MOUSE-TRACKING RESPONSE CONFLICT: ASSESSING BILINGUAL EFFECTS ON THEORY OF MIND

by

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(Under the Direction of Brian Haas)

ABSTRACT

Bilingual people have been shown to have an enhanced theory of mind, particularly with children. I tested whether this bilingual advantage would remain for adults when measuring their responses with mouse-tracking methodology. I hypothesized that mouse-tracking measures would indicate that bilingual individuals show less egocentric response conflict as compared to monolingual individuals. I tested this hypothesis with a set of false belief tasks and sets of theory of mind tasks which focused on cognitive and affective theory of mind respectively. Participants did not show a significant difference in their response conflict between monolinguals and bilinguals for any of the tasks, although initiation time was significantly different on the cognitive task. I discuss implications of this result and explore certain characteristics of the results as well as future directions of research.

INDEX WORDS: Theory of mind, Bilingualism, Perspective-taking, Mouse-tracking

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CHAPTER 1

INTRODUCTION

Bilingualism, an ability that tends to be a lifelong skill, affects those who possess it in myriad ways, which include differences on how they view the world. An individual language brings with it the perception of the world associated with its lexicon, and individuals who have a grasp on more than one language thus have an associated expanded lexicon encompassing a greater variety of nuances. This is evident to anyone who has spoken with a bilingual and has experienced how they are unable to translate certain words to into a different language. How this difference in understanding of the world manifests itself in a bilingual individual's social cognition is a central question to understanding the impact of bilingualism. Studies of various kinds have focused on studying theory of mind to assess differences between monolingual and bilingual individuals when it comes to social cognition. Theory of mind, as formulated by Premack and Woodruff, is about the ability of attributing the mental states of others to them, which means that an individual understands that others have their own mental states that can be different from his or her own understanding (1978). Studies have used various tasks focused on assessing theory of mind to understand the theory of mind developmental differences in bilingual and monolingual children (Schroeder, 2018; Goetz, 2003; Kovacs, 2009). Fewer studies have focused on differentiating between monolingual and bilingual adults on this ability. I focus on using mouse-tracking methodology that tracks response conflict across a person's decision process to investigate whether there can be a difference detected between adult monolinguals and bilinguals. The expectation is that bilingual adults will show a detectable theory of mind advantage in their processing of a theory of mind task.

Bilingualism Effects

Bilingualism has been shown to have a variety of impacts on a person. During development, bilingualism has been shown to affect a person's development linguistically and otherwise. For example, bilingual children can have negative consequences such as a smaller vocabulary in each of their languages as compared to their monolingual peers (Oller & Eilers, 2002). This, combined with evidence of differential performance on general achievement assessments for language or other areas, has been a part of the argument against the promotion of bilingual learning for children (Oller & Eilers, 2002). This argument, however, does not consider the multitude of factors that create this difference, such as a consistent influence by socioeconomic status and also the 'distributed characteristic' of bilingual knowledge that means that knowledge is spread throughout a person's languages (Oller & Eilers, 2002). This distributed knowledge can mean differential understandings in each language. The argument against bilingualism for the sake of development clashes with the support for the importance of the critical period for second language acquisition and the importance of age of acquisition for language attainment (Birdsong, 2018). As Birdsong expresses, how bilingualism and second language (L2) attainment develops and the way it affects a person depends on myriad factors including age of acquisition, which makes early bilingualism important (2018). What these different perspectives have in common is that they show that bilingualism is a mechanism that creates differences from individuals who remain monolinguals.

Bilingualism also has effects past development and beyond linguistic features. For example, personality differences are found when bilinguals switch between their languages, indicating the strong impact of language on characteristics like perception of the world

(Ramirez-Esparaza, et. al., 2006). Differences of personality imply different perceptions of the world in different languages, and given a person's bilingualism, this would indicate that they have more than one perception of the world and would be more likely to understand different perspectives. Such a feature of bilingualism would fall under cognitive ability differences between bilinguals and monolinguals, which have been found to mixed results (Bialystok, 2009). This cognitive difference has been described in relation to executive control ability. Specifically, bilinguals are described as needing constant monitoring of their target language to minimize interference from the competing language, given that evidence has shown that the two languages of a bilingual individual remain active while there is processing occurring in one language (Francis, 1999, Brysbaert, 1998). This requires the utilization of executive control, and it has been shown that bilinguals indeed have a stronger executive control system, particularly in terms of inhibition capabilities (Bialystok, 2009; Bialystok and Craik, 2010). This bilingual advantage has been found through performance on executive control tasks such as the Simon task for children, young adults, as well as older adults, which has shown that bilinguals have that better inhibition capacity (Martin-Rhee & Bialystok, 2008; Bialystok, Craik, Klein & Viswanathan, 2004). Such characteristics lead to questions about other cognitive performance differences between bilinguals and monolinguals such as the differences between them in understanding the perspective of others. Such a difference can be understood as an extension of how enhanced executive control and inhibition capacities due to language-switching necessities of being bilingual lead to an enhanced capacity to inhibit one's own perspective to take that of someone else's and to navigate and control these switches in perspective. The strength of such an enhancement in adults who have already passed the basic development of theory of mind in childhood is central to the current study.

