

Executive functions

For the TMT, a one-way ANCOVA controlling for the covariates was carried out for the ratio score (TMT-B / TMT-A), which showed no significant differences among the groups, $F<1$.

On the CWIT, one-way ANCOVAs were carried out for the two baseline measures and for the three contrast scores, controlling for the three covariates. The groups differed significantly on the Color Naming baseline, $F(2,128) = 4.37$, $p = .015$, $\eta^2_p = .064$, with pairwise comparisons showing significantly slower completion times for the HL group compared to the Native ML group, $p = .004$, and a trend when compared to the Nonstandard ML group, $p = .088$. The Nonstandard ML and Native ML groups did not differ significantly from each other, $p = .548$. For the Word Reading baseline, there were no significant differences between groups, $F<1$. Looking at the contrast scores, there were no significant differences between the groups for Inhibition Cost (Inhibition - Color Naming), $F<1$. However, for combined Inhibition/Switching Cost (Inhibition/Switching - combined Color Naming and Word Reading), there was a marginal difference, $F(2,128) = 2.75$, $p = .067$, $\eta^2_p = .041$. Pairwise comparisons showed that both the HL and Nonstandard ML groups displayed smaller costs, indicating better performance, compared to the Native ML group. The difference between the HL and Native ML groups was statistically significant, $p = .048$, while there was a strong trend for the comparison between the Nonstandard ML and Native ML groups, $p = .060$. The HL and Nonstandard ML groups did not differ from each other, $p = .783$. For Switching Cost (Inhibition/Switching – Inhibition), the overall ANCOVA was not significant, $F(2,128) = 2.13$, $p = .123$, $\eta^2_p = .032$.

Matching language background

As mentioned above, the HL and Nonstandard ML groups differed in their distribution of language backgrounds, though there was some overlap. Different language combinations may entail different accents, both in quality and in quantity. Furthermore, it is plausible that parents who feel comfortable enough to use English in their day-to-day home life have different cultural backgrounds, with different HLs, to those who prefer to use their native tongue. This may therefore produce systematic differences in HLs across groups, and in turn produce systematic differences in accent. Therefore, as was undertaken in Tao and Taft (2016), a matched subset of participants ($n = 20$) was selected from each of the HL and Nonstandard ML groups, in order to compare language task performance while removing differences in language background between the HL and Nonstandard ML groups. Comparisons between the two groups were conducted using data from the matched subsets. These comparisons did not reveal any significant differences between the two groups on any of the measures. However, there was a trend for the HL group to perform more slowly than the Nonstandard ML group on the Color Naming baseline of the CWIT, $t(38) = 1.99$, $p = .054$, which is consistent with results from analyses conducted with the full sample of participants described above.

Discussion

The present study extended the work of Tao and Taft (2016), further exploring the effects of early home language environment on linguistic and cognitive outcomes later in life. Performance on speech comprehension and cognitive functioning tasks were compared across the three participant groups: HL, Nonstandard ML, and Native ML groups.

Speech comprehension

With regard to sentence comprehension, differences between the groups were found on the RT measure, where the HL group was shown to perform significantly more slowly than the Native ML group. However, the lack of an interaction with accent type and with sentence type indicate that this weaker performance carried throughout the different types of stimuli, and were not due to the presence of accent or the presence of the often absurd meaning in the false statements. This result is consistent with findings by Tao and Taft (2016), where the HL group showed disadvantages compared to the Native ML group in an accented sentence transcription task, and in an auditory comprehension task with non-foreign-accented stimuli.

