Inhibition in language comprehension:

An investigation of bilingualism and inhibition development

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**Abstract**

Studies of inhibition and bilingualism within toddlers and infants have led some to believe that development of inhibitory control occurs early throughout a child’s development and plays a significant role in influencing their comprehension as bilinguals. While others have argued that there is no bilingual advantage in inhibition. There have also been studies done on adults which show a bilingual advantage for inhibition during language comprehension. However, it is still unclear the full extent that bilingualism influences inhibition development for language comprehension in toddlers. The study proposed here will focus on inhibition between four-year-old monolingual and bilingual native English speakers in an eye tracked of word recognition task. Based on existing studies, the prediction(s) for this study are differences in the number of looks post-stimulus-onset between monolinguals and bilinguals during the experimental trials. Specifically, it is expected that the bilinguals are faster at inhibiting competing information than monolinguals as well as focusing more on the correct information. Findings from this study could serve to expand the present knowledge on the development of inhibitory control for bilinguals.

**Introduction**

One of the primary goals of research in bilingualism is to understand the impact it has on cognitive development. The bilingual advantage has been reported across various cognitive areas including metalinguistic awareness, understanding complex instructions, role taking, etc. (Ricciardelli, 1992). But, how early on does this bilingual advantage appear? At what age does the bilingual advantage take effect, influencing cognitive development?

Before considering the impact that bilingualism has on developing infants, it is important to first understand how infants acquire language. Depending on the language(s) present in the environment of a baby growing up, their brain specializes in them (Ramirez & Kuhl, 2017). Language discrimination plays a significant role in language acquisition for bilingual babies, as they need to be able to distinguish between the two different languages that they are exposed to. In a study of bilingual Spanish-Catalan bilingual infants and monolingual Spanish infants, when tested in an orientation latency procedure between Spanish and English, the bilingual infants approached the task in a different manner than the monolinguals as they did not rely on the familiar vs different distinction to differentiate between the languages (Bosch & Sebastian-Galles, 1997). During the task, the Spanish-Catalan infants showed discrimination by orienting to the unfamiliar language first in comparison to the monolinguals that oriented to their native language (Bosch & Sebastian-Galles, 1997). They first attempted to identify which of their two known languages was being spoken and then they would orient to the unfamiliar language thus increasing the latency of their response (Werker & Byers-Heinlein, 2008). From this study, the authors speculated that the bilingual children were discriminating language through identification of the language being presented. Besides language discrimination, language production also plays a role in helping a child acquire a language. Inhibition plays a significant role in bilingualism for both language production and language comprehension, as infants need to be able to control what they choose to pay attention to and focus on linguistically. It remains unknown however, how bilingualism impacts inhibition development in infants and toddlers.

Inhibition has been tested and shown through various studies on infants. In a study done by Dunabeitiaet. al (2014), they compared bilingual and monolingual to focus on the effects of the bilingual advantage in inhibitory skills. They took 252 monolingual and 252 bilingual, from grades three, four, five and six and grades one and two of high school, children that were matched on multiple indices. Both groups were tested in a verbal Stroop task and a nonverbal version of the same task. For the verbal Stroop task, the participants were asked to name the color of the ink of the words. In the nonverbal task the participants were shown two digits displayed on the screen and they had to press a key in the keyboard for their choice, either left, right or same. Results from this study demonstrate that that the bilingual children performed equally to the monolingual children in both tasks across all markers of inhibitory skills explored (Dunabeitia et al., 2014). These results show that bilingual children do not exhibit any advantage in inhibitory tasks over monolingual children, indicating that the bilingual advantage does not apply to inhibition.