Theory of Mind

Theory of mind is a construct that represents a person's ability to represent and understand the mental state of others and subsequently attribute those thoughts and beliefs and other mental states to that other person (Premack & Woodruff 1978). Premack and Woodruff describe it as a system of inferences to make predictions about others (1978). More generally, it assesses the ability to understand that others see the world differently compared to oneself. It is a concept that is central to the study of social cognition, or understanding the cognitive aspects of interpersonal behavior. Theory of mind is a measure of the ability of an individual to understand someone else's perspective and is often measured using the false belief task (Baron-Cohen, Leslie, & Firth 1985; Wimmer & Perner, 1983). The specific definition of false belief reasoning utilized with false belief task can be summarized as the ability to reason about the beliefs of someone else and understand that these beliefs can be different from reality. False belief tasks are typically used with children to assess their development in this ability. It is not assessed with adults as much given that it has been shown to become established in development around 4-5 years of age (Rubio-Fernandez & Glucksberg, 2012; Wimmer & Perner, 1983).

One such classic task for false belief, the Sally-Anne task, features two children and a toy involved in a scenario in which a participant observes (Baron-Cohen, Leslie, & Firth, 1985). The children, Sally and Anne, play with the toy and then it gets put away into a certain box with both of them present. One of the children, Anne, leaves the scene, and then Sally ends up putting the toy in the other box. When Anne returns to the scene, the subject is asked where Anne will say the toy is. This task requires that the subject understand that Anne would have a different perspective and thus believe the toy to be in a different place than the subject saw in reality. Other false belief tasks may have different elements involved but they have a tendency to follow a similar principle of reconciling what someone else believes based on their perspective and what one has seen in reality.

Bilingual children have been found to do better on false belief tasks as compared to their monolingual peers (Goetz, 2003; Kovacs, 2009). This bilingual advantage has been attributed to a multitude of reasons including the previously mentioned executive functioning enhancement found in bilinguals (Bialystok, Craik, Klein & Viswanathan, 2004). Another theory about the reason for this bilingual advantage is the enhanced recognition of metalinguistic awareness among bilinguals. This means that bilinguals are better at understanding the formal characteristics of language act as an object of thought or a process, and this ability has been shown to be a unique contributor to the false belief advantage in children (Diaz & Farrar, 2016; Goetz, 2003).

Regardless of the reason behind such an advantage, despite mixed evidence on this phenomenon, a meta-analysis comparing monolingual and bilingual children on theory of mind tasks has shown a small bilingual advantage, as well as a medium bilingual advantage when the theory of mind results are corrected for the bilingual disadvantage of language proficiency (Schroeder, 2018). In terms of adults and theory of mind ability, eye-tracking methodology has been used to show that adults show interference of their own perspective on an adapted Sally-Anne task, but this effect was lessened in bilinguals compared to monolinguals, confirming the bilingual advantage (Rubio-Fernandez & Glucksberg, 2012). Whether this effect on adults extends to other tasks and methodology is to be explored further.

Adults and Mouse-tracking

False belief tasks, including the Sally-Anne task, tend to be used for children because this ability already establishes itself around 4 or 5 years old. Thus, while accuracy on these tasks can be assessed with children, it is not a useful metric with adults, who have already developed their theory of mind and will be consistently highly accurate. It thus becomes a challenge to find a way to assess differences in adults on theory of mind. One such way that experimenters have attempted to study false belief reasoning in adults is through the previously mentioned use of eye tracking software with an adapted Sally-Anne task. Significant results were found showing a bilingual advantage in which adults showed an egocentric bias to their own perspective in terms of gaze direction of first fixation and fixation latency, or the length it took to fixate on the correct response (Rubio-Fernandez & Glucksberg, 2012). Specifically, more bilingual adults first fixated on the correct container compared to monolingual adults, and it took bilingual adults less time to fixate on the correct response. This tells us that bilingual adults had less of an egocentric bias to first look at the response that represents where he or she knows the toy is themselves. They also were less affected by the egocentric bias by not deliberating on their response as long before they settled on the correct response for Anne's perspective.