The disadvantage for the HL group in speech comprehension may be a result of differences in the type of language exposure during early childhood (i.e., mostly exposed to non-English HLs). Previous studies with early or simultaneous bilinguals have shown that the amount of exposure to one language is associated with perceptual sensitivity and comprehension skills in that language (see e.g., Cattani, Abbot-Smith, Farag, Krott, Arreckx, Dennis & Floccia, 2014; McCarthy, Mahon, Rosen & Evans, 2014; Sebastián-Gallés & Bosch, 2002; Sebastián-Gallés et al., 2005). Therefore, those who received less exposure to English (i.e., the HL group), may show weaker comprehension when listening to English stimuli. Further, a weaker vocabulary for the HL group may have also contributed to their disadvantage in sentence comprehension. Specifically, Tao and Taft (2016) found that the HL group produced lower vocabulary scores than the Native ML group, while the Nonstandard ML group did not differ from either of the other two groups.

For processing accented speech with single-word stimuli, no significant differences were found between groups. However, there was an interaction between group and word type. The pattern of means across the groups indicate that the HL group had a bias to respond "Yes" to all items, thus resulting in fewer errors for word items and more errors for nonword items, while the Native ML group had tendencies to respond "No" to all items, thus producing more errors for real words and fewer errors for nonwords (see Table 2). It is possible, therefore, that the Native ML group was actually more affected by the presence of unfamiliar foreign accents than the HL group. When they heard accented words, they were more likely to say that it was not an English word, compared to participants in the HL group. The HL group, conversely, may have been less confident than the Native ML group in their knowledge of English words such that when they heard an accented utterance that they were unsure of, they were more willing to believe it was a word.

Of the two speech comprehension tasks, the task with sentence stimuli showed differences in speed of responding, whereas the one with single-word stimuli did not. This is likely due to differences in the level of linguistic processing that the tasks tap into. Specifically, decisions regarding whether each single-word stimuli is a real word or nonword mainly involves processing at the phonology or form level. The sentences task, on the other hand, requires not only form processing, but also processing at the semantics level. This higher-level processing likely produces greater individual differences in processing speed, and thus may be more sensitive to between-group differences in response times.

Executive functions

For executive functions, differences between the groups were found on the CWIT. In the baseline measures, the HL group showed weaker performance than the Native ML group for color naming, but not for word reading. The performance of the Nonstandard ML group was more similar to that of Native ML participants than that of HL participants, showing a marginal advantage over the HL group in color naming. The HL group disadvantage is consistent with previous findings showing that bilinguals typically perform less well in naming tasks (e.g., picture naming) compared to monolinguals (e.g., Bialystok et al., 2008; Gollan, Fennema-Notestine, Montoya & Jernigan, 2007; Gollan, Montoya, Fennema-Notestine & Morris, 2005; see Bialystok et al., 2009; Kroll & Gollan, 2014, for reviews). Research suggests that having two languages impedes the rapid lexical retrieval that is required in naming tasks, as there are potentially two competing lexical representations, one in each language, for the same semantic category (Gollan & Goldrick, 2012; Kroll & Gollan, 2014). Bilinguals are, therefore, less efficient in retrieving target lexical representations to name things in the appropriate language, compared to monolingual speakers.

For executive function processes in the CWIT, the HL group was found to have an advantage over the Native ML group, where they showed significantly smaller combined Inhibition/Switching Cost. The effect size was comparable to the effect size for between-group differences in baseline Color Naming (though slightly smaller), and larger than that for speech comprehension. The results indicate that, compared to the Native ML group, those in the HL group were more efficient at inhibiting the conflicting response (i.e., inhibiting reading of the word to name the incongruent ink color), and switching when prompted (i.e., switching to read the words enclosed in boxes rather than name the color), taking into account baseline performance. This finding is consistent with research demonstrating bilingual advantages in executive functions, particularly inhibitory control and task switching (see Bialystok et al., 2009, for a review). The continual practice in keeping their two languages apart may have allowed people in the HL group to develop stronger inhibition and switching abilities, which would then help to overcome their disadvantage in baseline color naming to produce smaller inhibition and switching costs compared to the Native ML group.