Other studies have shown that there is a difference in inhibition between monolingual and bilingual children. In order to see the impact of bilingualism and executive function, Yang, Yang and Lust (2010) compared 4-year-old monolinguals and bilinguals by studying the amount of errors and their speed at picking a correct answer. The participants were given two tests the ANT and PPVT. The ANT, Attention Network Test, that the children were given was a game-like non-verbal task where they saw fish swimming across the screen and had to press a key on a keyboard, left or right, that matched the direction of the swimming fish (Posner & Petersen, 1990). For the PPVT, Peabody Picture Vocabulary Test-III, the children were given a word by an experimenter, and then instructed to point at one of the four pictures they were presented with or say the number of the correct picture (Dunn & Dunn, 1997). Because the participant pool included Korean American monolinguals, American English monolinguals, Korean American bilinguals, and Korean monolinguals, they were able to remove culture as a confounding factor in the sense that being Korean or American did not influence the ways that the participants reacted. The results were that the bilingual group was both the most accurate and fastest in overall executive attention accuracy and reaction time in comparison to the other three monolingual groups (Yang, Yang & Lust, 2010). This can be interpreted as there being a bilingual advantage for executive function in children.

Diving in deeper into infant development, there have been a few studies focusing on preverbal infants and their cognitive gains. In a study by Kovacs and Mehler (2009), they studied 7-month-old monolingual and bilingual infants through a switch task, where they would change the rules regarding where to look at on the screen to get the reward. Before the switch the infants were presented with a speech cue followed by a visual reward; they had to learn that the cue predicted the appearance of the reward in a certain location. After the switch, the rules change and the infants have to learn the new rules in order to predict the appearance of the reward. The results of this study were that while both groups of infants learned the rules in the preswitch task equally well, for the postswitch the bilinguals had an enhanced performance; they were able to suppress the previously learned material and update their predictions whereas the monolinguals struggled to learn the new response for the postswitch (Kovacs & Mehler, 2009). These results are indicative of inhibition in preverbal infants as the bilingual infants have to be able to distinguish and control what they set to be the rules for prediction.

Inhibition also plays a role in language comprehension. In a study conducted by Blumenfeld & Marian (2011), they focused on mono and bilingual adults and how each of their inhibitory control was associated with processing linguistic ambiguity. This study looked at the auditory comprehension of each group through eye-tracking. Both groups were exposed to two trials: Word Recognition/Eye-tracking that tracked the activation of competitor and control words during word recognition and priming probe trials that were used for word inhibition (Blumenfeld & Marian, 2011). Participants listened to the auditory stimuli and then were presented with images in four quadrants, where they had to pick the target that they heard by pressing one of the four keys given. Then they were shown a priming probe trial where they had to pick a grey asterisk from four quadrants and press the corresponding key. After the two trials, they were given a Stroop test. The results from this study were that while the participants, whether bilingual or monolingual, were listening to words in their native language they both had similar activation of within-language competitor words, but monolinguals responded slower to negative priming on competitor probes than control ones (Blumenfeld & Marian, 2011). The results from this study were that monolinguals responded slower to competitor probes than to control probes while bilinguals responded equally quickly to competitor and control probes, thus showing that monolinguals had more residual inhibition than bilinguals.

In order to form a complete understanding on the influence of bilingualism in the development of inhibition in infants, it requires a detailed understanding of how it is used in various cognitive situations, such as learning, being focused and able to ignore other distractors, reading, etc. The previous studies discussed suggest that inhibition occurs early throughout a child’s development and plays a role in influencing at least some of their comprehension as bilinguals. There are still some questions about the complete role that bilingualism has in the development of inhibitory control for infants and toddlers, including variations within bilingual children and the types of care they received, from daycare to family care (Castro, 2014). Also, while it is known that there are differences between adult monolinguals and bilinguals abilities with inhibition and language comprehension, it is still unclear if differences arise as early as in infants and toddlers.

There is a lot of literature and studies focused on inhibition and development in infants and toddlers; however, it remains unclear the full extent of how bilingualism influences the development of inhibitory control in infants and toddlers. This study raises the question: “Does being bilingual at an early age lead to an increase in inhibitory control in infants and toddlers, specifically in language development?” By diving further into language comprehension and inhibition development, the true impact of bilingualism on inhibition development would allow both parents and childhood educators to make the most of the formative years to help enhance a child’s development.

Based on the existing literature, the experimental hypothesis predicts that bilingualism increases inhibition development in infants and toddlers (i.e. the participants that are bilingual will be faster at determining the correct answer than monolinguals when there is competition). The null hypothesis predicts that bilingualism does not impact the inhibition development of infants and toddlers. Observing the impact of bilingualism on inhibition development could pose more questions about differences within the styles and methods of child rearing amongst bilinguals.