Besides eye-tracking, another methodology that exists for tracking more subtle aspects of mental processing is mouse tracking. It differentiates itself from eye-tracking methodology because it is able to track the entire decision process in the form of the mouse trajectory a person makes and has more dimensions than fixation and time to fixation onto the correct response. It involves software called MouseTracker created by Jon Freeman, which tracks the path that a person takes with their computer mouse on the screen as they make choices from a starting point on the screen (Freeman, 2010). It is based on the idea of decision conflict, which presumes that during the making of a decision, a conflict is involved for deciding between the possible choices (Stillman, Shen, & Ferguson, 2018). In particular, by tracking how the participant moves their mouse as they make their decision on the computer screen during a task, this program is able to track the way in which conflicts are resolved when making the decision between choices, which is called the response conflict. This program has been argued to be a highly useful methodology for investigating social cognitive theory, which is related to the measuring of theory of mind, as it involves resolving a decision conflict between the perspective of the other and the perspective of the self (Stillman et. al., 2018). More specifically, how much a person's trajectory as they make they respond from the starting point to the correct choice differs from the projected straight line trajectory from the starting point to the correct choice indicates how much response conflict there was, and thus how much the person is affected by their own perspective or whatever the alternative response may be.

The primary measure that tends to be gathered from the data analyzed by this software is Area Under the Curve (AUC), which is the area between the trajectory of the participant as they go from the starting point to their response, and the projected straight line trajectory from the starting point to the response. Under the context of the false belief task, AUC would measure the degree to which the subject trended toward the wrong choice before settling on the correct one, presuming that most adults would correctly respond to the task most of the time. The greater this area is, the more there was deviation from the projected straightforward path, indicating more conflict during the decision due to the other choice reflecting what the participant knows is true in reality (Freeman 2018). Essentially, this measure acts as a quantification of the response conflict of the individual when they make their choice. Another measure related to AUC that is measured through MouseTracker is Maximum Deviation (MD) which is the greatest distance between the previously mentioned two trajectories, and follows the same principle as AUC. Reaction time (RT) is also collected, which measures the time it takes for the participant to respond. Finally another measure is initiation time, which is how long it takes for a participant to move from the starting point and start the process to choose their response. The advantage of this methodology is that the data that mouse-tracking is able to gather shows a psychological response as it evolves over time, since it is possible to graphically represent the trajectory and then mathematically analyze that graphical representation.

In the present study, the task used by Van der Wel, Sebanz, and Knoblich (2014) is modified and used for monolinguals and bilinguals to measure their abilities on the false belief task in terms of MouseTracker data. In addition, a task that involves cognitive and affective theory of mind assessment with the use of cartoon image sequences (Sebastian et. al., 2012) is used as an additional assessment of theory of mind. Self-reported data from a multi-dimensional empathy scale is also collected. It provides self-reported results for perspective-taking to compare to the data based on the experimental tasks. My hypothesis is that there will be a shorter reaction time, less AUC, and less MD for the bilingual participants as compared to the monolingual participants as they complete the false belief video task from Van der Wel, Sebanz, and Knoblich through the MouseTracker program (2013), consistent with previous data that showed a bilingual advantage on these cognitive tasks. Similarly, there will be shorter reaction time, less AUC, and less MD for the bilingual participants as compared to monolingual participants on both the cognitive and affective theory of mind cartoon tasks (Sebastian et al., 2012). Finally, there will be greater self-reported empathy for bilinguals than for monolinguals, although it may not be significantly different.

CHAPTER 2

THE STUDY

Participants

There was a total of 105 participants, with 63 females and 42 males. They were recruited through the Research Participant pool at the University of Georgia and are undergraduate students in introductory psychology courses. They participated by coming into the lab in the Psychology department of the University of Georgia. Participants first self-identified as either monolingual or bilingual in response to the description of participants needed for the study. Subsequently, the self-identified monolingual participants who came to the lab completed a questionnaire in which they answered the question “Are you fluent in any other language other than English,” with a response of ‘yes’ as a confirmation of monolingualism. For self-identified bilingual participants, they filled out a language background questionnaire adapted from Park and Ziegler (2014) as modeled from Bialystok (2006). The questionnaire had participants determine which languages they spoke, which language(s) was their native language, and estimate their general level of proficiency on each language on a 10-point scale with 10 being the most proficient and 1 being the least proficient. In addition, for the L1 and L2, they indicated their proficiency in speaking, listening, reading, and writing based on a 10-point scale, with 10 being the most proficient and 1 being the least proficient, with descriptive guidelines given for what constituted certain points on the scales for each category. Finally, the participants made an estimate of what percentage of time they used their L1 and L2 at home, at school, and at work (if applicable), on average.

Measures

The participants completed a false belief task adapted from the stimuli of Van der Wel, Sebanz and Knoblich in their study of false and true belief using MouseTracker (2014). There were thirty-two videos in total which were all completed through MouseTracker. For this task, the participants were given instructions to follow one of two objects: the cube or the sphere. This feature allows for more false belief conditions to be created for these videos. There would be another person that appears in the video, who would sometimes leave during the video. Participants were told that if that other person leaves the screen, they do not see what happens. The participant determines by the end of the video stimuli where that particular object was according to either their own perspective (prompted by YOU) or that other person's perspective (prompted by SHE). When prompted, the participant would click on either corresponding L and R responses in the two top corners of the screen based on which box of the video they thought the object was located according to one of the two perspectives. The 'L' labeled black box in the top left corner of the screen corresponded to the choice of the object being in the left box in the video, while the 'R' labeled black box in the top right corner of the screen corresponded to the choice of the object being in the right box in the video. An image of an example of what happens in these videos can be seen in Appendix A. These videos were located in the center bottom of the computer screen while the responses were in the top corners of the entire computer screen. Mouse-tracking data was collected, including AUC, MD, and RT. For reaction time data on this task, since MouseTracker tracks time from the start of the video when a video stimulus was used, rather than once the video ends, 15100 was subtracted from the RT number given by MouseTracker, indicating the length of the false belief videos. In addition, although MouseTracker also collects initiation times, the time between when the participant is prompted to start responding and when they move from their starting position, this was not used for the false belief video task due to the way that MouseTracker works with video stimuli making the interpretation of this data difficult.