Participants in the Nonstandard ML group, on the other hand, were on the whole less bilingual than those in the HL group, and many were functionally monolingual speakers. They were, therefore, not expected to show enhanced executive functions to the extent displayed by the HL group. That is, given their mostly monolingual environment and largely monolingual ability, those in the Nonstandard ML group would only need to exercise their inhibition and switching of language in limited circumstances. However, they may still show some advantage over the Native ML group, as they are still likely to have had some experience with non-English languages, more so than the Native ML group. The results, indeed, showed that the Nonstandard ML group displayed a less robust advantage over the Native ML group, compared to the advantage shown by the HL group. That is, they only showed a marginally significant smaller combined Inhibition/Switching Cost compared to native monolingual speakers.

Although they were largely monolingual, the Nonstandard ML group may still have had some exposure and experience with non-English languages at home, which may have helped to strengthen their inhibitory control and task switching abilities to some extent (see also Fan et al., 2015). Since the Nonstandard ML group was strongly dominant in English, when they do experience non-English languages (e.g., in the minority of times when their parents may have spoken in their HL), they may need to exercise stronger cognitive control to inhibit the predominant English representations and switch to the much weaker HL representations. Furthermore, previous research has shown that bilingual advantages in executive function are not exclusively brought about by continual practice through the verbal production of two languages, but also by practice through perception of multiple language input. It has been found that preverbal infants (at 7 months of age), who were raised with two languages from birth, display enhanced cognitive control abilities compared to age-matched infants raised in a monolingual environment (Kovács & Mehler, 2009). This suggests that even people who may not be able to speak two languages can have enhanced cognitive control. Processing auditory input from two languages and having to deal with the representations of each of them appears to be sufficient for enhancing executive functions, without the involvement of verbal expression. However, given their much lower exposure to the HL, and thus lower amount of practice in dealing with two languages, the Nonstandard ML group may not be able to gain the same degree of enhancement in executive functions as the HL group.

The TMT in the present study did not produce any differences between the groups. The results showed that both TMT-B raw score and ratio score (TMT-B / TMT-A) were correlated with the switching aspects of the CWIT. Specifically, stronger performance on TMT-B and ratio score were associated with stronger performance on CWIT Inhibition/Switching condition and on Switching Cost (r's between .18 and .47, p's<.05). Other research has also shown that the TMT assesses task switching ability more than other aspects of executive function (Arbuthnott & Frank, 2000; Sánchez-Cubillo, Periáñez, Adrover-Roig, Rodríguez-Sánchez, Ríos-Lago, Tirapu & Barceló, 2009). It is likely that the participant groups in the present study differed more on inhibitory control than on task switching (showing more robust differences in combined Inhibition/Switching Cost than on Switching Cost), thus not showing differences on the TMT.

Conclusion

The present study showed that people who were exposed mostly to non-English HLs have disadvantages relative to native monolingual speakers in auditory comprehension, particularly with sentence stimuli, whereas those exposed mostly to nonstandard English do not show an apparent disadvantage. This study also showed that the HL individuals have advantages in their executive functioning, particularly in response inhibition and task switching, but have disadvantages in lexical naming (i.e., the baseline color naming part of the CWIT). Although, the effect sizes for between-group differences across the tasks were small. The Nonstandard ML group, on the other hand, showed a less robust advantage in inhibition and switching over the Native ML group, and showed no disadvantage in lexical naming.

Corroborating the results of Tao and Taft (2016), findings of the present study suggest that people whose parents spoke to them mostly in English despite having an accent are more native-like when performing certain types of English language tasks, compared to those whose parents predominantly spoke to them in their HL. However, it should be cautioned that such findings only apply to the limited set of tasks and conditions tested in these two studies (the present study and Tao & Taft, 2016), and may not extend to other outcomes. Indeed, not all studies have shown that a greater amount of ML exposure inevitably leads to better outcomes in the ML, and that the QUALITY of input may be of greater importance than input quantity (Chondrogianni & Marinis, 2011; Hoff, Rumiche, Burridge, Ribot & Welsh, 2014; Paradis, 2011). It has been argued that, to truly facilitate ML development, the input needs to be from native ML speakers, and not to nonstandard versions (Hoff et al., 2014; Paradis, 2011; Unsworth, 2016). Although, the present study (and Tao & Taft, 2016) showed that even exposure to accented ML may lead to better performance on certain ML tasks compared to reduced ML exposure (i.e., greater exposure to HL).

