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The influence of proficiency and language combination on bilingual lexical access

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THE INFLUENCE OF PROFICIENCY AND LANGUAGE COMBINATION ON BILINGUAL LEXICAL ACCESS

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ABSTRACT

The present study examines the nature of bilingual lexical access using category fluency across five language combinations using 109 healthy speakers of Hindi-English, Kannada-English, Mandarin-English, Spanish-English, and Turkish-English. Participants completed a category fluency task in each of their languages in three main categories (*animals*, *clothing*, *food*), each with two subcategories, as well as a language use questionnaire assessing their proficiency in each of their languages. Multivariate analyses of variance revealed that the average number of correct items named in the category fluency task across the three main categories varied across the different groups for English items only. A series of repeated-measures analyses of covariance revealed that the exposure component that had been extracted from the language use questionnaire using a principal component analysis significantly affected the average number of items named across the three main categories. When the effect of exposure was controlled, the effect of language combination was no longer significant. A regression analysis showed that the relative amount of exposure participants had to each of their languages predicted participants' relative performance in each language. Additional multivariate analyses of variance found significant differences in the number of correct items named in each main category and subcategory in both English and participants' other language based on language combination. Overall, these results demonstrate the effects of particular

language combinations on bilingual lexical access and provide important insights into the role of proficiency on access.

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LIST OF ABBREVIATIONS

ANCOVA: Analysis of covariance

BIA: Bilingual interactive activation

L1: First language

L2: Second language

MANOVA: Multivariate analysis of variance

PCA: Principal component analysis

RHM: Revised hierarchical model

INTRODUCTION

Several models regarding lexical access in bilinguals have been proposed in the literature. Two prominent models of bilingual lexical access include the bilingual interactive activation (BIA) model (Dijkstra & Van Heuven, 1998) and the revised hierarchical model (RHM) (Kroll & Stewart, 1994). The BIA model is a hierarchical model of word recognition composed of nodes for features, letters, words, and languages. In this model, when a bilingual individual sees a word, other words with similar features and letters in both languages are activated. The word with the highest activation surpasses its activation threshold and the language nodes inhibit the words from the other language, allowing the word to be recognized correctly. This model is described as being most applicable to "proficient bilinguals" (Sunderman & Kroll, 2006, p. 389). Support for the BIA model has been found using cross-language neighbors (words across languages that are orthographically but not semantically related) (Van Heuven, Dijkstra, & Grainger, 1998; Jared & Kroll, 2001), interlingual homographs (words that are orthographically identical, but not semantically related) (De Groot, Delmaar, & Lupker, 2000; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998), and cognates (Dijkstra et al., 1998; Van Hell & Dijkstra, 2002).

The RHM is an asymmetrical model that consists of three modules: first language (L1), second language (L2), and a conceptual system. Kroll and Stewart (1994) proposed that the conceptual link between L1 and the conceptual system is stronger than the conceptual link between L2 and the conceptual system. Furthermore, the lexical link between L1 and L2 is stronger from L2 to L1 than from L1 to L2 because when L2 learners first learn the translations of L2 words, they form the connection from L2 to L1. Kroll and Stewart (1994) also suggest that translations from L1 to L2 usually go through the conceptual system due to the strong link between L1 and the conceptual system and the relatively weak lexical link from L1 to L2; translations from L2 to L1 usually go directly to L1 via the strong lexical link between the two lexical systems. The conceptual link from L2 to the conceptual system may strengthen and the lexical link from L2 to L1 may weaken as proficiency in L2 increases (Sunderman & Kroll, 2006). Support for the RHM comes primarily from translation studies (Kroll & Stewart, 1994; Talamas, Kroll, & Dufour, 1999). Kroll and Stewart (1994) used a word translation task to assess the validity of the revised hierarchical model. Dutch-English bilinguals translated lists of words that were either semantically organized into categories or were organized randomly. The authors found that translation from L2 to L1 was faster than translation from L1 to L2 and that category interference only occurred when translating from L1 to L2. In other words, translation from L2 to L1 appeared to be using the lexical link, as the conceptual organization of the words did not affect translation speed. When translating from L1 to L2, the conceptual links were used because the conceptual organization of the words interfered with access. The BIA model does not account for lexical access in less proficient bilinguals, whereas the RHM allows for changes in the strength of the various connections as proficiency increases. The RHM is more applicable to the present study because participants were of varying degrees of proficiency.

The above models provide a theoretical basis for bilingual lexical access, which can be examined in a variety of ways, including verbal fluency. Verbal fluency tasks are a measure of language access used to assess cognitive and linguistic functioning, particularly naming ability. They may be phonemic, in which individuals are asked to name as many items as they can in a given time period beginning with the same sound, or semantic, in which individuals are asked to name items in a given category. The present study focuses on semantic fluency, or category fluency, in bilingual individuals.

Category fluency tasks have been used to compare lexical access in different languages, both within bilingual individuals (i.e., comparing performance in L1 and L2) and across specific languages (i.e., comparing Finnish to English). Studies that have examined category fluency have investigated a variety of variables, including the overall difference in the number of items in each of a bilingual's languages, differences based on proficiency, differences based on particular languages, and differences based on word length.

There are relatively few studies comparing bilingual performance in L1 to performance in L2. Most studies of this type that investigated the overall difference in the number of items named in each language found no significant differences between performance in L1 and L2, suggesting that bilingual individuals are able to access words in both of their languages at the same rate. Roberts and Le Dorze (1997) found no difference in the amount of items generated within animal and food categories in French and English for French-English bilinguals. However, participants produced longer semantic associations (three or more consecutive words from the same subcategory) and a greater percentage of words in semantic associations in French than in English. Similarly, Roselli et al. (2002) found no language-based difference in performance on an animal fluency task in Spanish-English bilinguals. While there were no differences across languages within the bilingual group, bilinguals did produce fewer English animals than did monolingual English speakers and they performed equivalently to Spanish monolingual speakers. Bilinguals produced more semantic associations in Spanish than in English, possibly because Spanish was their native language. Overall, these results suggest that while there may be no difference in the number of items named in their two languages, there may be differences in the way they name items in each language. Roselli et al. (2000) also found no difference in performance across languages for Spanish-English bilinguals, although participants did produce more words in English in a picture description task. In the above studies, participants were noted to be equally proficient in L1 and L2 or of varying degrees of proficiency in each language. Bethlehem, de Picciotto, and Watt (2003) studied category fluency in bilingual Zulu-English speakers for whom Zulu was L1 and again found no significant differences in performance across languages. Zulu-English speakers performed equally well on category fluency tasks in Zulu, English, and in a bilingual category fluency task, in which they were permitted to code-switch. Despite the lack of difference between category fluency scores, English scores did not significantly correlate with Zulu scores. Thus, one could not expect the same result in both languages. English scores and bilingual scores were significantly correlated, as were Zulu and bilingual scores. Overall, it is likely that the levels of proficiency in L1 and L2 were similar in the above studies, which may account for participants' equivalent access to both of their languages. Taken together, the results of bilingual category fluency studies that compare participants' performance in L1 and L2 suggest that (a) performance does not differ across an individual's languages in terms of the number of items generated and (b) level of proficiency may account for this equivalent access to both languages.

Other studies have looked at the effects of proficiency on category fluency performance more directly. Kamat et al. (2012) found that individuals who had a higher level of proficiency in Hindi, their second and less-dominant language, performed better on an animal fluency task administered in Marathi, their first and more-dominant language. Unfortunately, the task was not administered in Hindi as well, so effects of proficiency on performance in both languages cannot be assessed. Bethlehem et al. (2003) found differences based on age of acquisition of English in Zulu-English speakers. The later English was learned, the poorer the score on an English and bilingual category fluency task. However, regardless of this difference, there was no significant difference between Zulu and English scores. Luo, Luk, & Bialystok (2010) investigated the effects of English proficiency on performance on an English verbal fluency task. Monolingual and bilingual speakers were included in this study. Monolingual speakers spoke English and bilingual speakers spoke English and a variety of other languages. Participants' expressive and receptive vocabularies were assessed and bilingual participants were placed into either a high-vocabulary or low-vocabulary group. Luo et al. (2010) found that while bilingual individuals with higher vocabulary scores (an index of proficiency) performed better than individuals with lower vocabulary scores on a letter fluency task, they did not differ in performance on a semantic fluency task. Similarly, Poreh and Schweiger (2002) found that age of acquisition of Hebrew affected performance on a phonemic fluency task, but not on a semantic fluency task. No effects were found for the degree of use of Hebrew. Thus, although the research regarding the effects of proficiency on category fluency is inconclusive, there may be effects of proficiency on lexical access and these effects may be mediated by the type of content.

Some studies have explored the role of language in category fluency performance by asking bilinguals of varying degrees to perform in one language. González, Mungas, and Haan (2005) compared the category fluency performance of English- and Spanish-speaking older Mexican Americans and found that language accounted for a small but significant 0.4% of the variance in performance. While some participants in this study may have been bilingual, not all were; participants chose to take the test in either English or Spanish based on preference. Agranovich and Puente (2007) found no significant differences in category fluency performance for Russian and English speakers. While the study did not state whether participants were monolingual or bilingual, participants only performed the task in their native language. Russian speakers named more animals than did English speakers on the category fluency task, but this difference was not significant. To summarize, one study found that language accounted for variance in category fluency performance (Gonzalez et al., 2005), while another found no difference in performance due to language (Agranovich & Puente, 2007). As such, it is necessary to further investigate the effects of particular languages on lexical access.

Differences in lexical access based on language may be due to factors such as word length. Kempler, Teng, Dick, Taussig, and Davis (1998) assessed the effects of ethnic group on category fluency and found that word length may play a role in performance. Participants were Chinese, Hispanic, Vietnamese, English-speaking White, and English-speaking African American. Chinese, Hispanic, and Vietnamese participants were bilingual. All participants performed the category fluency task in their native language. Kempler et al. (1998) found that Vietnamese participants produced significantly more animal names than did Chinese, White, and Hispanic participants and Spanish participants produced significantly fewer animal names than did Chinese, White, and Vietnamese participants. The authors attribute this finding to the fact that Vietnamese animal names are very short (usually one syllable) and Spanish animal names tend to be longer (usually two to three syllables). Word length affects word retrieval and storage and may therefore play a role in performance on category fluency tasks. While this study did not assess language differences within bilingual participants, it is possible that these results may be applied to language differences across bilingual language combinations, either within a bilingual individual or across bilingual speakers of various languages. However, unlike Kempler et al. (1998), Pekkala, Goral, Hyun, Obler, Erkinjuntti, and Albert (2009) found no difference due to word length: there were no significant differences in the total number of words produced or the number of words produced in the first 30 seconds between monolingual Finnish and English speakers on a category fluency task despite the fact that Finnish words are significantly longer than English words. There were differences in the types and frequencies of the 10 most common words produced in the animals and clothing categories. For instance, English speakers tended to name pets first and then zoo animals while Finnish speakers usually named farm animals and pets followed by zoo animals. The authors suggest that these differences are due to sociocultural variation. Thus, there is conflicting evidence regarding the effects of word length on category fluency (Kempler et al., 1998; Pekkala et al., 2009. It remains to be seen if category fluency performance differs based on the particular language used. Most studies have only compared two languages and differences may be exaggerated or underestimated depending on what two languages are being studied. A larger data sample is needed to address the issue of whether particular languages or language combinations influence lexical access.

To summarize, the RHM suggests that proficiency alters the strength of connections between the lexical and conceptual systems and may therefore affect lexical access. Category fluency studies that did not specifically investigate the role of proficiency have not found differences in lexical access in L1 and L2, suggesting that access to each language is equal. Studies exploring the role of proficiency more directly have had mixed results, with some suggesting that proficiency has no effect on performance and others suggesting that proficiency improves performance for some verbal fluency tasks but not all. Factors that may play a role in lexical access include language, word length, type of task, and proficiency. It remains to be seen whether bilingual speakers of different language combinations perform differently on category fluency tasks and whether performance is influenced by category and proficiency. Gaining a better understanding of how these factors affect lexical access will help build a better understanding of what is typical for speakers of various languages at various levels of proficiency. The present study investigates these issues via a category fluency task using a set of healthy bilingual individuals across five different language combinations:

Hindi-English, Kannada-English, Mandarin-English, Spanish-English, and Turkish-English. The present study provides insight into whether speakers of different language combinations perform differently on a category fluency task by investigating the following questions:

(1) Is there an effect of language combination on lexical access?