A second task was used coming from a study that adapted cartoon images to assess both cognitive and affective theory of mind (Sebastian, et. al. 2012) from a cartoon story paradigm developed by Vollm et al. (2006). The task was also completed through the MouseTracker program in the current study. In this task, participants are asked to watch a series of three cartoons that occur in sequence, each of which is on screen for 2.5 seconds. Following the three cartoon images, two options are shown on screen on the top left and right corners as the possible next cartoon image in the sequence. The participant is asked to choose which of those options best answers the question of “What happens next?” In this task, there are 3 types of sequences. The first type consists of 10 sets of cognitive sequences which reflect understanding of the beliefs or intentions of others, 10 sets of affective sequences which reflect understanding how others would react to someone’s affective state, and 10 sets of physical causality sequences that show basic physical phenomena and serves as a baseline (Sebastian, et. al., 2012). For example, an affective cartoon has three cartoons in a sequence that show a child with a cat. The cat runs up a tree and gets stuck on the tree and the child becomes upset. There is an adult present who sees all of this happen. The participant is then shown two different cartoons as the two choices for what happens next, one of those cartoons shows the adult just walks away. In the other, the adult helps get the cat out of the tree for the child. The expectation is that the correct response to ‘What happens next?’ is to choose the cartoon of the adult helping get the cat out of the tree. The cognitive cartoons follow similar principles, but are just about the intentions of people in the cartoons, such as buying a bakery item out of a bakery and not something not found in a bakery, while the affective cartoons involve understanding some sort of affect of another person. These thirty sets of sequences were randomized for each participant through MouseTracker.

In both the false belief video task and the cartoon task, participants completed practice trials prior to starting the test trials both in order to understand the interface of the MouseTracker program and to ensure understanding of the task itself. The practice trials for the false belief task were selected from the test trials as four different trials that allowed the participant to see the varieties possible for the videos: following the cube or the sphere, the other person stays or leaves, the object changes location or not, and the prompt is ‘SHE’ or ‘YOU.’ For the practice trials of the cartoon task, the original practice trials used by Sebastian et. al., were used (2012).

Finally, the participants completed the Interpersonal Reactivity Index (IRI) which is a 28-point multi-dimensional self-report measure of empathy and can be found in the Appendix as Item B (Davis 1983). The focus for using this measure was the perspective-taking subscale, which matches with the principles of theory of mind that this study is focusing on as an assessment of the ability to adopt the psychological perspective of others spontaneously (Davis 1983). Participants respond to twenty-eight statements on scale of A to E, with A representing “does not describe me well” and E representing “describes me very well.” A, B, C, D, E were scored as 0, 1, 2, 3, 4 respectively, except for the reverse-score items, which were scored in the reverse direction. The perspective-taking subscale contains seven of the items on the IRI, of which two of them are reverse scored. Composite scores were calculated for each participant by calculating the sum of the score for each item on the subscale.

Procedure

The researcher started by verbally confirming whether the participant was participating as part of the monolingual or bilingual group. Accordingly, each participant was given either the monolingual questionnaire or the language background questionnaire to complete. After the completion of the questionnaire, the researcher gave each participant an overview of the false belief video task and then asked them to read the instruction slides for the practice trials of the false belief video slides. They were also told to ask any questions that came up while they read the instructions. After the instructions were over, the researcher verbally confirmed that there were no other questions, and asked to participant to begin the practice trials, observing all four of the practice trials to point out any misunderstandings about understanding the task along the way. After completion of the practice trials, the researcher verbally confirmed with the participant that they understood the task and had no other questions, and then proceeded to the test trials.

After completion of the false belief video task, the researcher proceeded to move to the practice trials of the cartoon theory of mind task. Instructions slides were provided and read through, with the researcher available for questions. After verbal confirmation of and understanding of the instructions, the participant started the practice trials. There was a total of three practice trials, and the researcher remained throughout to observe that the participant was responding correctly and understanding the task, making corrections as necessary. After another verbal confirmation that the participant understood the questions and no questions, the researcher proceeded to the thirty test trials of the cartoon task.

After the cartoon task was completed, the participant was then asked to complete the IRI.