**Methods**

**Participants**

The participants will be 60 four-year-olds from the San Diego area. Subjects will be recruited through their pediatricians that are affiliated with UC San Diego Health. Participants must be either English-native monolinguals or English-native bilinguals who also speak Spanish. For each group there will be 30 participants recruited.

**Design**

This study will be a 2 between (monolingual, bilingual) x 2 within (competitor: existence and nonexistence in trials). Bilingualism will be assessed based on substantial current exposure to Spanish, having at least one family member who speaks to them daily in Spanish. Participants will be tested on their grasp of the language(s): how many words they use in their sentences, their coherency, etc. Participants whose IQs are below expected for their age range, under 100, will be excluded. For the existence/nonexistence of the competitor, the amount of time it takes for a participant’s eyes to fixate on the target post-onset-stimulus will be measured.

**Materials**

Trials will contain a quadrant of images with either a competitor present or another control (Appendix A). The images will be of four semantically unrelated words with a central fixation cross. Of the images one will be the target word, a second will either be a control or a competitor word. The remaining two images will be control words. The images will be simple blackline drawings manipulated in photoshop, so they all have similar line thickness. The voice recording that the participants will hear will be recorded by a native female speaker of American English in a sound-proof booth. There will be 30 experimental trials and 60 filler trials. Experimental control and competitor words will be chosen by ensuring they have high phonological overlap, where the overlap contains at least two phonemes shared at the onset of the word and the duration of the acoustic overlap is similar. Filler trials will not have a competitor word and instead have a third control word. Because children have smaller lexicons, the words chosen will be short and common. The guardians of the participants will also be asked to fill out a questionnaire to further understand family background including socio-economic standing and educational background.

The experiment will be run focusing on eye tracking using the Superlab software program on a computer modeled after Blumenfeld & Marian (2011). The participants responses will be recorded automatically when they point at the screen by the computer program. There will be a computer screen to show the word recognition trials.

**Procedure**

Participants will be instructed to listen to a word and point to the right image as quickly as possible shown on a screen in front of them. The participants will enter the room and be given ten trial runs to practice fixating on the cross and responding by pointing at their answer. At the beginning of each trial the participants will see a fixation cue in the middle of the screen. Once their eyes land on the fixation point, the images will appear on the screen and the recording will play simultaneously. The participants then have to respond as fast as possible by pointing at the screen. The experiment will take about 20 minutes to complete.

The quadrants will have four images with either a target, a competitor, and two controls; or a target and three controls. A possible experimental trial quadrant could have a cap (target), cat (competitor), fork (control), and pen (control) (Appendix A). A possible control trial quadrant could have a cap (target), string (control), fork (control), and pen (control). There will be a 1:2 ratio for control trials and experimental ones so the participants don’t realize the phonological overlap. The participants will be shown all the trials, both control and experimental, so this will be a single factor design focusing on accuracy. During the word recognition task, the eye movements will be tracked to look at how long it takes for the participants’ eyes to focus on the target word. They will also be tested for accuracy based on their responses by pointing at the screen.

**Predictions**

The null hypothesis predicts that bilingualism does not impact the inhibition of infants and toddlers, so the length of time it takes for bilingual and monolingual toddlers to focus on the target image will be similar even with the existence of a competitor image. The alternate hypothesis predicts that bilingualism increases inhibition development in infants and toddlers so bilingual toddlers should move their eyes faster to the target image when there is competition compared to monolingual toddlers.

**Results and Analysis**

**Statistical tests**

A 2 x 2 ANOVA will compare trial type (competitor/control) by type of group (bilingual/monolingual). The dependent variable that is being analyzed is the amount of time that it takes for the participants to land their eyes upon the target image. There will be four different analyses comparing: the accuracy of between each individual group, bilingual and monolingual, the difference between their activation of English targets and competitors during the word activation task, as well analysis of each individual group and their performance for each given condition (control, target, and competitor). The comparison of the accuracy of each group bilingual vs monolingual will focus on the percentage that each gets correct for the task. The analysis on the difference between the groups for activation will focus on comparing the difference between the amount of looks given to the target and the competitor in the milliseconds post-stimulus-onset. Each group will be individually analyzed for the amount of looks they have for each condition in milliseconds post-stimulus-onset.