Based on previous studies suggesting that particular languages may play a role in lexical access, it is hypothesized that there will be differences in how speakers of each language combination perform on the category fluency task and that some groups will perform more similarly than others. For example, speakers of Hindi-English and Kannada-English should perform more similarly than speakers of Hindi-English and Turkish-English due to cultural proximity.

(2) How does relative proficiency in each language relate to performance across the different groups of participants?

Based on previous studies suggesting that proficiency may play a role in lexical access, it is hypothesized that greater relative proficiency in one language will predict a greater number of items named in that language across language combinations.

(3) How does the nature of each category influence lexical access?

Based on previous studies suggesting variations in performance based on the type of category, it is expected that there will be differences between language combinations across the three categories of *food*, *clothing*, and *animals* as well as across subcategories. It is further hypothesized that clothing and animals should generate similar results across language combinations, while food should generate different results for various combinations. It is expected that food will vary to a greater extent because cultural differences are likely to have a large impact on this category.

METHODS

Participants

Participants included 109 healthy bilingual individuals between the ages of 18 and 56 (mean age = 27.72 years). The breakdown of participants by language combination is as follows: 14 Hindi-English speakers, 14 Kannada-English speakers, 30 Mandarin-English speakers, 29 Spanish-English speakers, and 22 Turkish-English speakers. All participants self-reported typical language development. Individuals interested in participating scheduled an appointment in the lab via phone or email. Upon arriving at the lab they were given a copy of the informed consent and met with an investigator to review any questions or concerns they had about the study before signing the consent form. Data from Hindi-English, Mandarin-English, and Spanish-English participants were collected in Austin, Texas. Data from Kannada-English participants were collected in India and data from Turkish-English participants were collected in Turkey. All participants completed an extended language use questionnaire (Kiran, Peña, Bedore, & Sheng, 2010).

Materials

Language use questionnaire. All participants filled out a language use questionnaire before completing the category fluency task. The 15 items on the questionnaire can be broken up into the following sections: exposure, confidence, daily use, family proficiency, educational history, and self-rating of language ability.

Exposure. Participants were asked to select a percentage of time by increments of age for how frequently they heard, spoke, and read each of their two languages. Each increment spanned a three-year range up to age 30, with a final slot for over 30. The age slots began at zero for hearing, three for speaking, and three for reading. There were five options for indicating frequency: 100% other language, 25% English/75% other language, 50% in each language, 75% English/25% other language, and 100% English. For example, one could indicate that they heard English 25% of the time and Hindi 75% of the time from ages three to six and six to nine, but that they heard each language 50% of the time from ages nine to 12. The percentages were averaged across the age increments with a weight adjustment for participants over age 30, resulting in three scores: exposure for hearing, exposure for speaking, and exposure for reading. Scores were reported separately for English and the other languages.

Confidence. Participants used a similar percentage scale to indicate their confidence in hearing, speaking, and reading each language by increments of age. Again, each increment spanned a three-year range up to 30 years, with a final slot for over 30. The age slots began at three for hearing, three for speaking, and six for reading. There were five options for indicating confidence: not confident, 25% confident, 50% confident, 75% confident, and strong confident. Participants rated each language separately. Using this scale, a participant could indicate that they were 25% confident in speaking English and 75% confident in speaking Turkish between ages six and nine. The percentages were averaged across the age increments with a weight adjustment for participants over age 30, resulting in three scores: confidence in hearing, confidence in speaking, and confidence in reading. Scores were reported separately for English and the other languages.

Daily use. The next set of questions asked participants to list any activities in which they were engaged on an hourly basis between 7am and 11pm, to list their conversation partners at each activity, and which language or languages they and their partner(s) used at each activity. This was completed once for weekdays and once for weekends. The percentage of time participants spent using each language was calculated, as was the percentage of time their partners used each language. A total score for use of each language was also computed. These calculations resulted in three scores: input, output, and total use. Scores were reported separately for English and the other languages.

Family proficiency. Participants then rated their parents' and siblings' confidence in each language using a percentage scale. The scale had five options: not confident, 25% confident, 50% confident, 75% confident, strong confident. Participants gave a separate rating for their mother, father, and siblings and rated each language separately. Average percentages of confidence were calculated for each language for each family member, creating three scores: mother's proficiency, father's proficiency, and siblings' proficiency. Scores were reported separately for English and the other languages.

Educational history. Following the family proficiency questions, participants answered questions about their educational history. They indicated which language they used at school at each of three levels of education: elementary, high school, and college. They indicated language by circling a 1 (other), 2 (English), or 3 (both). Participants used the same scale to indicate which language they preferred to speak at school and what language other students spoke at school at each level of education. A percentage of education in each language was calculated, resulting in one score: education. Scores were reported separately for English and the other languages.

Self-rating of language ability. Finally, participants completed a self-rating of fluency using a scale ranging from 1 to 5, with 1 being non-fluent and 5 being native fluency. Participants rated their level of fluency overall, when speaking in casual conversations, when listening in casual conversations, when speaking in formal situations, when listening in formal situations, when reading, and when writing for each language. An average score was created for self-rating of language ability in each language.

Category fluency task. For the category generation task, three broad categories were examined: *clothing*, *animals*, and *food*. Subordinate categories for each category were examined as well. For the *clothing* category, participants were asked to list *hot weather clothing* and *cold weather clothing*. For the *animals* category, participants listed *zoo animals* and *farm animals*. For the *food* category, participants listed *food items for lunch* and *food items at a birthday party*.

Design and Procedure

The order of language and tasks was counterbalanced in two tracks, each with two sessions. Session 1 for track 1 included *clothing*, *zoo animals*, *food*, and *farm animals* in English and *lunch food*, *hot weather clothing*, *animals*, *cold weather clothing*, and *birthday food* in participants' other language, as well as the language use questionnaire. Session 2 for track 1 included *zoo animals*, *food*, *clothing*, and *farm animals* in participants' other language and *cold weather clothing*, *lunch foods*, *hot weather clothing*, *birthday foods*, and *animals* in English. The languages were reversed for track 2. Tables listing the order of items in tracks 1 and 2 can be found in Appendix A. For each category, participants listed as many items as they could in a given category in one minute. All data was audio recorded and the samples were transcribed.

Scoring

Each item was coded as one of the following: correct (e.g, "tie" in the English *clothing* category), code-switched (e.g., "bird" in the other language *animals* category), borrowed (e.g., "taco" in the English *food* category), superordinate (e.g., "mammal"), subordinate (e.g., "polar bear," "grizzly bear"), no English translation, repetition, or incorrect (e.g., "ring" in the *clothing* category). Items including a mix of two languages (e.g., one Mandarin word and one English word) were marked as code-switched. There were also separate codes for items borrowed and code switched from a third language (e.g., "sashimi," which is borrowed from Japanese). All items were coded by an English speaker working off of English translations made by a native speaker of each language. A word was considered to be borrowed if no translation existed for that word.

Overall correct responses. Correct items, borrowed words, superordinate items, and words without translations were scored as overall correct responses.

Incorrect responses. Code-switched items, subordinate items, repetitions, and incorrect items were scored as incorrect. See Appendix B for examples of scored items.

Statistical Analysis

For research question 1, which assesses the effect of language combination on lexical access, a one-way multivariate analysis of variance (MANOVA) with the average number of correct items generated in English and the other language in the three main categories as the dependent variables and language combination as the independent variable was used.

To answer research question 2 regarding how proficiency in each language relates to performance in each language across the different groups of participants, principal component analyses (PCA) were performed to determine if any questions on the language use questionnaire loaded onto separate components. Repeated-measures analyses of covariance (ANCOVA), each with the total number of correct items named in English and the other language as dependent variables and language combination as the independent variable were performed to assess whether there were differences in the number of items named in each of participants' languages within participants based on language combination. To determine if the degree of bilingualism of the participants accounted for the differences in the number of correct items named for each language combination, each of the proficiency components extracted from the language use questionnaire was used as a covariate in the ANCOVAs. To investigate how proficiency predicted performance, a regression analysis using the components extracted from the principal components analysis and the difference in the number of correct items produced in English and participants' other language across the three main categories was performed.

In response to research question 3 regarding the effects of category on lexical access, a one-way MANOVA with all of the categories as dependent variables and language combination and the independent variable was conducted, first for English and then for the other language. These MANOVAs assessed differences between subcategories for each language pair group.

RESULTS

Research Question 1: Effect of Language Combination on Performance

See Table 1 for means and standard deviations of each category by language combination. Results from a one-way MANOVA revealed that there was a significant difference in the average number of correct items named in English and participants' other language based on language combination, $F(8, 206) = 7.082$, $p < .001$; Wilks' $\Lambda = 0.615$, partial $\eta^2 = .216$. The main effect of language was significant for English ($F(4, 104) = 13.206$, $p < .001$, partial $\eta^2 = 0.337$). This effect was not found for participants' other language ($F(4, 104) = 0.837$, $p > .05$, partial $\eta^2 = 0.031$). Post-hoc LSD tests revealed differences between individual language combinations. See Figure 1 for a bar graph of the mean number of correct items named in English across the three main categories by language combination. Speakers of Hindi-English and Spanish-English named significantly more items in English than did speakers of Mandarin-English (*p*

< .005). Speakers of Turkish-English produced significantly fewer English words across the three main categories than did speakers of all other language combinations (*p* < .005).

Research Question 2: Relationship between Proficiency and Performance

Thirteen participants were dropped from the analysis of proficiency due to missing data. Average scores for each section of the language use questionnaire can be found in Tables 2 and 3. A PCA was used to extract components from the 15 English scores from the language use questionnaire. The first four components had eigenvalues greater than 1 and explained 78.58% of the variance. Component 1 explained 44.74% of the variance, Component 2 explained 15.79% of the variance, Component 3 explained 11.20% of the variance, and Component 4 explained 6.85% of the variance. A scree plot confirmed that only the first four components were meaningful. The factor loadings of the first four components were examined using a varimax normalized factor rotation, which assumes that factors are uncorrelated. An item was said to load onto a particular component if the factor loading was greater than 0.6. The following questionnaire scores loaded together onto Component 1: exposure to hearing, exposure to speaking, exposure to reading, mother's proficiency, father's proficiency, and education. The following questionnaire scores loaded together onto Component 2: total use, input, output, and age. Three questionnaire scores loaded onto Component 3: confidence in hearing, confidence in speaking, and confidence in reading. Self-rating of language ability loaded by itself onto Component 4. The factor loadings for the four English components are displayed in Table 4.

A second PCA was used to extract components from the 15 scores in participants' other language on the language use questionnaire. The first four components had eigenvalues greater than 1 and explained 78.69% of the variance. Component 1 explained 40.04% of the variance, Component 2 explained 21.20% of the variance, Component 3 explained 9.09% of the variance, and Component 4 explained 8.36% of the variance. A scree plot confirmed that only the first four components were meaningful. As with the English data, the factor loadings of the first four components were examined using a varimax normalized factor rotation and an item was said to load onto a particular component if the factor loading was greater than 0.6. Three questionnaire scores loaded onto Component 1: confidence in hearing, confidence in speaking, and confidence in reading. The following questionnaire scores loaded onto Component 2: total use, input, output, and self-rating of language ability. Four factors loaded onto Component 3: exposure to hearing, exposure to speaking, exposure to reading, and education. The following factors loaded together onto Component 4: mother's proficiency, father's proficiency, and siblings' proficiency. The factor loadings for the four non-English components are displayed in Table 5.

The components extracted from the analysis of the English scores were used for further analysis because English is the common language across participants and would allow for a more clear-cut comparison of the effect of proficiency across the different languages. Components 1, 2, 3, and 4 were renamed exposure, use, confidence, and self-rating of language ability, respectively. A composite score was created for each component by computing the difference of the averages of the English and other language scores for each variable within the component for each participant. See Figure 2 for a histogram displaying the average degree of bilingualism of participants by language combination. As can be seen, the Hindi-English, Spanish-English and Mandarin-English groups were more proficient in English than the Kannada-English and Turkish-English groups.