CHAPTER 3

RESULTS

Data

After looking at the data, one participant among the bilingual group was removed for not indicating a secondary non-English language, since that meant not being able to confirm that they are bilingual. Two participants among the monolingual group were also removed because of technical difficulties leading to missing data for the false belief video task. Approximately half of the participants were monolingual speakers of English (N = 53) while the others were bilingual speakers of English and at least one other language (N = 50). The average age for the bilingual participants was 19.84 while the average age for the monolingual participants was 19.62. The gender ratio was similar for both the monolingual group (males = 21, females = 32) and the bilingual group (males = 19, females = 31). The non-English secondary languages included Spanish (8); Vietnamese (5); Korean (5), Mandarin Chinese (4); Urdu (4); Japanese (3); Hindi (2); Malaylam (2); Gujarati (2), French (2); Arabic, Russian, Romanian, Telugu, Afrikaans, Oromo, Hebrew, Amharic, Persian, Harari, Hmong, Marathi, Tulu (1).

The results also indicated that the bilingual participants spoke both languages for at least 10 years. Among the 50 bilingual participants counted, 10 indicated English to be their native language while 10 indicated that English and another language were both their native language, and one person indicated two non-English languages as their native language. The rest of the participants indicated a single non-English language as their native language. This was based on the criteria of indicating which language(s) were spoken first, and being able to include more than one if that is the case. Given that, the participants rated their speaking and listening skills consistently above 9 on average for L1 as well as L2, with speaking being 9.14 and listening being 9.28 on average, while L1 was rated at 7.65 and 8.86 on average for reading and writing, respectively. A possible reason for this pattern is that many of these participants (62%) indicated a non-English language as their L1, which is likely their heritage language and the language they first spoke and used at home, but English is the language that they use in society and school, which is where reading and writing would be most relevant. This is also shown to be possible through the differing overall 63.78% to 47.94% ratio for average percentage of time spent in L1 vs L2 at home compared to 37.72% to 69.58% for average percentage of time spent in L1 vs L2 at school. To analyze the validity of this hypothesis about these characteristics of the data would require asking questions about heritage language for participants and make analyses based on that.

False Belief Video Task

Analysis did not indicate any significant difference between monolinguals (M = 0.28, SD = 0.61) and bilinguals (M = 0.39, SD = 0.58) for the AUC measure with the false belief videos, $t(101) = -0.93$, $p = .356$; d = 0.18. The false belief videos in this case were the particular set of videos in which the participant was asked to respond to where the other person thought the object was and that location from the other perspective is different from what the participant saw in reality. Monolinguals (M = 0.16, SD = 0.58) and bilinguals (M = 0.19, SD = 0.23) were also not significantly different for the MD measure on the false belief videos, $t(101) = -0.57$, $p = .559$; d = 0.12. Subsequently, Monolinguals (M = 1720.05, SD = 846.92) and bilinguals (M = 1679.28, SD = 2068.97) were found to not be significantly different in terms of RT either, $t(101) = 0.13$, $p = .895$; d = 0.03. The SD for bilinguals in RT was very large, and thus analyzing for outliers, it was found that there was both a high and a low outlier at 11,649 milliseconds and -8281.25 milliseconds each. This range would account for the large SD, while the negative RT would indicate that this participant must have been responding before the video was over. Given that this would indicate that this person was not appropriately responding on this video task, this participant's data on this task was removed and analysis was rerun. The results show that the results were still not significantly different for AUC, $t(100) = -0.58$, $p = .579$; $d = .11$, for MD, $t(100) = -0.53$, $p = .595$; $d = .12$, or for RT, $t(100) = -0.68$, $p = .499$; $d = .14$. The data for the results of the false belief video task, with the excluded outlier considered, can be seen in Table 1.

Baseline Measures

For both the false belief video task and the cartoon tasks, there were sets of stimuli that served as a baseline measure. For the false belief video task, these were the videos that involved a true belief, in which the participant was asked where the other person in the video would think the particular object is located, and that location is the same as where the participant saw the object in reality. With this baseline, it was expected that the measures of AUC, MD, and RT will be smaller for bilinguals than monolinguals. Analysis showed that there was no significant difference between monolinguals ($M = 0.09$, $SD = 0.42$) and bilinguals ($M = 0.23$, $SD = 0.49$) on the AUC measure, $t(100) = -1.63$, $p = .107$; $d = 0.32$, between monolinguals ($M = 0.09$, $SD = 0.19$) and bilinguals ($M = 0.12$, $SD = 0.21$) on the MD measure, $t(100) = -0.69$, $p = .490$; $d = 0.15$, or between monolinguals ($M = 397.33$, $SD = 736.90$) and bilinguals ($M = 619.94$, $SD = 1906.32$) in RT, $t(100) = -0.77$, $p = .446$; $d = 0.16$, when baseline was considered, and with the previously identified outlier removed.