On the other side of the coin, a greater amount of exposure to ML would inevitably reduce exposure to HL, which would in turn lead to poorer HL outcomes (Hoff et al., 2014; Unsworth, 2016). Both the present study and Tao and Taft (2016) showed a trade-off between English task performance and HL proficiency. The Nonstandard ML group in the present study again reported lower levels of proficiency in their HL, compared to the HL group (see Table 1). Furthermore, people who have been exposed mostly to non-English HLs, while showing disadvantages in aspects of language task performance in the ML, may have enhancements in aspects of cognitive functioning, likely as a result of being bilingual, whereas those mostly exposed to English with an accent may not develop the full extent of such enhancements when they have limited ability to speak their HL. Both the cognitive advantages and the linguistic disadvantages found for the HL group are consistent with research demonstrating such advantages and disadvantages in bilinguals (see Bialystok et al., 2009; Kroll & Gollan, 2014, for reviews).

References

Abutalebi, J., & Green, D. W. (2007). Bilingual language production: The neurocognition of language representation and control. *Journal of Neurolinguistics, 20,* 242–275. doi: 10.1016/j.jneuroling.2006.10.003

Arbuthnott, K., & Frank, J. (2000). Trail Making Test, Part B as a measure of executive control: Validation using a set-switching paradigm. *Journal of Clinical and Experimental Neuropsychology, 22,* 518–528. doi: 10.1076/1380-3395(200008)22:4;1-0;FT518

Baddeley, A. D., Emslie, H., & Nimmo-Smith, I. (1992). *The speed and capacity of language processing (SCOLP) test.* Bury St Edmunds, UK: Thames Valley Test.

Baddeley, A. D., Gardner, J. M., & Grantham-McGregor, S. (1995). Cross-cultural cognition: Developing tests for developing countries. *Applied Cognitive Psychology, 9,* S173–S195. doi: 10.1002/acp.2350090711

Bialystok, E., Craik, F. I. M., Green, D. W., & Gollan, T. H. (2009). Bilingual minds. *Psychological Science in the Public Interest, 10,* 89–129. doi: 10.1177/1529100610387084

Bialystok, E., Craik, F. I. M., & Luk, G. (2008). Cognitive control and lexical access in younger and older bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34,* 859–873. doi: 10.1037/0278-7393.34.4.859

Bosch, L., & Sebastián-Gallés, N. (2003). Simultaneous bilingualism and the perception of a language-specific vowel contrast in the first year of life. *Language and Speech, 46,* 217–243. doi: 10.1177/00238309030460020801

Bradlow, A. R., & Bent, T. (2008). Perceptual adaptation to non-native speech. *Cognition, 106,* 707–729. doi: 10.1016/j.cognition.2007.04.005

Burman, D. D., Bitan, T., & Booth, J. R., (2008). Sex differences in neural processing of language among children. *Neuropsychologia, 46,* 1349–1362. doi: 10.1016/j.neuropsychologia.2007.12.021

Carlson, S. M., & Meltzoff, A. N. (2008). Bilingual experience and executive functioning in young children. *Developmental Science, 11,* 282–298. doi: 10.1111/j.1467-7687.2008.00675.x

Cattani, A., Abbot-Smith, K., Farag, R., Krott, A., Arreckx, F., Dennis, I., & Floccia, C. (2014). How much exposure to English is necessary for a bilingual toddler to perform like a monolingual peer in language tests? *International Journal of Language and Communication Disorders, 49,* 649–671. doi: 10.1111/1460-6984.12082

Chiu, M. M., & McBride-Chang, C. (2006). Gender, context, and reading: A comparison of students in 43 countries. *Scientific Studies of Reading, 10,* 331–362. doi: 10.1207/s1532799xssr1004_1