Four repeated-measures ANCOVAs with the average number of correct items named in English and the other language as dependent variables and language combination as the independent variable were performed to assess whether there were differences in the number of items named in each of participants' languages based on language combination. The composite scores for each component extracted from the language use questionnaire were used as covariates in each ANCOVA, with confidence in the first ANCOVA, exposure in the second, use in the third, and self-rating of language ability used in the fourth. The first analysis revealed a main effect of the task language (English vs. other language) ($F(1, 90) = 48.417$, $p < .001$; Wilks' $\Lambda = 0.650$, partial $\eta^2 = .350$), an interaction effect of task language and confidence ($F(1, 90) = 16.000$, $p < .001$; Wilks' $\Lambda = 0.849$, partial $\eta^2 = .151$), and an interaction effect of task language and language combination ($F(4, 90) = 6.032$, $p < .001$; Wilks' $\Lambda = 0.789$, partial $\eta^2 = .211$). In addition, there was no main effect of language combination ($F(4, 90) = 2.100$; $p > .05$; partial $\eta^2 = .085$) or confidence ($F(1, 90) = 2.600$; $p > .05$; partial $\eta^2 = .028$) on the average number of correct items named across the three main categories when performance in both languages is taken into account. Thus, while the interaction of confidence and task language had an effect on category fluency performance, confidence alone did not affect performance.

The second repeated-measures ANCOVA was performed using exposure as a covariate. The analysis revealed a main effect of the task language ($F(1, 90) = 52.670$, $p < .001$; Wilks' $\Lambda = 0.631$, partial $\eta^2 = .369$), an interaction effect of task language and exposure ($F(1, 90) = 21.859$, $p < .001$; Wilks' $\Lambda = 0.805$, partial $\eta^2 = .195$), and an interaction effect of task language and language combination ($F(4, 90) = 3.322$, $p = .014$; Wilks' $\Lambda = 0.871$, partial $\eta^2 = .129$). There was a main effect of exposure on performance in each task language ($F(1, 90) = 4.135$; $p = .045$; partial $\eta^2 = .044$), but no main effect of language combination ($F(4, 90) = 1.016$; $p > .05$; partial $\eta^2 = .043$). Therefore, exposure had an effect on category fluency performance and when the effects of exposure were controlled for, there was no longer a significant effect of language combination on category fluency performance.

A third ANCOVA was performed using use as a covariate. The main effect was significant for task language ($F(1, 90) = 21.441$, $p < .001$; Wilks' $\Lambda = 0.808$, partial $\eta^2 = .192$) and there was a significant interaction effect of task language and language combination ($F(4, 90) = 6.737$, $p < .001$; Wilks' $\Lambda = 0.770$, partial $\eta^2 = .230$). There was no significant interaction effect of task language and use ($F(1, 90) = 0.049$, $p > .05$, Wilks' $\Lambda = 0.999$, partial $\eta^2 = .001$). There was a main effect of language on performance in each task language ($F(4, 90) = 4.029$, $p = .005$, partial $\eta^2 = .152$). The main effect of use was not significant ($F(1, 90) = 0.327$, $p < .05$, partial $\eta^2 = .004$). Use did not significantly affect category fluency performance.

A final ANCOVA was performed using the self-rating of language ability as a covariate. The main effect was significant for task language ($F(1, 90) = 22.079$, $p < .001$;

Wilks' $\Lambda = 0.803$, partial $\eta^2 = .197$) and there was a significant interaction effect of task language and language combination ($F(4, 90) = 8.712$, $p < .001$; Wilks' $\Lambda = 0.721$, partial $\eta^2 = .279$). The interaction effect of task language and self-rating of language ability was not significant ($F(1, 90) = 0.158$, $p > .05$; Wilks' $\Lambda = 0.998$, partial $\eta^2 = .002$). There was a main effect of language on performance in each task language ($F(4, 90) = 4.300$; $p = .003$; partial $\eta^2 = .160$). The main effect of self-rating of language ability was not significant ($F(1, 90) = 0.010$; $p > .05$; partial $\eta^2 < .001$). Self-rating of language ability did not affect category fluency performance.

In all four repeated-measures ANCOVAs, speakers of all language combinations except Turkish-English named more items in English than they did in their other language. Exposure was found to have a significant effect on overall task performance. Overall, the results from these analyses suggest that performance on the category fluency task varied based on whether the task was completed in English or another language and this effect varied based on both language combination and proficiency. See Figure 3 for a comparison of category fluency performance in each task language by language combination.

A backward stepwise regression analysis measuring whether exposure, confidence, use, and self-rating of language ability predicted the difference in the number of correct items produced in English and participants' other language across the three main categories was used to further investigate the effects of proficiency on task performance. The analysis revealed that the most predictive model included exposure only ($F(1, 94) = 51.284$, $p < .001$, $\beta = 0.594$). Four steps were needed to obtain this model and all variables except relative exposure were removed. The model accounted for approximately 35.3% of the variance of relative category fluency performance (R^2 = 0.353, Adjusted R^2 = 0.346). The exposure component includes participants' relative exposure to hearing, speaking, and reading each language, their parents' proficiency in each language, and the amount of education they had in each language. Thus, the degree to which one is exposed to each language predicts their ability to access lexical items in each language.

Research Question 3: Effects of Category on Performance

Main categories in English. Results from a one-way MANOVA for English responses revealed that the overall effect of the total number of correct items named in English in each of the main categories was significant ($F(12, 270.158) = 8.335$, $p < .001$; Wilks' $\Lambda = 0.435$, partial $\eta^2 = .243$). The main effect for the total number of correct items named in English in each of the main categories was significant for *clothing* ($F(4, 104) = 4.757$; $p = .001$, partial $\eta^2 = .155$), *animals* ($F(4, 104) = 23.429$, $p < .001$, partial $\eta^2 = .474$), and *food* ($F(4, 104) = 5.683$, $p < .001$, partial $\eta^2 = .179$). Post-hoc LSD tests revealed differences between individual language combinations. Speakers of Spanish-English named significantly more correct *clothing* items in English than did speakers of Mandarin-English and Turkish-English ($p < .001$). Participants who spoke Turkish-English named significantly fewer correct *animals* in English than did speakers of all other language combinations ($p < .001$) and speakers of Mandarin-English named significantly fewer correct *animals* in English than did speakers of Hindi-English, Kannada-English, and Spanish-English ($p < .04$). Additionally, speakers of Hindi-English and Spanish-English named significantly more correct English *foods* than did speakers of Mandarin-English and Turkish-English ($p < .025$) and speakers of Hindi-English named significantly more correct English *foods* than did speakers of Kannada-English ($p = .009$). See Figure 4 for a graph of results.

Main categories in other languages. Results from a second one-way MANOVA for responses in participants' other language revealed that the overall effect of the total number of correct items named in participants' other language in each of the main categories was significant ($F(12, 302) = 3.298$, $p < .001$; Wilks' $\Lambda = 0.709$, partial $\eta^2 = .108$). The main effect was significant for *clothing* ($F(4, 104) = 2.459$; $p = .050$, partial $\eta^2 = .086$), *animals* ($F(4, 104) = 3.971$, $p = .005$, partial $\eta^2 = .132$), and *food* ($F(4, 104) = 3.771$, $p = .007$; partial $\eta^2 = .127$). Post-hoc LSD tests revealed differences between individual language combinations. Speakers of Spanish-English named significantly more correct *clothing* items in their non-English language than did speakers of Kannada-English and Mandarin-English ($p < .025$). Participants who spoke Mandarin-English named a significantly greater number of correct *animals* in their non-English language than did participants who spoke Hindi-English, Spanish-English, and Turkish-English ($p < .04$) and speakers of Kannada-English named more correct *animals* than did speakers of Turkish-English ($p = .012$). Additionally, speakers of Spanish-English and Turkish-English named significantly more correct *foods* in their non-English language than did speakers of Kannada-English and Mandarin-English ($p < .04$) and speakers of Hindi-English named more correct *foods* than did speakers of Mandarin-English ($p = .043$). See Figure 5 for a graph of results.

Subcategories in English. Results from a third one-way MANOVA for responses in English revealed that the overall effect of the total number of correct items named in English in each of the subcategories was significant ($F(24, 346.580) = 4.727$, $p < .001$; Wilks' $\Lambda = 0.372$, partial $\eta^2 = .219$). The main effect of language combination differences was significant for *hot weather clothing* ($F(4, 104) = 6.244$, $p < .001$, partial $\eta^2 = .194$), *cold weather clothing* ($F(4, 104) = 7.159$, $p < .001$, partial $\eta^2 = .216$), *farm animals* ($F(4, 104) = 7.710$, $p < .001$, partial $\eta^2 = .229$), *zoo animals* ($F(4, 104) = 6.907$, $p < .001$, partial $\eta^2 = .210$), *lunch foods* ($F(4, 104) = 11.698$, $p < .001$, partial $\eta^2 = .310$), and *birthday foods* ($F(4, 104) = 19.296$, $p < .001$, partial $\eta^2 = .426$). Post-hoc LSD tests revealed differences between individual language combinations. See Figure 6 for a graph of results.

Hot weather clothing. Speakers of Hindi-English named significantly more correct *hot weather clothing* items in English than did speakers of Turkish-English ($p = .004$) and speakers of Spanish-English named significantly more correct *hot weather clothing* items than did speakers of Kannada-English and Turkish-English ($p < .035$).

Cold weather clothing. Speakers of Hindi-English, Spanish-English, and Kannada-English named significantly more correct English *cold weather clothing* items than did speakers of Turkish-English ($p < .035$). Additionally, participants who spoke Spanish-English named a significantly greater number of correct *cold weather clothing* items than did participants who spoke Kannada-English and Mandarin-English ($p < .04$).

Farm animals. Speakers of Turkish-English named significantly fewer correct English *farm animals* than did speakers of all other language combinations ($p < .001$).

Zoo animals. Speakers of Turkish-English named significantly fewer correct English *zoo animals* than did speakers of all other language combinations ($p < .003$).

Lunch foods. Participants who spoke Turkish-English named significantly fewer correct English *lunch foods* than did speakers of all other language combinations ($p < .04$). Furthermore, speakers of Kannada-English named significantly fewer correct *lunch food* items in English than did speakers of Mandarin-English and Spanish-English ($p < .02$).

Birthday foods. Participants who spoke Turkish-English named significantly fewer correct English *birthday foods* than did participants who spoke Hindi-English, Kannada-English, Mandarin-English, and Spanish-English ($p < .001$). Additionally, speakers of Spanish-English named significantly more correct English *birthday foods* than did speakers of Hindi-English and Mandarin-English ($p < .02$).

Subcategories in other languages. Results from a fourth one-way MANOVA for responses in participants' other language revealed that the overall effect of the total number of correct items named in the other language in each of the subcategories was significant ($F(24, 346.580) = 4.819$, $p < .001$; Wilks' $\Lambda = 0.366$, partial $\eta^2 = .222$). The main effect of language combination was significant for *hot weather clothing* ($F(4, 104) = 3.346$, $p = .013$, partial $\eta^2 = .114$), *cold weather clothing* ($F(4, 104) = 3.381$, $p = .012$, partial $\eta^2 = .115$), *farm animals* ($F(4, 104) = 5.573$, $p < .001$, partial $\eta^2 = .177$), *zoo animals* ($F(4, 104) = 4.131$, $p = .004$, partial $\eta^2 = .137$), *lunch foods* ($F(4, 104) = 5.217$, $p = .001$, partial $\eta^2 = .167$), and *birthday foods* ($F(4, 104) = 11.975$, $p < .001$, partial $\eta^2 = .315$). Post-hoc LSD tests revealed differences between individual language combinations. See Figure 7 for a graph of results.

Hot weather clothing. Speakers of Hindi-English and Spanish-English named significantly more correct *hot weather clothing items* in their non-English language than did speakers of Mandarin-English and Turkish-English ($p < .04$).

Cold weather clothing. Participants who spoke Hindi-English and Spanish-English named a significantly greater number of correct *cold weather clothing* items in their non-English language than did participants who spoke Kannada-English and Mandarin-English ($p < .025$).

Farm animals. Speakers of Mandarin-English and Kannada-English named significantly more correct *farm animals* in their non-English language than did speakers of Spanish-English and Turkish-English ($p < .035$) and speakers of Mandarin-English named more correct *farm animals* than did speakers of Hindi-English ($p < .033$).