Cognitive Cartoon Task

Analysis did not indicate any significant difference between monolinguals ($M = 0.56$, *SD*

= 0.97) and bilinguals (*M* = 0.48, *SD* = 1.02) for the AUC measure with the cognitive theory of mind task, *t*(101) = 0.4, *p* = .692; *d* = 0.08. Monolinguals (*M* = 0.16, *SD* = 0.25) and bilinguals (*M* = 0.16, *SD* = 0.21) were also not significantly different for the MD measure on cognitive theory of mind, *t*(101) = -0.06, *p* = .955, *d* = 0.01. Monolinguals (*M* = 2105.82, *SD* = 643.32) and bilinguals (*M* = 2245.21, *SD* = 566.65) were not significantly different in terms of RT either, *t*(101) = -1.93, *p* = .058; *d* = 0.38, although it is approaching significance with an effect size between a small and medium size in which bilinguals have a longer reaction time during the task. The data for the results of the cognitive cartoon task can be seen in Table 2.

Baseline Measures

For the cartoon task, the baseline measure was the physical causality sequences, which served as a baseline since it assesses basic understanding of physical phenomena such as gravity and physical movement of object, in contrast to understanding others involved in the two sets of theory of mind tasks. Taking the baseline into account, there is not a significant difference between monolinguals (*M* = 0.10, *SD* = .96) and bilinguals (*M* = 0.03, *SD* = 1.12) for the AUC measure *t*(101) = 0.35, *p* = .725; *d* = 0.0002. Similarly, there is not a significant difference for the MD measure between monolinguals (*M* = -0.01, *SD* = 0.20) and bilinguals (*M* = -0.02, *SD* = 0.24), *t*(101) = 0.192, *p* = .848; *d* = 0.04. Finally, there is not a significant difference for the RT measure either between monolinguals (*M* = -143.69, *SD* = 478.58) and bilinguals (*M* = -293.85, *SD* = 490.94), *t*(101) = 1.572, *p* = .119; *d* = 0.31.

Initiation Time

For the cartoon tasks, an initiation time measure was analyzed. For the cognitive theory of mind set, results indicated a significant difference between the monolingual group (*M* = 775.45, *SD* = 291.36) and the bilingual group (*M* = 912.13, *SD* = 362.05) in which the bilingual group had a longer time before initiating their process to respond, *t*(101) = -2.12, *p* = .037; *d* = .42. This would appear to indicate that bilinguals take longer to initiate their response, which means how long it takes for them to start moving their mouse, than monolinguals, for this cognitive theory of mind task.

Affective Cartoon Task

Analysis did not indicate any significant difference between monolinguals (*M* = 0.59, *SD* = 0.85) and bilinguals (*M* = 0.47, *SD* = 0.61) for the AUC measure with the affective theory of mind task, *t*(101) = 0.80, *p* = .427; *d* = 0.15. Monolinguals (*M* = 0.21, *SD* = 0.22) and bilinguals (*M* = 0.21, *SD* = 0.21) were also not significantly different for the MD measure on this affective task, *t*(101) = 0.02, *p* = .985; *d* = 0.004. Monolinguals (*M* = 2234.12, *SD* = 572.25) and bilinguals (*M* = 2462.08, *SD* = 872.87) were not significantly different in terms of RT either, *t*(101) = -0.62, *p* = .537; *d* = 0.12. The data for the results of the affective cartoon task can be seen in Table 3.

Baseline Measures

The baseline measure of the physical causality cartoons, was used with the affective theory of mind responses as well. The results indicated that there was not a significant difference between monolinguals (*M* = 0.14, *SD* = 0.70) and bilinguals (*M* = 0.04, *SD* = 0.52) for the AUC measure, *t*(101) = 0.91, *p* = .37; *d* = 0.18 when the baseline physical causality measure on AUC is subtracted. There is also not a significant difference between monolinguals (*M* = 0.04, *SD* = 0.20) and bilinguals (*M* = 0.02, *SD* = 0.19) on the MD measure, *t*(101) = 0.15, *p* = .880; *d* = 0.03 when baseline is considered. Finally there was not a significant difference between monolinguals (*M* = -15.39, *SD* = 486.50) and bilinguals (*M* = -32.08, *SD* = 595.82) for RT results *t*(101) = 0.16, *p* = .876; *d* = 0.03 when baseline is considered.

Initiation Time

For the cartoon tasks, an initiation time measure was analyzed. For the affective theory of mind set, results indicated there was not a significant difference between the monolingual group (*M* = 839.87, *SD* = 370.15) and the bilingual group (*M* = 929.87, *SD* = 409.56) in terms of this task $t(101) = -1.17$, $p = .244$; $d = 0.23$.

Interpersonal Reactivity Index

Cronbach's alpha for the perspective-taking subscale was .618 showing internal reliability. Results did not indicate any significant difference between monolinguals (*M* = 19.57, *SD* = 4.19) and bilinguals (*M* = 19.74, *SD* = 3.44) on the perspective-taking subscale, $t(101) = 0.25$, $p = .819$; $d = 0.04$. This was expected to be likely given the presumption that self-report would not be discriminant enough to differentiate between monolinguals and bilinguals on such a subtle difference.