Chondrogianni, V., & Marinis, T. (2011). Differential effects of internal and external factors on the development of vocabulary, tense morphology and morpho-syntax in successive bilingual children. *Linguistic Approaches to Bilingualism, 1,* 318–345. doi: 10.1075/lab.1.3.05cho

Clarke, C. M., & Garrett, M. F. (2004). Rapid adaption to foreign-accented English. *The Journal of the Acoustical Society of America, 116,* 3647–3658. doi: 10.1121/1.1815131

Costa, A., Hernández, M., Costa-Faidella, J., & Sebastián-Gallés, N. (2009). On the bilingual advantage in conflict processing: Now you see it, now you don't. *Cognition 113,* 135–149. doi: 10.1016/j.cognition.2009.08.001

Cristia, A., Seidl, A., Vaughn, C., Schmale, R., Bradlow, A., & Floccia, C. (2012). Linguistic processing of accented speech across the lifespan. *Frontiers in Psychology, 3*: 479. doi: 10.3389/fpsyg.2012.00479

Delis, D. C., Kaplan, E., & Kramer, J. M. (2001). *Delis-Kaplan Executive Function System (D-KEFS) examiner's manual*. San Antonio, TX, USA: The Psychological Corporation.

Duñabeitia, J. A., Hernández, J. A., Antón, E., Macizo, P., Estévez, A., Fuentes, L. J., & Carreiras, M. (2014). The inhibitory advantage in bilingual children revisited: Myth or reality? *Experimental Psychology, 61,* 234–251. doi: 10.1027/1618-3169/a000243

Durrant, S., Delle Luche, C., Cattani, A., & Floccia, C. (2015). Monodialectal and multidialectal infants' representation of familiar words. *Journal of Child Language, 42,* 447–465. doi: 10.1017/S0305000914000063

Fan, S. P., Liberman, Z., Keysar, B., & Kinzler, K. D. (2015). The exposure advantage: Early exposure to a multilingual environment promotes effective communication. *Psychological Science, 26,* 1090–1097. doi: 10.1177/0956797615574699

Fine, E. M., Delis, D. C., Wetter, S. R., Jacobson, M. W., Jak, A. J., McDonald, C. R., Braga, J. C., Thal, L. J., Salmon, D. P., & Bondi, M. W. (2008). Cognitive discrepancies versus APOE genotype as predictors of cognitive decline in normal-functioning elderly individuals: A longitudinal study. *The American Journal of Geriatric Psychiatry, 16,* 366–374. doi: 10.1097/JGP.0b013e3181629957

Floccia, C., Butler, J., Girard, F., & Goslin, J. (2009). Categorization of regional and foreign accent in 5- to 7-year-old British children. *International Journal of Behavioral Development, 33,* 366–375. doi: 10.1177/0165025409103871

Floccia, C., Delle Luche, C., Durrant, S., Butler, J., & Goslin, J. (2012). Parent or community: Where do 20-month-olds exposed to two accents acquire their representation of words? *Cognition, 124,* 95–100. doi: 10.1016/j.cognition.2012.03.011

Forster, K. I., & Forster, J. C. (2003). DMDX: A windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, and Computers, 35,* 116–124. doi: 10.3758/BF03195503

Gollan, T. H., Fennema-Notestine, C., Montoya, R. I., & Jernigan, T. L. (2007). The bilingual effect on Boston Naming Test performance. *Journal of the International Neuropsychological Society, 13,* 197–208. doi: 10.1017/S1355617707070038

Gollan, T. H., & Goldrick, M. (2012). Does bilingualism twist your tongue? *Cognition, 125,* 491–497. doi: 10.1016/j.cognition.2012.08.002

Gollan, T. H., Montoya, R. I., Fennema-Notestine, C., & Morris, S. K. (2005). Bilingualism affects picture naming but not picture classification. *Memory and Cognition, 33,* 1220–1234. doi: 10.3758/BF03193224