Zoo animals. Participants who spoke Mandarin-English named significantly more correct *zoo animals* in their non-English language than did participants who spoke Hindi-English, Spanish-English, and Turkish-English ($p < .015$).

Lunch foods. Speakers of Turkish-English named significantly fewer correct *lunch foods* in their non-English language than did speakers of all other language combinations ($p < .045$).

Birthday foods. Participants who spoke Turkish-English named significantly fewer *birthday foods* in their non-English language than did speakers of all other language combinations ($p < .001$). Furthermore, speakers of Kannada-English named significantly more *birthday foods* in their non-English language than did speakers of

Mandarin-English and Spanish-English ($p < .04$).

Follow-up Analyses

Follow-up analyses were run to determine if there were any differences in the numbers of incorrect items named across language combinations that may have inflated the differences between correct items, particularly those between Turkish-English speakers and speakers of all other languages. For instance, if Turkish-English participants had named more subordinate items than speakers of other languages, their correct item score would be deflated compared to the number of items they listed in total. A one-way MANOVA using language combination as the independent variable and the average number of incorrect items except for repetitions produced in each language revealed that the overall effect of the average number of incorrect items named in each language combination was significant ($F(8, 206) = 13.539$, $p < .001$, Wilks' $\Lambda = 0.430$, partial $\eta^2 = .345$). The main effect was significant for both English ($F(4, 104) = 10.370$, $p < .001$, partial $\eta^2 = .285$) and the other languages ($F(4, 104) = 20.907$, $p < .001$, partial $\eta^2 = .446$). However, post-hoc LSD analyses indicated that speakers of Turkish-English named significantly fewer incorrect English items than did speakers of all other language combinations ($p < .03$). Thus, Turkish-English speakers named fewer items overall than did speakers of the other four language combinations.

DISCUSSION

The aim of the present study was to investigate the effect of language combination and proficiency on category fluency performance in a group of healthy bilingual individuals. Speakers of five different language combinations (Hindi-English, Kannada-English, Mandarin-English, Spanish-English, and Turkish-English) completed a language use questionnaire and a category fluency task in each of their languages. The following research questions were addressed: (1) Is there an effect of language combination on lexical access? (2) How does relative proficiency in each language relate to performance across the different groups of participants? (3) How does the nature of each category influence lexical access? It was hypothesized that (1) speakers of different language combinations would perform differently on the category fluency task, (2) greater relative proficiency in one language would predict a greater number of items named in that language across language combinations, and (3) there would be differences between language combinations across the three categories of *food*, *clothing*, and *animals* as well as across subcategories. It was further hypothesized that clothing and animals would generate similar results across language combinations, while food would generate different results for various combinations.

It was found that lexical access varied based on the language combinations that we studied. To examine the effect of language combination, we examined the number of items produced in English by each language group. Participants who spoke Hindi-English, Kannada-English, Mandarin-English, and Spanish-English named significantly more correct items in English than did speakers of Turkish-English. The fact there were significant differences based on language combination for the English portion of the task provides a window into lexical or cultural differences based on language combination. Because English is a common language for all participants, any differences based on language combination must be due to the influence of the other language or differences in culture. The data for the Kannada-English and Turkish-English speakers were collected outside of the United States, while the data for the Hindi-English, Mandarin-English, and Spanish-English speakers were collected in Austin, Texas. Cultural differences based on where participants lived and grew up as well as differences in cultural heritage may have affected lexical access. Differences in category fluency performance could also be due to variation in the non-English languages. Most of the languages in this study come from different language families. Spanish and Hindi are Indo-European languages, Kannada is a Dravidian language, Mandarin is a Sino-Tibetan language, and Turkish is a Turkic language (Dalby, 1998). The fact that Hindi and Spanish come from the same language family may explain the similar performances of Hindi-English and Spanish-English speakers in this study.

Additionally, it was found that proficiency plays a role in lexical access. Four components were extracted from the 15 scores of the language use questionnaire: exposure, use, confidence, and self-rating of language ability. These factors were then used to examine the role of proficiency in performance on the category fluency task. Participants' relative exposure in each language significantly affected category fluency production. When the effects of exposure were controlled for, the effect of language combination was no longer significant, indicating that differences between the number of items were not significant after accounting for differences in individual's level of exposure. In other words, relative exposure to each language accounts for some of the differences found based on language combination. This finding is not surprising because it means that the amount of exposure one has to each of their languages has an effect on their ability to access words in each language. Previous studies have suggested that age of acquisition affects verbal fluency performance (Poreh & Schweiger, 2002). While an earlier age of acquisition of an L2 does not necessarily mean increased exposure over the course of one's lifetime, this is most likely the case for many individuals. None of the other proficiency variables had a significant effect on category fluency performance.

The impact of exposure on lexical access was further supported using a backward stepwise regression analysis. This analysis found that the best model for predicting relative performance on the category fluency task included only relative exposure as an independent variable. In other words, relative exposure significantly predicted relative performance on the category fluency task, further bolstering the conclusion that exposure plays a significant role in bilingual lexical access.

Additionally, performance on the category fluency task varied based on whether the task was completed in English or in participants' other language. The interaction effects of task language and relative confidence and exposure on category fluency performance were significant, suggesting that both confidence and exposure play a role in category performance in a particular task language. The effect of task language also varied based on language combination. Speakers of all languages except Turkish-English named more correct items in English than in their other language.

These findings support the use of the RHM as a model for bilingual lexical access. The RHM predicts that as proficiency in a language increases, the conceptual link between the language and the concept strengthens (Kroll & Stewart, 1994). Category fluency tasks ask participants to name words based on a concept. If one is not highly proficient in L2, he or she may need to use the conceptual link from the concept to L1 and then the lexical link from L1 to L2 to name the item. As proficiency increases and the connection between L2 and the concept strengthens, one can take a faster route directly from the conceptual system to the word in L2. In the present study, Mandarin-English speakers named fewer items in English than Spanish-English speakers. The Mandarin-English bilinguals in this study had less exposure to English than did the Spanish-English bilinguals. Thus, the Mandarin-English speakers may have needed to use a route from the concept to the Mandarin lexical system and then use a lexical link to translate from Mandarin to English to access an English word while the Spanish-English speakers could use a route directly from the conceptual system to the English word. In this way, the RHM accounts for the proficiency-based differences in category fluency performances seen in this study.

In addition, the amount of correct items participants named in each category varied based on language combination, although speakers of some language combinations performed more similarly than others for specific categories. In the main categories, there was no difference in the number of correct *clothing* items produced in both English and participants' other language by speakers of most language combinations. However, the number of correct *animals* and *foods* varied to a greater extent based on language combination. In English subcategories, there were more differences between language combinations when naming *foods* than when naming *clothing* and *animals*. In the other language subcategories, there were more differences between language combinations when naming *birthday foods* and *farm animals* than when naming *clothing* items, *zoo animals*, or *lunch foods*. It is possible that cultural differences may contribute to greater amount of variation in some categories; cultural differences likely play a role in the greater variation in the number of items named in *food* categories across language combinations because food has such a strong cultural significance. An early study by Ronch, Cooper, and Fishman (1969) found that Yiddish-English speakers who participated in a word naming task performed better in Yiddish than in English when naming items related to culture and a Passover seder. They performed better in English when naming words related to the home and performed equally well in both languages when naming words related to the neighborhood and work. These results suggest that items that are culturally salient may be more easily accessed in one of a bilingual's languages. Because food carries cultural significance for many cultures, it is unsurprising that the *food* categories (both the main category and the subcategories) produced a greater degree of variation across language combinations than most of the other categories.

Additionally, although Roberts and Le Dorze (1997) did not find differences in the number of animals named by French-English bilinguals in each of their languages, they did find that participants produced significantly longer semantic associations and a greater percentage of words in semantic associations in French than in English. In the present study, subordinate items were classified as incorrect and were not included in the total number of correct items named in each category. Semantic associations are likely to include subordinate items (e.g., "polar bear," "brown bear," "grizzly bear"). Although analyses for the number of incorrect items named in each category were not completed, there were differences in the number of correct items named across categories based on language combination. Thus, differences in the number of incorrect items may have increased the differences in the total number of items named in the *animals* category across language combinations. Differences in the number of *animals* named across language combinations may also be due to geographic variation. Carneiro, Albuquerque, and Fernandez (2008) noted that the norms for category generation may be influenced by both culture and geographic region; for this reason, separate norms may need to be developed for different regions.

Because subordinate items were scored as incorrect in this study, it is possible that participants' scores were deflated and that they had access to more words than were counted in the analysis. This was a particular concern for the Turkish-English group, who scored lower than all of the other languages in English production. To account for this, a follow-up analysis assessing whether there were differences in the number of incorrect items (other than repetitions) named by speakers of each language combination was completed. Turkish-English speakers named fewer incorrect items in English than did speakers of all other language combinations. Thus, their correct score was not deflated by a high amount of code-switched or subordinate items. There may be something different about the way Turkish-English speakers access lexical items that is not well-suited to a category fluency task. It is also possible that the sample of Turkish-English speakers used in this study were less fluent in English than in Turkish. However, they named fewer items in many of the categories in Turkish than did speakers of other language combinations in their non-English languages.

Limitations

One limitation of this study is that it is impossible to separate cultural effects from linguistic effects. Perhaps one language combination produced more *birthday food* items than another because birthday celebrations have a larger variety of food in that culture. Pekkala et al. (2009) concluded that sociocultural differences affected qualitative category fluency performance, so it is possible that these differences affected quantitative performance as well.

A second limitation is that all data was coded by a single English-speaking individual. Thus, the coding may have an English bias. It is possible that items that are considered subordinate in English may be basic in another language. However, the fact that there was a single scorer also provides a degree of consistency of scoring across the data set.

Furthermore, there were different numbers of participants in each language combination and some groups were much smaller than others. This study should be replicated with a larger sample size and with groups of equal sizes.

Future Directions

The current study focused on the quantitative differences in category fluency production based on language combination and category. Future studies should investigate the qualitative differences, as there may be differences in the types of items produced by speakers of different language combinations. Do speakers of certain languages name more subordinate items than speakers of another language? When asked to name food items, are speakers of one language more likely to name dishes while speakers of another language are more likely to list fruits, vegetables and types of meat? Future studies may also wish to investigate differences in degree of code-switching based on language combination.

Another direction for this study is to create a set of category fluency norms for bilingual speakers of various languages. Category fluency is often used as a diagnostic tool for people with aphasia and cognitive disorders (Tombaugh, Kozak, & Rees, 1999). However, there are no norms for category fluency for bilingual speakers of most language combinations, which means there is no basis for comparison when a speaker of one such language is assessed using category fluency.

CONCLUSIONS

The results of this study suggest that bilingual lexical access varies based on language combination. Even in the same language, speakers of different language combinations produced different numbers of items. Proficiency, particularly the degree of exposure to each language, also plays a role in lexical access as shown by the fact that relative exposure significantly predicted relative performance on the category fluency task. Category fluency performance is also affected by the language and category in which the task was completed.