Exploratory Analysis

Gender Differences

I explored the results with regards to gender differences across these variables to see if there is a gender difference. In fact, there is a significant difference by gender for the perspective taking subscale. Specifically, males (*M* = 18.48, *SD* = 4.06) self-report lower composite scores than females (*M* = 20.40, *SD* = 3.50) on the perspective-taking subscale, $t(101) = .45$, $p = .012$; $d = .52$. This falls in line with previous research that showed a gender difference on the Spanish version of the IRI in which females had higher scores than males, although it was not significant for the perspective-taking subscale (Lucas-Molina, et. al. 2017). Given that, I tested whether there was an interaction between the language condition and gender for this perspective-taking subscale. There was indeed a significant interaction $F(1, 99) = 6.25$, $p = .014$;

ηp$_2$ = .06 between these two factors. A simple main effects analysis shows that females scored significantly higher than males on the subscale for the monolinguals (p = .001), but there were not differences between gender for the bilinguals (p = .996). Figure 1 shows the breakdown of this interaction in terms of the means across the interaction of the language and gender factors.

Correlations of Measures

Correlational data was examined to explore possible characteristics about the relationship between these variables. In general, there was not a consistent direction of correlation for different measures or any consistent pattern. The cognitive and affective cartoon tasks were significantly correlated for measures of AUC, $r(101) = .551$, $p < .001$ and MD, $r(101) = .515$, $p < .001$ in the expected positive direction. The perspective-taking subscale was not significantly correlated with any of the other measures. When looking at the correlations of these measures split by language group of monolinguals or bilinguals, some of them are differentially significant between the different groups and some of them have correlations in different directions depending on their group. Specifically, the false belief task and the affective theory of mind task are significantly correlated for AUC, $r(101) = .438$, $p <.001$ and for MD, $r(101) = .203$, $p = .04$, but are significantly correlated for the monolinguals on AUC, $r(101) = .71$, $p < .001$ and for MD, $r(101) = .52$, $p < .001$, but not for the bilinguals on AUC, $r(101) = .05$, $p = .732$ or for MD, $r(101) = -.17$, $p = .231$. This would indicate a difference in the performance on these particular measures of these task when comparing monolinguals and bilinguals, and the differing directions of correlations for the bilinguals would indicate a diversity in the results for that group. The results of this exploratory analysis can be seen in Table 6-7.

CHAPTER 4

GENERAL DISCUSSION

The results did not show any of the expected differences between bilingual and monolingual adults through MouseTracker measures of AUC and MD or RT for any of the theory of mind tasks. One possible reason for this result is that mouse tracking methodology is not an effective methodology to differentiate between monolingual and bilingual theory of mind differences in adults. It may not be discriminant enough to distinguish between bilingual and monolingual adults, whose theory of mind capacity differs subtly since the general ability itself develops early in childhood. The differences may not reflect in the trajectory of the participants to differentiate between monolinguals and bilinguals. However, this is also not likely given the differentiation that was found in adults with eye-tracking.

Another possibility is that these tasks may not be the ideal ones to be used with MouseTracker. However, an iteration of the false belief video task had already been used with adults and analyzed with MouseTracker to detect whether tracking of others' beliefs was more of an automatic or controlled process (Van der Waal, Sebanz, Knoblich 2014). Nevertheless, this task did not look to differentiate between two groups like bilinguals and monolinguals, which means that it could be the case that the AUC and MD as measured through MouseTracker with this task does not make this kind of distinction. Additionally, the cartoon tasks were also previously used with adults to compare theory of mind in adolescents and adults (Van der Waal, Sebanz, Knoblich 2014, Sebastian et. al. 2014). This study, however, was not looking at monolinguals and bilinguals either, so once again, mouse-tracking may not differentiate between any differences between monolinguals and bilinguals.

Comparing the means of the monolingual and bilingual groups on these measures, several of them have a smaller AUC or MD measure and a greater RT for bilinguals compared to monolinguals, as can be seen in Tables 1-3, which is the opposite direction of difference between the means than was predicted. There are still some measures with means in the predicted direction, but the inconsistency is indicative of an inconclusive result. When looking at the means for this same set of measures when the baseline is considered, the measures for the two sets of cartoon tasks are all in the direction as expected, which includes a smaller AUC and MD, and a shorter or smaller RT for bilinguals compared to monolinguals, which can be seen with the means of Tables 2-3. This implies that this cartoon task may be a possible viable theory of mind task to use, as long as a baseline is considered, but more data should be collected to test this possibility, especially given the differences are not statistically significant. As the false belief videos remain non-significant with the baseline considered, and the means did not differ in the same direction as predicted, it appears that this task used through MouseTracker is not discriminant enough to differentiate monolingual and bilingual adults on their theory of mind, even with a baseline considered. One possible reason for this may be that the simplicity and repetitiveness of these videos is not engaging enough, and participants respond in reflexive ways rather than having to actually focus and process the stimuli presented to them. In contrast, the cartoon tasks are all different and essentially involves a story that is more engaging than variations of the same handful of possibilities and simplistic objects on screen.