Gordon-Salant, S., & Fitzgibbons, P. J., (1997). Selected cognitive factors and speech recognition performance among young and elderly listeners. *Journal of Speech, Language, and Hearing Research, 40,* 423–431. doi: 10.1044/jslhr.4002.423

Green, D. W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition, 1,* 67–81. doi: 10.1017/S1366728998000133

Hoff, E., Rumiche, R., Burridge, A., Ribot, K. M., & Welsh, S. N. (2014). Expressive vocabulary development in children from bilingual and monolingual homes: A longitudinal study from two to four years. *Early Childhood Research Quarterly, 29,* 433–444. doi: 10.1016/j.ecresq.2014.04.012

Kovács, Á. M., & Mehler, J. (2009). Cognitive gains in 7-month-old bilingual infants. *Proceedings of the National Academy of Sciences of the United States of America, 106,* 6556–6560, doi: 10.1073/pnas.0811323106

Kroll, J. F., Dussias, P. E., Bogulski, C. A., & Valdés Kroff, J. (2012). Juggling two languages in one mind: What bilinguals tell us about language processing and its consequences for cognition. In B. Ross (Ed.), *The psychology of learning and motivation* (Vol. 56, pp. 229–262). Waltham, MA, USA: Academic Press. doi: 10.1016/B978-0-12-394393-4.00007-8

Kroll, J. F., & Gollan, T. H. (2014). Speech planning in two languages: What bilinguals tell us about language production. In M. Goldrick, V. Ferreira, & M. Miozzo (Eds.), *The Oxford handbook of language production* (pp. 165–181). Oxford, UK: Oxford University Press. doi: 10.1093/oxfordhb/9780199735471.013.001

Marzecová, A., Asanowicz, D., Krivá, L., & Wodniecka, Z. (2012). The effects of bilingualism on efficiency and lateralization of attentional networks. *Bilingualism: Language and Cognition, 16,* 608–623. doi: 10.1017/S1366728912000569

Mattys, S. L., Davis, M. H., Bradlow, A. R., & Scott, S. K. (2012). Speech recognition in adverse conditions: A review. *Language and Cognitive Processes, 27,* 953–978. doi: 10.1080/01690965.2012.705006

May, J., Alcock, K. J., Robinson, L., & Mwita, C. (2001). A computerized test of speed of language comprehension unconfounded by literacy. *Applied Cognitive Psychology, 15,* 433–443. doi: 10.1002/acp.715

Maye, J., Aslin, R. N., & Tanenhaus, M. K. (2008). The weckud wetch of the wast: Lexical adaptation to a novel accent. *Cognitive Science, 32,* 543–562. doi: 10.1080/03640210802035357

McCarthy, K. M., Mahon, M., Rosen, S., & Evans, B. G. (2014). Speech perception and production by sequential bilingual children: A longitudinal study of voice onset time acquisition. *Child Development, 85,* 1965–1980. doi: 10.1111/cdev.12275

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex frontal lobe tasks: A latent variable analysis. *Cognitive Psychology, 41,* 49–100. doi: 10.1006/cogp.1999.0734

Paap, K. R., & Greenberg, Z. I. (2013). There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive Psychology, 66,* 232–258. doi: 10.1016/j.cogpsych.2012.12.002

Paap, K. R., Johnson, H. A., & Sawi, O. (2015). Bilingual advantages in executive functioning either do not exist or are restricted to very specific and undetermined circumstances. *Cortex, 69,* 265–278. doi: 10.1016/j.cortex.2015.04.014

Paradis, J. (2011). The impact of input factors on bilingual development: Quantity versus quality. *Linguistic Approaches to Bilingualism, 1,* 67–70. doi: 10.1075/lab.1.1.09par

Raven, J., Raven, J. C., & Court, J. H. (1998). *Manual for Raven's progressive matrices and vocabulary scales. Section 4: The advanced progressive matrices*. San Antonio, TX, USA: Harcourt Assessment.

Reitan, R. M. (1992). *Trail Making Test Manual for administration and scoring*. Mesa, AZ, USA: Reitan Neuropsychology Laboratory.