APPENDIX A

Track 1 – Session 1

Task	Language
Category generation: Clothing	English
Category generation: Animals in zoo	English
Category generation: Foods	English
Category generation: Animals in a farm	English
Category generation: Food for lunch	Language 2
Category generation: Clothing when it is warm	Language 2
Category generation: Animals	Language 2
Category generation: Clothing when it is cold	Language 2
Category generation: Meals at birthday celebration	Language 2
Word familiarity task/AOA (age of acquisition)	Language 2
Language Use Questionnaire	Language 2

Track 1 – Session 2

Task	Date
Category generation: Animals in a zoo	Language 2
Category generation: Foods	Language 2
Category generation: Clothing	Language 2
Category generation: Animals in a farm	Language 2
Category generation: Clothing in cold weather	English
Category generation: Foods for lunch	English
Category generation: Clothing in warm weather.	English
Category generation: Foods at a birthday part	English
Category generation: Animals	English

Track 2 – Session 1

Task	Date
Category generation: Clothing	Language 2
Category generation: Animals in a zoo	Language 2
Category generation: Foods	Language 2
Category generation: Animals in a farm	Language 2
Category generation: Foods to lunch	English
Category generation: Clothing in warm weather	English
Category generation: Animals	English
Category generation: Clothing in cold weather	English
Category generation: Foods in a birthday party	English
AOA	
Questionnaire	

Track 2 – Session 2

Task	Date
Category generation: Animals at the zoo	English
Category generation: Foods	English
Category generation: Clothing	English
Category generation: Animals in a farm	English
Category generation: Clothing in cold weather	Language 2
Category generation: Food for lunch	Language 2
Category generation: Clothing in warm weather	Language 2
Category generation: Food in a birthday celebration	Language 2
Category generation: Animals	Language 2

APPENDIX B

Sample of Scored Items: English

Category	**Correct**	**Code-switched**	**Code-switched from third language**	**Borrowed**	**Borrowed from third language**	**Superordinate**	**Subordinate**	**No English Translation**	**Incorrect**
Clothing	Trousers	*Lehanga* (Hindi)	N/A	*Saree* (Hindi)	*Dhoti* (Kannada)	Indian clothes	Jeans	N/A	Handkerchief
Hot Weather Clothing	Shirt	*Chappals* | sandals (Kannada)	N/A	*Chudidar* (Kannada)	*Dothi* (Kannada)	Thin clothes	T-shirt	N/A	Handkerchief
Cold Weather Clothing	Sweater	Full sleeves t-shirt (Hindi)	N/A	*Jerkin* (Kannada)	N/A	Warm clothing	Jeans	N/A	Full sleeves
Animals	Lion	*Sambars* | deer (Kannada)	N/A	N/A	N/A	Fish	Water buffalo	N/A	Amoeba
Farm Animals	Cow	N/A	N/A	N/A	N/A	Birds	Lamb	N/A	People
Zoo Animals	Tiger	*Sarang* | deer (Kannada)	N/A	N/A	N/A	Fish	White tiger	N/A	Humans
Food	Rice	*Chawal* | rice (Hindi)	N/A	*Roti* (Hindi)	*Sashimi* (Mandarin)	Fruits	Black beans	N/A	Medicinal extracts
Lunch Foods	Burger	*Dal* (Hindi)	N/A	*Curry* (Hindi)	*Sabji* | vegetable curry (Kannada)	Vegetables	Spaghetti	N/A	Fingertips
Birthday Foods	Cake	Vegetable *palav* (Kannada)	*Bath* | rice (Kannada)	*Samosa* (Hindi)	*Sushi* (Mandarin)	Sweets	Mini burger	N/A	Carbohydrated drinks

Sample of Scored Items: Hindi

Category	Correct	Code-switched	Code-switched from third language	Borrowed	Borrowed from third language	Superordinate	Subordinate	No English Translation	Incorrect
Clothing	*Topi* | hat	Suit	N/A	Jacket	N/A	N/A	Baniyan | *undershirt*	*Salwar*	*Toliya* | towel
Hot Weather Clothing	*Mozhe* | socks	Socks	N/A	Jeans	N/A	N/A	Baniyan | *undershirt*	*Kameez*	*Chashma* | eyeglasses
Cold Weather Clothing	*Pantaloon* | pants	Shirt	N/A	Sweater	N/A	N/A	Woolen jacket	*Kurta*	*Rumal* | handkerchief
Animals	*Balu* | bear	N/A	N/A	Cheetah	N/A	*Panchi* | bird	*Safeed shear* | type of lion	*Cheel*	N/A
Farm Animals	*Bhel* | ox	N/A	N/A	Turkey	N/A	*Chidiya* | bird	N/A	*Chitti*	N/A
Zoo Animals	*Shear* | lion	Hippopotamus	N/A	Giraffe	N/A	*Machali* | fish	*Papar shear* | type of lion	*Bhagera*	N/A
Food	*Chawal* | rice	Bread	N/A	Pasta	N/A	*Sabzi* | vegetables	*Roti*	*Seetapal*	N/A
Lunch Foods	*Kela* | banana	Rice	N/A	Cereal	N/A	*Sabzi* | vegetables	*Roti*	*Tori*	N/A
Birthday Foods	*Aam* | mango	Juice	N/A	Burger	N/A	*Mittai* | sweets	*Masala dosa*	*Gatiya*	N/A

Sample of Scored Items: Kannada

Category	Correct	Code-switched	Code-switched from third language	Borrowed	Borrowed from third language	Superordinate	Subordinate	No English Translation	Incorrect
Clothing	*Chaddi* | shorts	Jacket	*Dothi*	Sweater	N/A	Partywear	*Baninu* | undershirt	*Chudidara*	Minis
Hot Weather Clothing	*Chaddi* | *shorts*	Shorts	*Dothi*	Bermuda	N/A	Cotton clothes	*Chappal* | sandals	*Jubba*	Topless
Cold Weather Clothing	*Muffleru* | scarf	Socks	*Saree*	Jeans	N/A	*Becchagiruva battegalu* | warm clothes	*Jerkin* | type of jacket	*Chudidar galu*	Woolen materialu
Animals	*Bekku* | cat	Wolf	N/A	Giraffe	N/A	*Meenu* | fish	*Havrani* | garden lizard	N/A	*Kalingasarpa* | five-headed serpent
Farm Animals	*Koli* | hen	Mule	N/A	*Mongoosee* | mongoose	N/A	*Pakshi* | bird	*Karugalu* | calves	N/A	*Marushya* | human
Zoo Animals	*Aane* | elephant	Cheetah	N/A	Zebra	N/A	*Meenu* | fish	*Hebbavu* | python	N/A	Man
Food	*Kosu* | cabbage	Chicken curry	*Bath*	Coffee	N/A	*Meenu* | fish	*Mosaranna* | yogurt rice	*Puri*	*Panpattu*
Lunch Foods	*Mosaru* | yogurt	Vegetable rice	*Bath*	Tomato	N/A	*Kaipalye* | vegetables	*Kosambri* | legume salad	*Parata*	*Kanbattu*
Birthday Foods	*Anna* | rice	Vegetable rice	N/A	Cake	N/A	*Madhyepana* | alcohol	*Parota*	*Jamoon*	Dinner

Sample of Scored Items: Mandarin

Category	**Correct**	**Code-switched**	**Code-switched from third language**	**Borrowed**	**Borrowed from third language**	**Superordinate**	**Subordinate**	**No English Translation**	**Incorrect**
Clothing	*Xie* | shoes	Polo *shan* | polo shirt	N/A	T-shirt	N/A	*Xiu xian yi* | leisure wear	*Pi xie* | leather shoes	N/A	*Er zhao* | earmuff
Hot Weather Clothing	*Qun zi* | skirt	Sandals	N/A	T-shirt	N/A	*Dong dong zhuang* | breezy outfits	*Liang xie* | sandals	N/A	*Tai yang yan jing* | sunglasses
Cold Weather Clothing	*Mao yi* | sweater	Sweater	N/A	N/A	N/A	N/A	*Yu rong fu* | down jacket	N/A	*Hu xi* | kneepad
Animals	*Shi zi* | lion	Kangaroo	N/A	N/A	N/A	*Xiao niao* | bird	*Hai gui* | sea turtle	N/A	*Ren lei* | human
Farm Animals	*Niu* | cow	N/A	N/A	N/A	N/A	*Xiao niao* | *bird*	*Xiao ya* | duckling	N/A	*Ren lei* | *human*
Zoo Animals	*Hou zi* | monkey	Shark	N/A	Mammal	N/A	*Yu* | fish	*Xiong mao* | panda	N/A	*Guan li yuan* | zookeeper
Food	*Mi fan* | rice	Pepperoni roll	N/A	Spaghetti	*Shusi* | sushi	*Rou* | meat	*Pai gu* | pork rib	N/A	*Zhu shi* | main dish
Lunch Foods	*Luo bo* | daikon	Yogurt	N/A	Pizza	Sashimi	*Shu cai* | vegetables	*Mi fen* | rice noodles	N/A	Subway
Birthday Foods	*Ping gao* | apple	*Shui gao pai* | fruit pie	N/A	Pizza	N/A	*Shui guo* | fruit	*Chang shou mian* | longevity noodles	N/A	*Ma ma de hao cai* | tasty dish made by mom

Sample of Scored Items: Spanish

Category	Correct	Code-switched	Code-switched from third language	Borrowed	Borrowed from third language	Superordinate	Subordinate	No English Translation	Incorrect
Clothing	*Vestidos* | dresses	Pants	N/A	Shorts	N/A	*Ropa deportiva* | gym clothes	*Tenis* | tennis shoes	N/A	Calcetones
Hot Weather Clothing	*Faldas* | skirts	Capris	N/A	Shorts	N/A	N/A	*Sandalias* | flip flops	N/A	*Lentes* | glasses
Cold Weather Clothing	*Chamarra* | jacket	Pants	N/A	*Suéter* | sweater	N/A	N/A	*Botas* | boots	N/A	*Paraguas* | umbrella
Animals	*Perro* | dog	N/A	N/A	Hamster	N/A	*Pajaros* | birds	*Chivo* | kid	N/A	Rinoscero
Farm Animals	*Vacas* | cows	N/A	N/A	N/A	N/A	*Pajaros* | birds	*Pollito* | chick	N/A	N/A
Zoo Animals	*Gorilas* | gorillas	N/A	N/A	N/A	N/A	*Pescados* | fish	*Anaconda* | anaconda	N/A	Rinoscero
Food	*Pan* | bread	N/A	N/A	Pizza	N/A	*Pescados* | fish	*Jugo de naranja* | orange juice	N/A	N/A
Lunch Foods	*Arroz* | rice	Pancakes	N/A	Sandwiches	N/A	*Pescado* | fish	*Pollo frito* | fried chicken	N/A	N/A
Birthday Foods	*Pastel* | cake	Cupcakes	N/A	Pizza	N/A	*Botanas* | appetizers	*Salsa picante* | spicy sauce	N/A	N/A

Sample of Scored Items: Turkish

Category	Correct	Code-switched	Code-switched from third language	Borrowed	Borrowed from third language	Superordinate	Subordinate	No English Translation	Incorrect
Clothing	*Palto* | coat	Jean	N/A	*Şort* | shorts	N/A	N/A	*Tişört* | t-shirt	N/A	*Toka* | buckle
Hot Weather Clothing	*Şapka* | hat	N/A	N/A	Bikini	N/A	N/A	*Sandalet* | sandals	N/A	*İnce penyeler* |thin texture
Cold Weather Clothing	*Eldiven* | gloves	Sweatshirt	N/A	N/A	N/A	N/A	*Bot* | short boots	N/A	*Yağmur* | rain
Animals	*Kedi* | cat	N/A	N/A	*Pelikan* | pelican	N/A	*Kuş* | bird	*Kuzu* | lamb	N/A	*Domuz* | pork
Farm Animals	*Koyun* | sheep	N/A	N/A	N/A	N/A	*Balık* | fish	*Kuzu* | lamb	N/A	*Domuz* | pork
Zoo Animals	*Aslan* | lion	Gorilla	N/A	Flamingo	N/A	*Kuş* | bird	*Kutup ayısı* | polar bear	N/A	*Sürafa*
Food	*Makarna* | pasta	N/A	N/A	Hamburger	N/A	*Et* | meat	*Mandalina* | tangerine	N/A	*Sabah kahvaltısı* | breakfast
Lunch Foods	*Ekmek* | bread	Yogurt	N/A	Hamburger	N/A	*Meyve* | fruit	*Patates kız* | fried potatoes	N/A	*Türlü* | hodge podge
Birthday Foods	*Pasta* | cake	N/A	N/A	*Cips* | chips	N/A	*Çerez* | snacks	*Tuzlu kurab* | salted cookies	N/A	*Ev yapımı şeyler* | homemade things

TABLES AND FIGURES

Table 1

Means and Standard Deviations by Language Combination and Category

Language Combination			Hindi-English		Kannada-English		Mandarin-English		Spanish-English		Turkish-English	
Category	Task Language		E	H	E	K	E	M	E	S	E	T
		N	14	14	14	14	30	30	29	29	22	22
	All Clothing	Mean	11.14	9.36	10.57	8.29	9.50	8.37	12.86	10.59	9.05	9.00
		SD	3.30	2.98	4.33	3.36	3.25	3.03	4.19	3.15	2.57	2.58
	Hot Weather Clothing	Mean	4.71	4.36	3.93	3.43	3.60	2.87	5.21	4.17	2.86	3.09
		SD	1.38	1.98	2.37	2.17	1.99	1.48	1.88	1.69	1.21	1.51
	Cold Weather Clothing	Mean	8.43	6.79	7.43	4.36	6.87	5.00	9.31	6.45	5.36	5.27
		SD	1.91	2.81	3.13	2.10	3.13	1.46	3.13	3.10	1.76	2.05
	All Animals	Mean	23.21	16.07	23.57	19.29	19.87	20.17	23.55	16.69	12.00	14.09
		SD	5.13	5.41	3.92	4.25	4.84	3.85	4.69	6.53	4.81	8.24
	Farm Animals	Mean	10.43	8.36	10.79	10.07	9.90	10.67	9.97	7.72	5.95	6.91
		SD	2.87	3.05	4.89	4.48	2.90	3.24	3.42	3.63	2.01	1.85
	Zoo Animals	Mean	15.21	10.07	17.50	13.21	14.47	15.13	16.17	12.24	10.00	11.91
		SD	7.12	4.51	3.96	4.17	3.88	3.93	6.14	3.98	2.49	4.80
	All Foods	Mean	20.79	15.64	14.36	11.93	14.10	11.87	17.97	16.52	11.95	16.05
		SD	5.70	4.60	5.05	3.67	6.36	6.02	6.61	4.52	7.10	7.86
	Lunch Foods	Mean	13.14	13.36	10.14	11.00	13.50	11.10	14.55	13.10	7.00	7.86
		SD	4.59	4.25	5.02	4.22	4.42	4.92	4.69	4.78	2.71	3.54
	Birthday Foods	Mean	9.29	8.57	11.64	10.86	10.27	7.53	12.62	8.66	3.91	3.86
		SD	3.50	2.85	5.49	4.35	3.41	3.07	3.76	3.62	2.49	2.14

Note. Task language is denoted by the first letter of the language (e.g., English is denoted by "E," Hindi is denoted by "H").