**Anticipated results**

It is expected that the findings show no significant difference in the accuracy between monolinguals and bilinguals for the word recognition task (Appendix B). For each individual group, it is expected for some confusion to be present in the initial 600 ms post stimulus onset with looks varying between the three conditions; however, by 1000 ms post stimulus onset, with most participants focusing on the target, their attention should slowly decrease after the 1000 ms mark as they lose interest and respond to the task (Appendix C and D). When comparing the difference in looks between monolinguals and bilinguals, it is expected that the bilinguals are faster to look towards the target image with the existence of a competitor image (Fig 1). It is also expected to be seen that overall bilingual participants focus a greater number of looks on the target than monolinguals (Fig 2).

**Figure 1.**

Expected difference in milliseconds between monolinguals and bilinguals for number of looks to target and competitor images post-stimulus-onset

**Figure 2.**

Expected number of looks post-stimulus-onset to competitor and target images for bilinguals and monolinguals

If bilingual participants spend less time focusing on the competitor image and reach the target image faster, then it would be consistent with the hypothesis (H1) that bilingual individuals have greater cognitive inhibition during language comprehension than monolinguals. This is consistent with theories of the bilingual advantage and existing studies on the behavior of adult bilinguals vs adult monolinguals on inhibition for language comprehension, Blumenfeld & Marian, 2011, as well as existing studies on the benefits of bilingualism and inhibition in other cognitive functions for infants and toddlers, Dunabeitia et al., 2014. Because there have not been many studies done on toddlers and language comprehension with respect to inhibition this would further the knowledge on the effects on being bilingual from an early age. If bilingual toddlers are proven to have greater inhibition compared to monolinguals with respect to language comprehension, future research could dive deeper and look into comparisons between the different parenting techniques of bilingual children and the effect it has upon their language comprehension. Usually bilingual children are grouped together regardless of their background in terms of child rearing, but some bilingual children are raised at home with family members and others are sent to nursery and preschool. Further understanding the effect of bilingualism and the influence of a child’s environment will help expand upon the current knowledge of a bilingual child’s language comprehension and inhibitory development.

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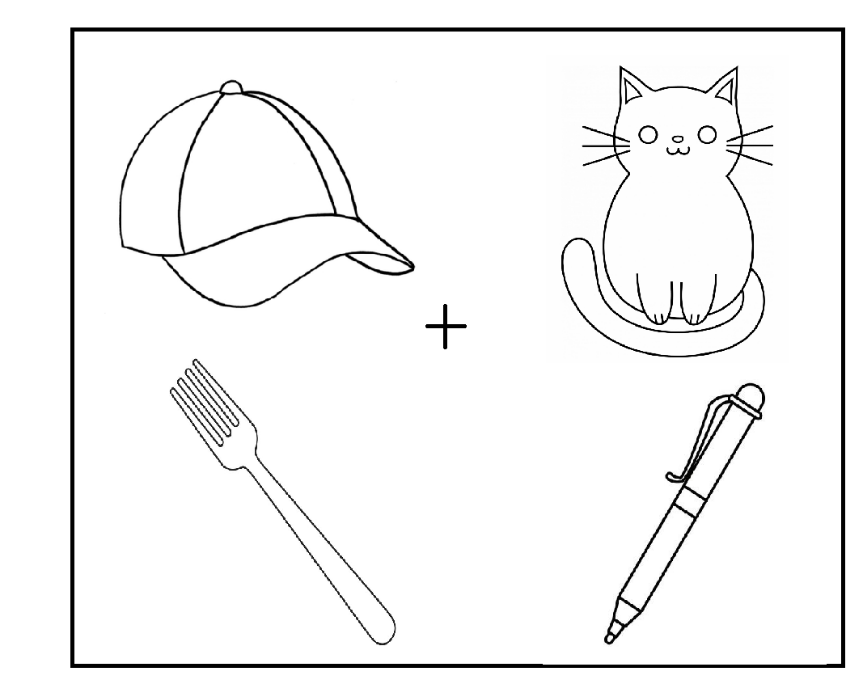
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**APPENDIX A**



**APPENDIX B**

**APPENDIX C**

**APPENDIX D**