Samuel, A. G., & Kraljic, T. (2009). Perceptual learning for speech. *Attention, Perception, and Psychophysics, 71,* 1207–1218. doi: 10.3758/APP.71.6.1207

Sánchez-Cubillo, I., Periáñez, J. A., Adrover-Roig, D., Rodríguez-Sánchez, J. M., Ríos-Lago, M., Tirapu, J., & Barceló, F. (2009). Construct validity of the Trail Making Test: Role of task-switching, working memory, inhibition/interference control, and visuomotor abilities. *Journal of the International Neuropsychological Society, 15,* 438–450. doi: 10.1017/S1355617709090626

Sebastián-Gallés, N., & Bosch, L. (2002). Building phonotactic knowledge in bilinguals: Role of early exposure. *Journal of Experimental Psychology: Human Perception and Performance, 28,* 974–989. doi: 10.1037//0096-1523.28.4.974

Sebastián-Gallés, N., & Bosch, L. (2009). Developmental shift in the discrimination of vowel contrasts in bilingual infants: Is the distributional account all there is to it? *Developmental Science, 12,* 874–887. doi: 10.1111/j.1467-7687.2009.00829.x

Sebastián-Gallés, N., Echeverría, S., & Bosch, L. (2005). The influence of initial exposure on lexical representation: Comparing early and simultaneous bilinguals. *Journal of Memory and Language, 52,* 240–255. doi: 10.1016/j.jml.2004.11.001

Sidaras, S. K., Alexander, J. E. D., & Nygaard, L. C. (2009). Perceptual learning of systematic variation in Spanish-accented speech. *Journal of the Acoustical Society of America, 125,* 3306–3316. doi: 10.1121/1.3101452

Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research, 75,* 417–453. doi: 10.3102/00346543075003417

Stevens, C., Lauinger, B., & Neville, H. (2009). Differences in the neural mechanisms of selective attention in children from different socioeconomic backgrounds: An event-related brain potential study. *Developmental Science, 12,* 634–646. doi: 10.1111/j.1467-7687.2009.00807.x

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643–662. doi: 10.1037/h0054651

Tao, L., Marzecová, A., Taft, M., Asanowicz, D., & Wodniecka, Z. (2011). The efficiency of attentional networks in early and late bilinguals: The role of age of acquisition. *Frontiers in Psychology, 2*: 123. doi: 10.3389/fpsyg.2011.00123

Tao, L., & Taft, M. (2016). Effects of early home language environment on perception and production of speech. *Bilingualism: Language and Cognition*. Advance online publication. doi: 10.1017/S1366728916000730

Tao, L., & Taft, M. (2017). Influences of cognitive processing capacities on speech perception in young adults. *Frontiers in Psychology, 8*: 266. doi: 10.3389/fpsyg.2011.00123

Tao, L., Taft, M., & Gollan, T. H. (2015). The bilingual switching advantage: Sometimes related to bilingual proficiency, sometimes not. *Journal of the International Neuropsychological Society, 21,* 531–544. doi: 10.1017/S1355617715000521

Trude, A. M., & Brown-Schmidt, S. (2012). Talker-specific perceptual adaptation during online speech perception. *Language and Cognitive Processes, 27,* 979–1001. doi: 10.1080/01690965.2011.597153

Unsworth, S. (2016). Quantity and quality of language input in bilingual language development. In E. Nicoladis & S. Montanari (Eds.). *Bilingualism across the lifespan: Factors moderating language proficiency* (pp. 103–121). Washington, DC, US: American Psychological Association. doi: 10.1037/14939-007

Wallentin, M. (2009). Putative sex differences in verbal abilities and language cortex: A critical review. *Brain and Language, 108,* 175–183. doi: 10.1016/j.bandl.2008.07.001

Zwitserlood, P. (1989). The locus of the effects of sentential-semantic context in spoken-word processing. *Cognition, 32,* 25–64. doi: 10.1016/0010-0277(89)90013-9