Table 2

Means and Standard Deviations for English Language Use Questionnaire Items by Language Combination

		Hindi-English	Kannada-English	Mandarin-English	Spanish-English	Turkish-English
	N	13	12	29	26	16
Exposure for Hearing	**Mean**	53.01	54.35	29.49	62.34	31.73
	SD	13.96	14.90	13.55	20.50	10.23
Exposure for Speaking	**Mean**	50.16	53.41	27.31	63.43	34.04
	SD	17.41	18.88	17.18	21.12	12.80
Exposure for Reading	**Mean**	76.83	55.84	36.46	80.00	42.56
	SD	13.80	21.06	18.77	16.91	12.46
Confidence in Hearing	**Mean**	83.05	47.79	67.02	86.84	61.39
	SD	13.86	23.54	41.05	23.95	27.73
Confidence in Speaking	**Mean**	76.70	42.87	61.34	85.75	61.50
	SD	16.86	19.99	40.24	26.02	24.36
Confidence in Reading	**Mean**	89.63	48.23	67.92	92.57	68.64
	SD	8.11	14.37	40.11	22.89	24.75
Input	**Mean**	72.06	46.16	81.98	77.97	20.83
	SD	18.05	21.11	16.10	14.06	22.41
Output	**Mean**	72.06	46.16	81.36	74.20	20.22
	SD	18.05	21.11	15.69	21.60	22.23
Total Use	**Mean**	27.94	53.84	40.06	22.14	75.57
	SD	18.05	21.11	15.04	14.53	21.49
Age	**Mean**	26.46	27.17	25.20	23.90	38.35
	SD	2.33	9.49	5.44	7.40	10.23
Mother's Proficiency	**Mean**	61.54	41.67	30.36	70.00	12.50
	SD	42.84	35.89	29.15	36.08	22.36
Father's Proficiency	**Mean**	75.00	68.75	35.71	76.00	14.06
	SD	30.62	24.13	29.99	34.97	28.82
Siblings' Proficiency	**Mean**	87.50	70.83	65.00	97.92	43.75
	SD	21.25	32.37	36.63	7.06	44.33
Education	**Mean**	55.56	46.76	39.08	75.43	34.72
	SD	20.29	18.87	26.50	18.34	19.51
Self-Rating of Language Ability	**Mean**	95.64	84.44	91.84	98.21	95.00
	SD	7.86	10.86	11.04	3.68	5.71

Table 3

Means and Standard Deviations for Non-English Language Use Questionnaire Items by Language Combination

		Hindi-English	Kannada-English	Mandarin-English	Spanish-English	Turkish-English
	N	13	12	29	26	16
Exposure for Hearing	**Mean**	46.99	42.63	70.51	37.66	68.27
	SD	13.96	17.70	13.55	20.50	10.23
Exposure for Speaking	**Mean**	49.84	42.99	72.69	36.57	65.96
	SD	17.41	22.41	17.18	21.12	12.80
Exposure for Reading	**Mean**	23.17	42.55	63.54	20.00	57.44
	SD	13.80	20.28	18.77	16.91	12.46
Confidence in Hearing	**Mean**	84.98	73.38	134.41	76.06	96.96
	SD	17.11	17.02	53.03	27.88	9.33
Confidence in Speaking	**Mean**	83.32	69.91	131.42	68.50	103.56
	SD	18.13	17.03	51.94	30.67	26.66
Confidence in Reading	**Mean**	73.66	52.02	126.15	64.45	94.64
	SD	26.54	19.70	54.79	28.23	12.93
Input	**Mean**	27.94	53.84	18.02	22.03	72.92
	SD	18.05	21.11	16.10	14.06	29.15
Output	**Mean**	27.94	53.84	18.64	21.95	67.28
	SD	18.05	21.11	15.69	16.05	33.49
Total Use	**Mean**	27.94	53.84	40.06	22.14	75.57
	SD	18.05	21.11	15.04	14.53	21.49
Age	**Mean**	26.46	27.17	25.20	23.90	38.35
	SD	2.33	9.49	5.44	7.40	10.23
Mother's Proficiency	**Mean**	92.31	93.75	97.41	74.04	96.88
	SD	12.01	11.31	10.23	42.12	8.54
Father's Proficiency	**Mean**	84.62	91.67	97.41	67.00	98.33
	SD	16.26	16.28	7.75	43.73	6.45
Siblings' Proficiency	**Mean**	87.50	80.56	92.50	56.25	88.75
	SD	13.18	33.82	18.32	39.18	30.86
Education	**Mean**	44.44	53.24	60.92	24.57	65.28
	SD	20.29	18.87	26.50	18.34	19.51
Self-Rating of Language Ability	**Mean**	83.33	90.83	77.82	82.63	98.75
	SD	11.14	9.55	10.77	10.56	5.00

Table 4

Factor Loadings for English Language Use Questionnaire Items

	Component 1	**Component 2**	**Component 3**	**Component 4**
Confidence in Hearing	0.243947	0.088850	*0.927504*	0.033676
Confidence in Speaking	0.285190	0.099663	*0.913483*	0.127846
Confidence in Reading	0.236639	0.057940	*0.931353*	0.018753
Exposure for Hearing	*0.906685*	0.050039	0.193173	0.018290
Exposure for Speaking	*0.886676*	0.045460	0.178573	0.054260
Exposure for Reading	*0.785506*	0.076707	0.347221	-0.143271
Total Use	0.339615	*0.848560*	0.222937	0.041545
Input	0.100360	*0.934760*	0.163526	0.050072
Output	0.048741	*0.916306*	0.136318	0.045367
Age	-0.136876	*-0.632818*	0.114097	-0.011707
Mother's Proficiency	*0.691034*	0.308540	0.196430	0.139435
Father's Proficiency	*0.795568*	0.222764	0.088341	-0.026292
Siblings' Proficiency	0.375409	0.224628	0.412132	-0.473965
Education	*0.631578*	0.297210	0.427542	-0.045592
Self-Rating of Language Ability	0.105345	0.184893	0.192728	*0.884684*

Note. Factor loadings greater than 0.6 are italicized and highlighted.

Table 5

Factor Loadings for Non-English Language Use Questionnaire Items

	Component 1	**Component 2**	**Component 3**	**Component 4**
Confidence in Hearing	*0.929944*	-0.066404	0.176570	0.198185
Confidence in Speaking	*0.909046*	0.001464	0.228804	0.257041
Confidence in Reading	*0.933453*	-0.025655	0.242075	0.117175
Exposure for Hearing	0.329662	0.019430	*0.775673*	0.390365
Exposure for Speaking	0.348689	0.010554	*0.790262*	0.311177
Exposure for Reading	0.377651	0.110279	*0.731011*	0.213293
Total Use	0.051735	*0.847456*	0.350870	0.158755
Input	-0.071435	*0.939528*	0.071395	0.097182
Output	-0.062333	*0.924096*	0.085833	0.102575
Age	-0.141191	0.481609	0.318202	-0.216705
Mother's Proficiency	0.170384	0.089497	0.225944	*0.807288*
Father's Proficiency	0.159947	0.118594	0.208615	*0.851689*
Siblings' Proficiency	0.200436	0.166465	0.217005	*0.732727*
Education	0.055331	0.256058	*0.835863*	0.141473
Self-Rating of Language Ability	0.133313	*0.606907*	-0.219283	0.253330

Note. Factor loadings greater than 0.6 are italicized and highlighted.

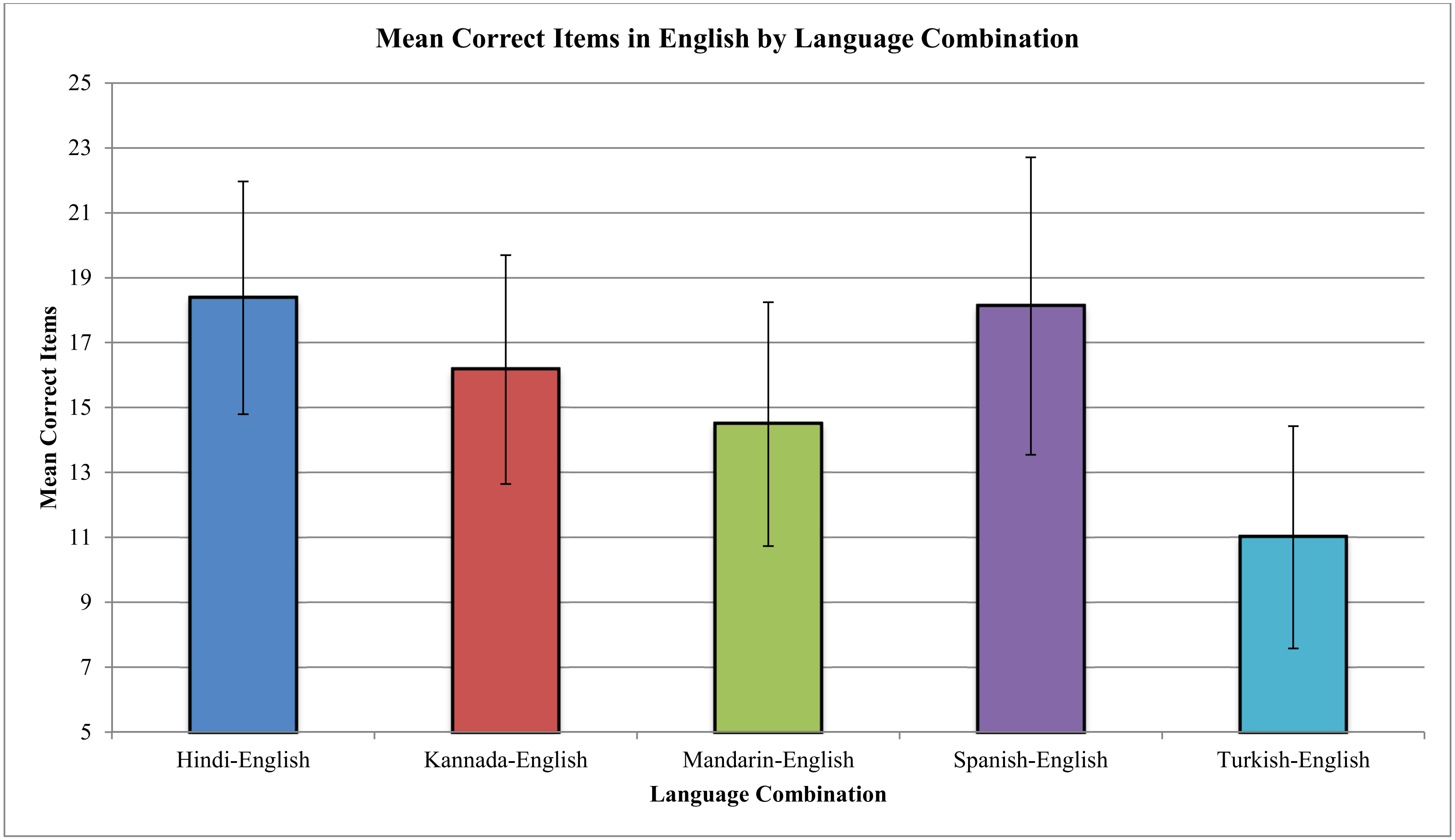

Figure 1. Bar graph showing the average number of correct items named in English for each language combination. Error bars represent the standard deviations of the means.

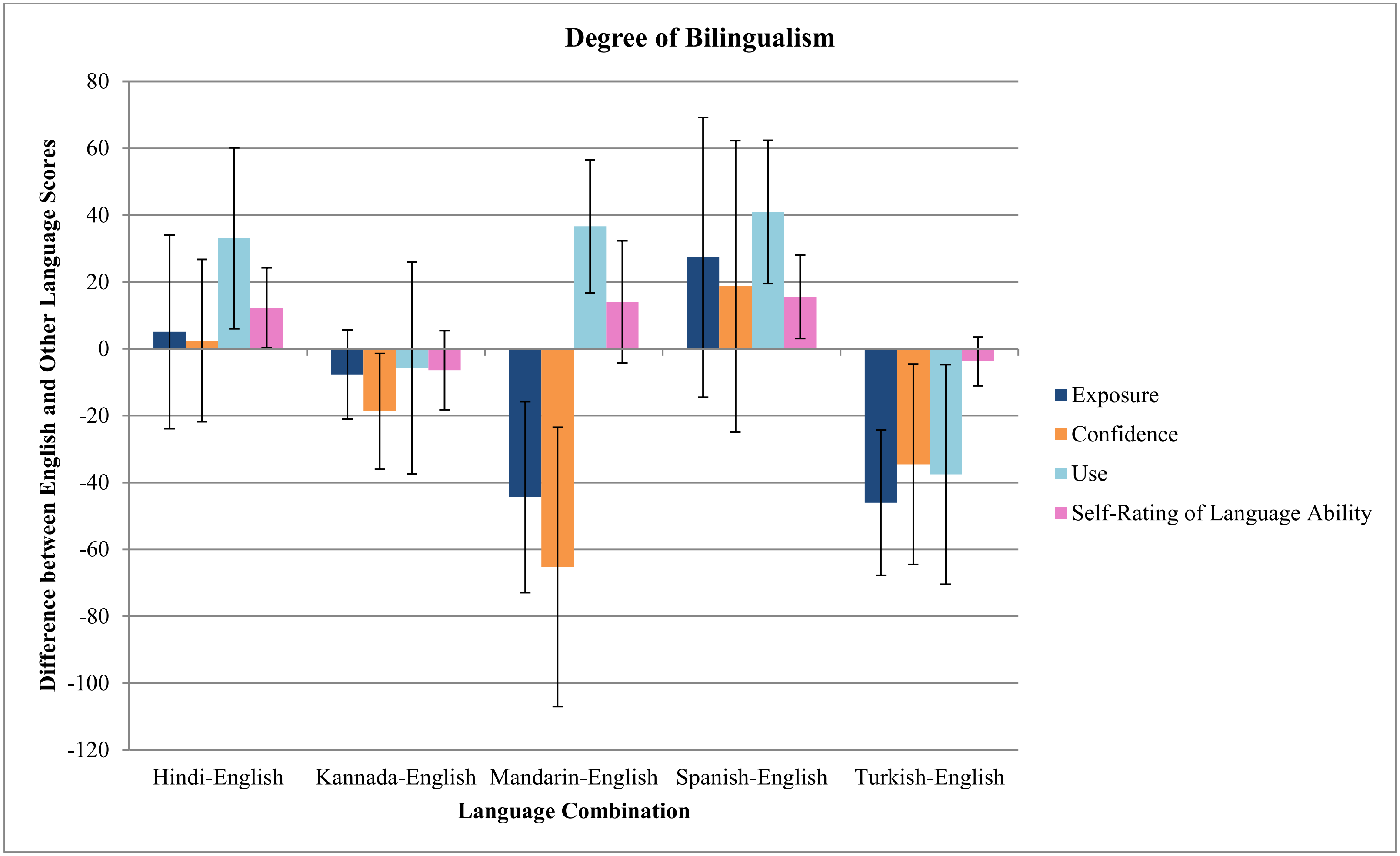

Figure 2. Bar graph showing the average relative proficiency of participants by language combination. Each bar represents one of the four components extracted from the principal component analysis. A positive bar means the group is more proficient in English on average. A negative bar means the group is more proficient in their non-English language on average.

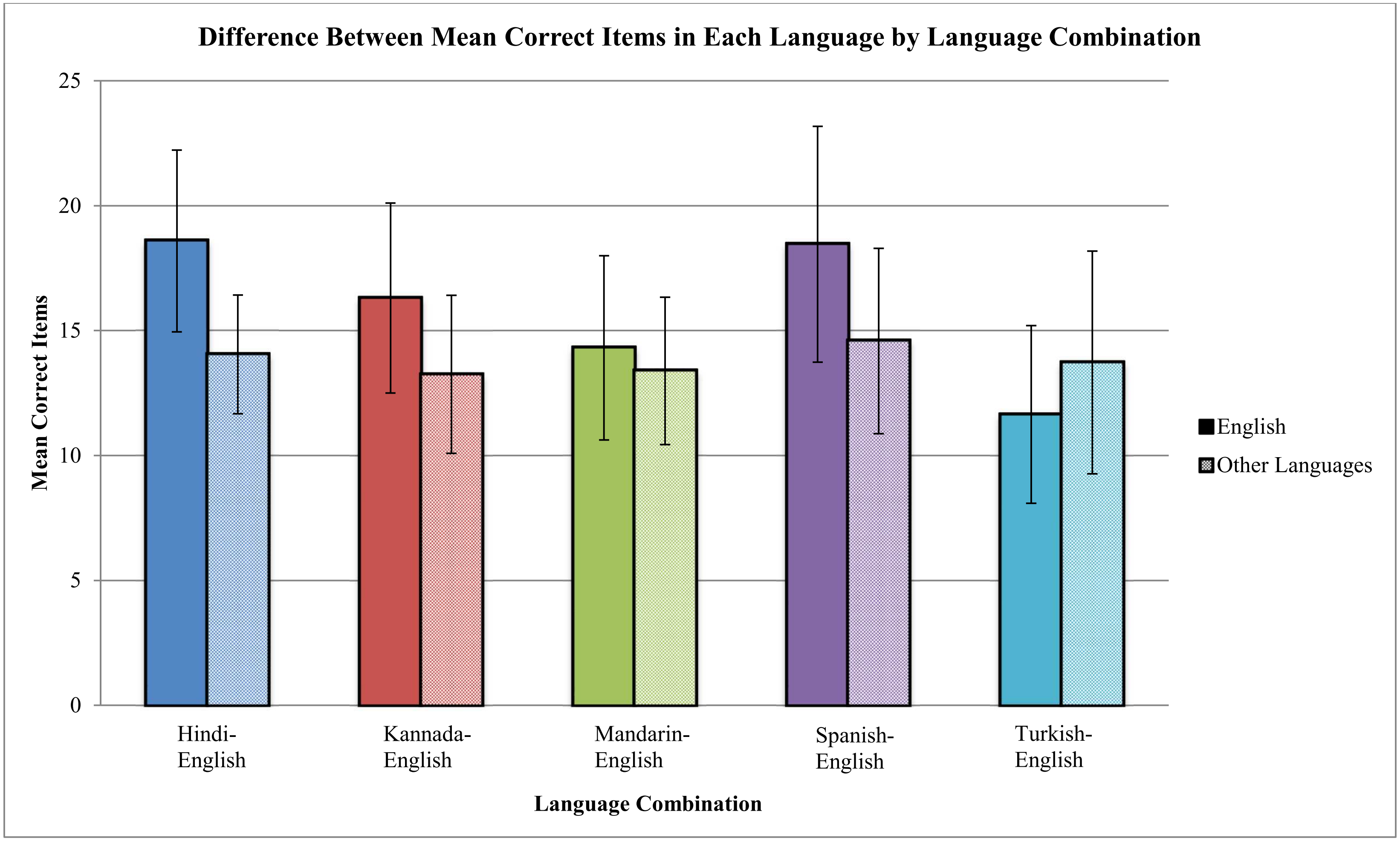

Figure 3. Bar graph showing the average number of correct items named in each task language within each language combination. Error bars represent the standard deviations of the means.

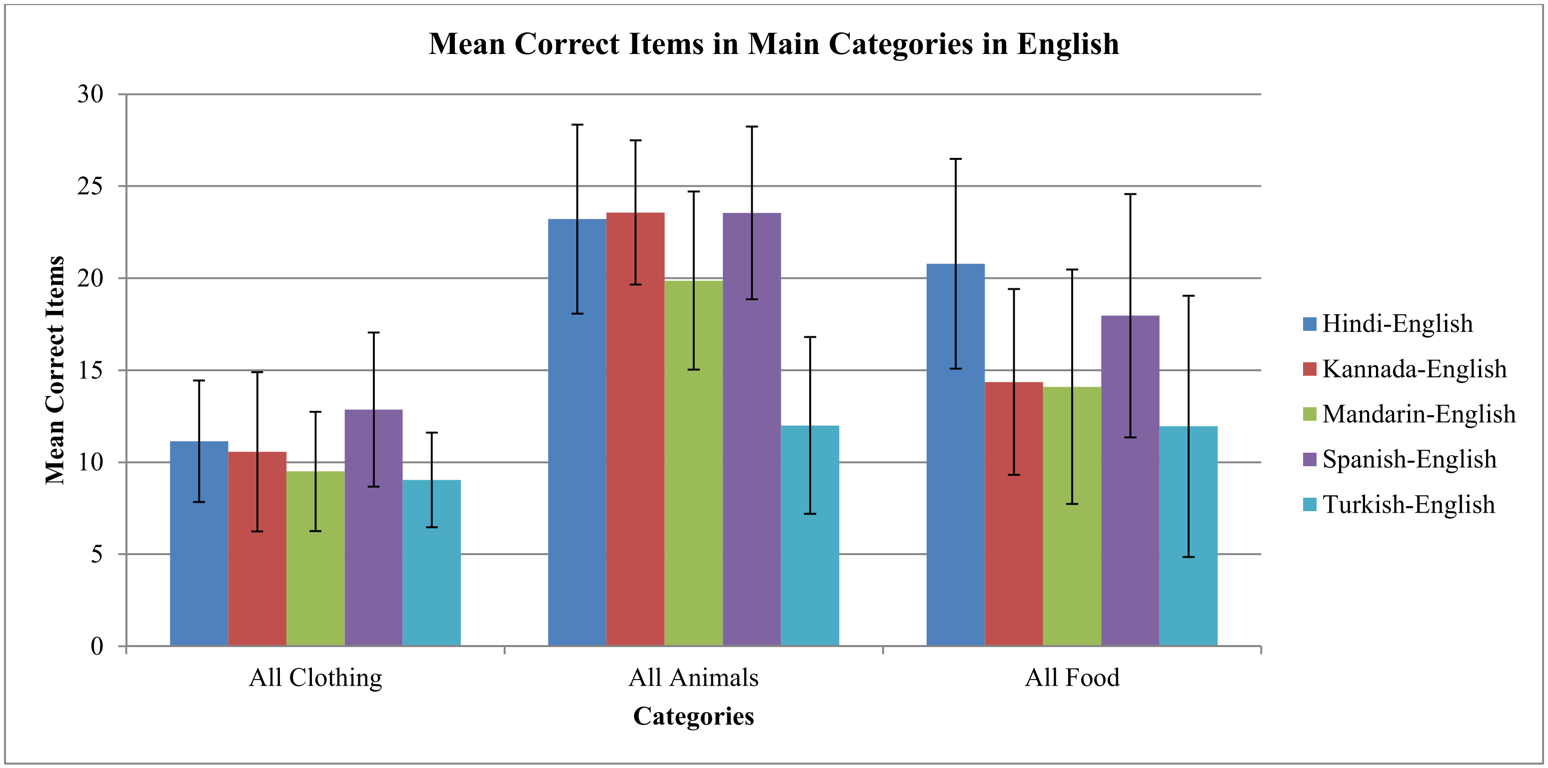

Figure 4. Bar graph showing the average number of correct items named in English for the main categories by language combination. Error bars represent the standard deviation of the mean.

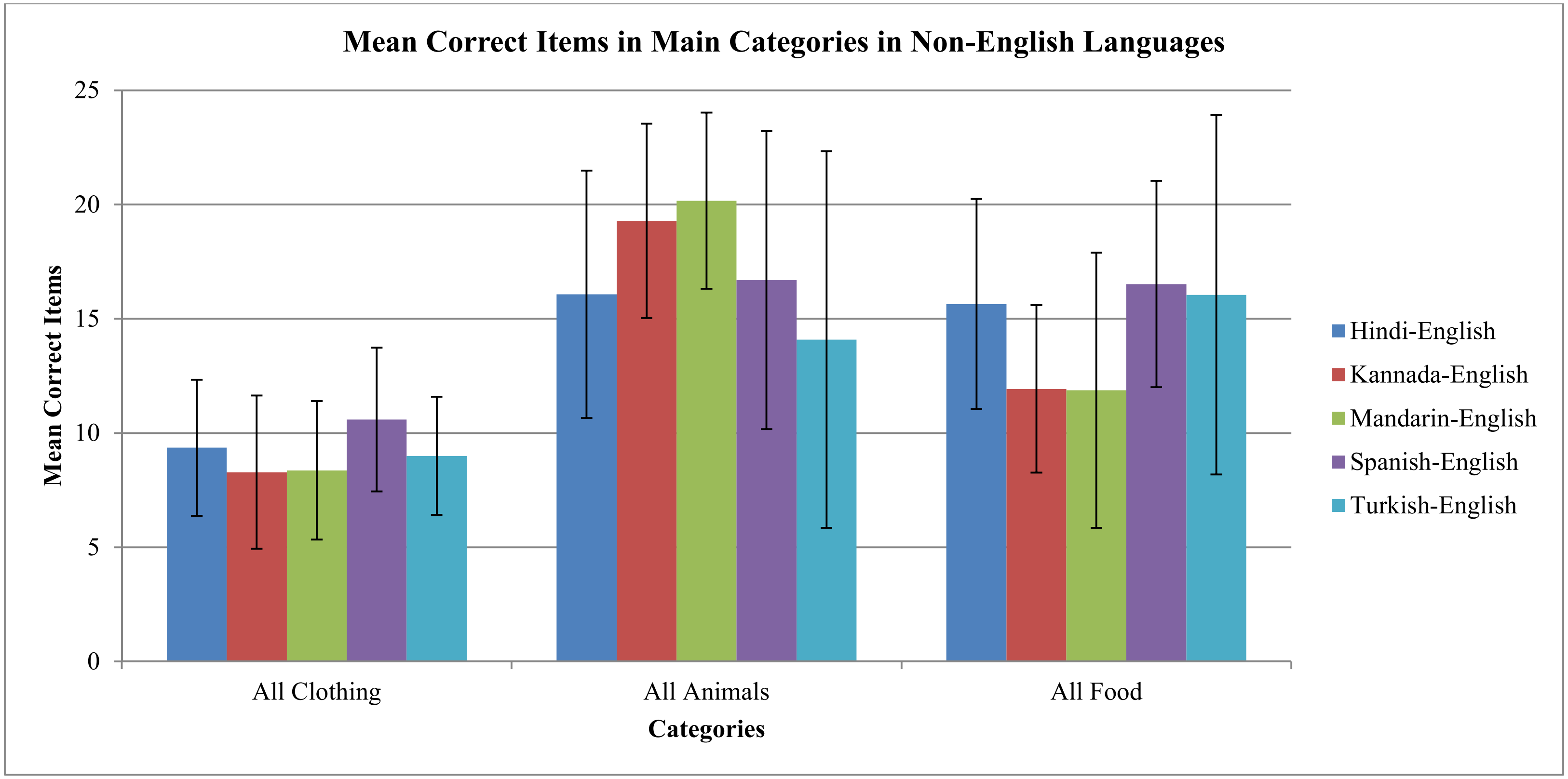

Figure 5. Bar graph showing the average number of correct items named in languages other than English for the main categories by language combination. Error bars represent the standard deviation of the mean.

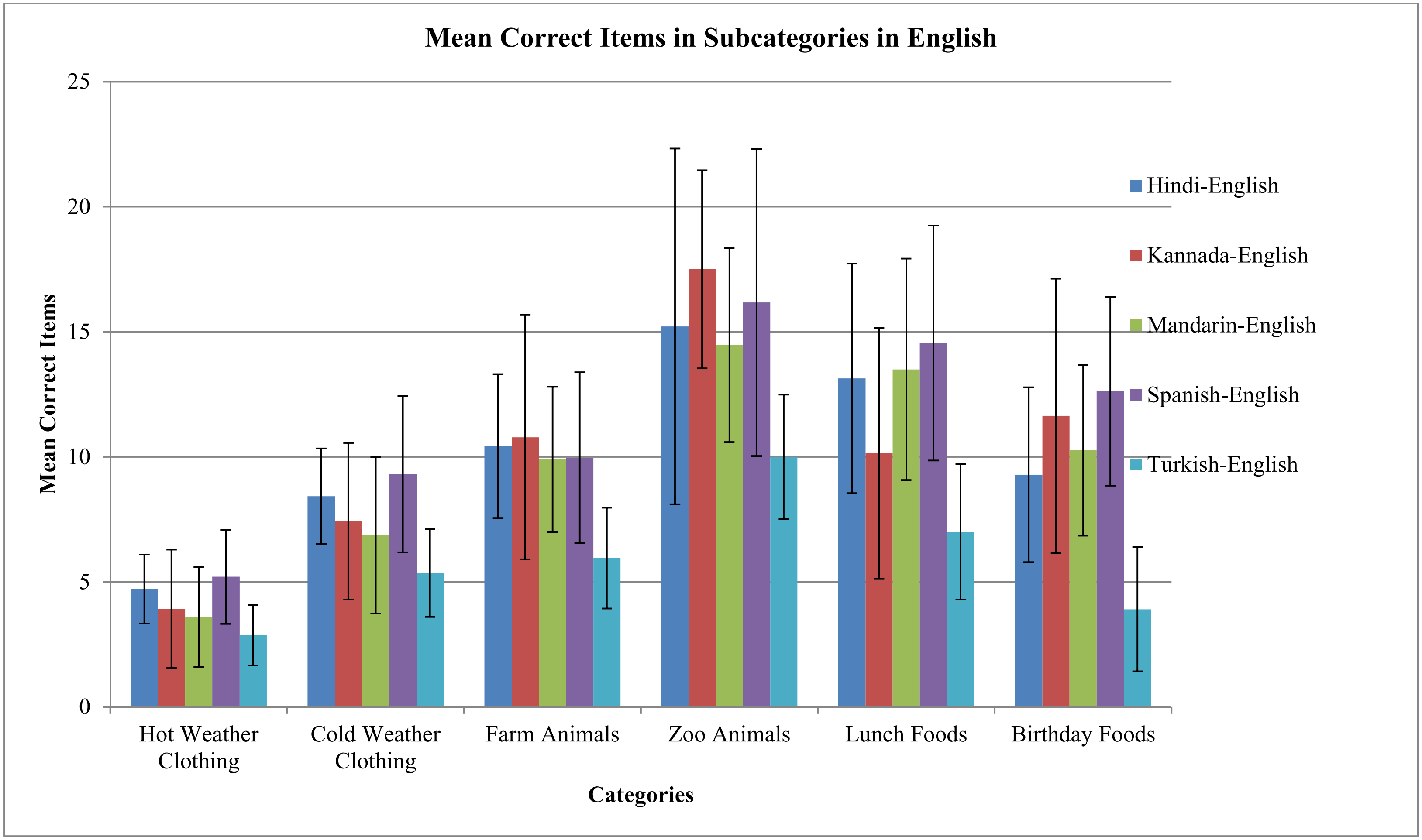

Figure 6. Bar graph showing the average number of correct items named in English for the subcategories by language combination. Error bars represent the standard deviation of the mean.

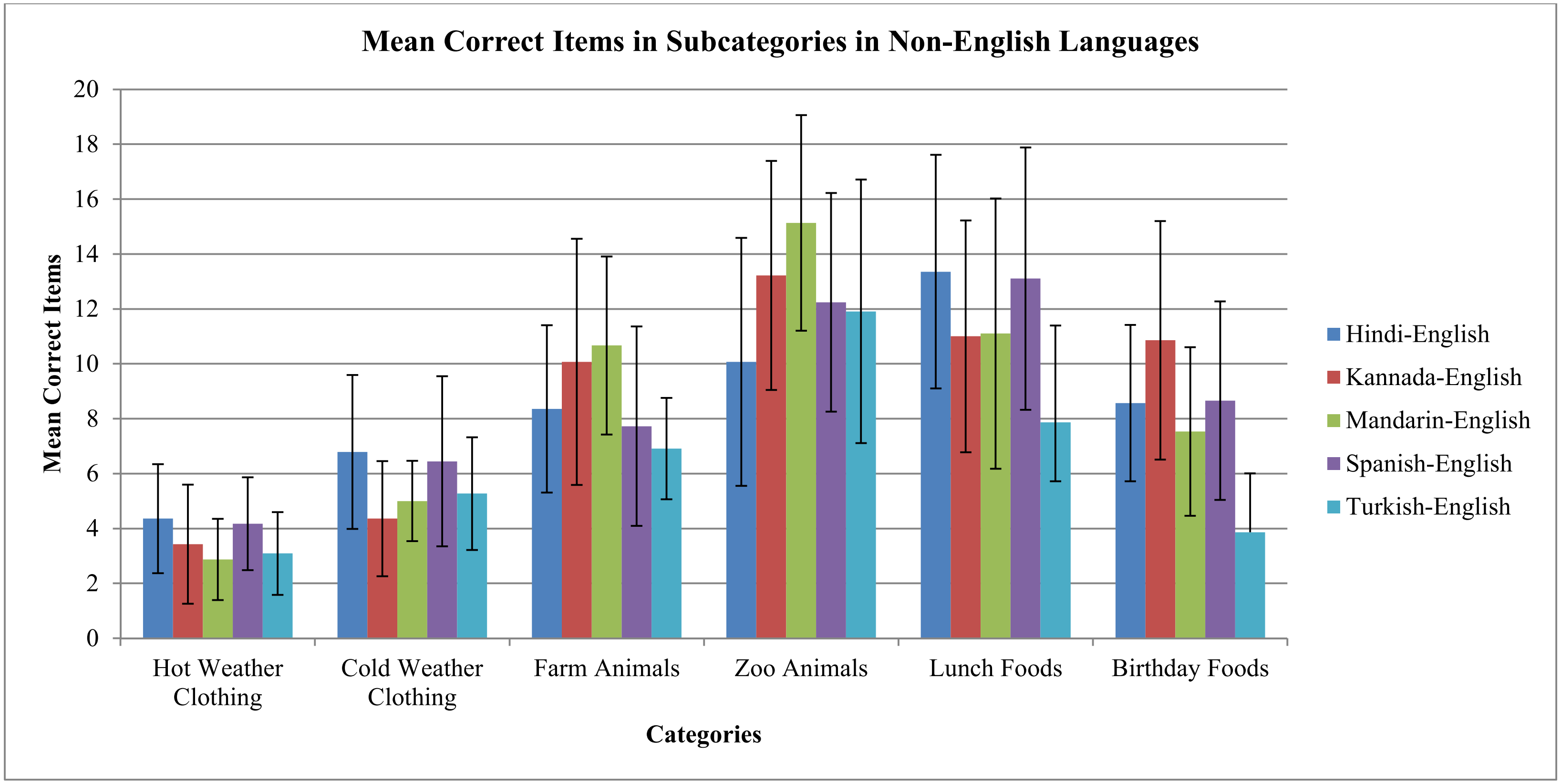

Figure 7. Bar graph showing the average number of correct items named in languages other than English for the subcategories by language combination. Error bars represent the standard deviation of the mean.

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VITA

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