The significant difference on initiation time for the cognitive cartoon task showed the means of initiation time for the bilingual group was significantly greater than the means of the monolingual group for this measure. Thus, bilingual individuals took more time before they moved from the starting position to initiate their response. A possible implication of this is that bilingual people take more time to think before they get ready to move their mouse to start their response process. Since this significant difference only occurred with the cognitive cartoon task, it is possible that it is about the nature of the considerations being made about the cognition of others that is distinctively different for bilinguals compared to monolinguals. What goes along with this pattern is the characteristics of the means for RT and the means for performance accuracy between the monolinguals and bilinguals of the cognitive task, as seen in Tables 2 and Table 5 respectively. Although there is no significant difference between monolinguals and bilinguals for RT or for accuracy, for the cognitive task, while the mean reaction time was longer for bilinguals, the mean accuracy was also higher for bilinguals, which could mean that bilinguals are taking longer to go from the starting point to click on the response, in order to be more accurate. However, since there is not a statistically significant difference, this is merely a possible explanation for what is happening and would need to be tested further, specifically looking for these patterns in a sample with less extreme variety in language background for fewer variables to affect these measures. That this pattern and the significant difference on initiation time all occurred for the cognitive theory of mind task, is further indication of the possibility of something particular about the way this type of cognitive theory of mind reasoning which prompts bilinguals to be slower to start and slower to respond.

The significant interaction that was observed by the factors of gender and language indicate a difference across these factors. Figure one shows that among the monolingual individuals, females had a higher composite perspective-taking self-report score than males, while among the bilingual group, the females and males have basically equivalent scores. This is confirmed with the simple main effects analysis that shows a significant difference between males and females for monolinguals, but not for bilinguals. A possibility for what this means is that bilingualism makes a greater impact for males compared to females on this self-reported perspective-taking measure. Bilingualism as a mechanism potentially makes a differential impact between different genders on theory of mind. Since the bilingual advantage has been found in adults on theory of mind (Rubio-Fernandez & Glucksberg, 2012) and the gender difference found with the IRI (Lucas-Molina, et. al., 2017), it is possible for these to be effects to occur at the same time and interact. This possibility would need to be properly assessed with a greater sample size that has a sufficient size for all conditions of the gender and language interaction.

When it comes to the exploratory correlational analysis, the inconsistencies and lack of strong patterns make it difficult to draw any significant conclusions. The cognitive and affective theory of mind cartoon tasks being consistently correlated for AUC and MD measures makes sense given they are part of the same set of tasks and indicate that they are indeed related. There are also positive correlations that do not differ by group, meaning AUC and MD increase together, as expected, on these tasks. The significance of the correlations for the AUC and MD measures of the false belief video task and the affective cartoon task being different by group while they are significantly correlated overall implies that this relationship is different for monolinguals and bilinguals. Given that monolinguals all have positive significant correlations for these four relationships, while bilinguals have non-significant correlations with different directions, it appears that bilinguals have inconsistent directions for their performance on these tasks while it is consistent for monolinguals. This could imply that a potential reason there were no significant results is that there was a lot of variety in bilingual performance that occurred in different directions. Of course, this is only a possibility based on exploratory analysis, although it is reinforced by the large SD's for some of RT data found with the false belief video task which indicated a wide range for bilinguals. To understand this further, it would be necessary to have a larger sample size with less extreme language background differences to try to find more consistent results and consistent patterns. A larger sample size would help to not have as much extreme variety.

Although the purpose of being inclusive of a range of bilingual conditions, including which additional non-English language the participant spoke, whether English was their L1 or L2, etc., was to focus on the general phenomenon of bilingualism rather than a particular subset of bilingual characteristics, this also inevitably creates the problem of many possible confounding variables. On the other hand, focusing on particular languages may mean that the phenomenon is particular to some characteristic about that particular bilingual language set. This conflict is difficult to resolve. One possible future approach is to place certain limits that are not too restrictive on types of bilinguals in order to focus on a particular characteristic, such as focusing on those with L1 English or comparing L1 English bilinguals with L2 English bilinguals. There could also be a larger sample size collected to include more language background variables, and a larger sample size for subsets of the bilingual background, such as L1 and L2 English bilinguals, heritage language bilinguals and non-heritage language bilinguals, and others. Given the previous evidence of the importance of the critical period and the age of acquisition, differentiating between those who learned their L2 before and after the critical period would be valuable (Birdsong, 2018). These methods would provide for opportunities to isolate certain groups of the bilinguals and compare across them, since different backgrounds may have different theory of mind results.

This study was able to assess the differences in theory of mind for monolinguals and bilinguals in adults using mouse tracking methodology. The results are inconclusive but show potential possible directions for future research. Exploring more about the particular characteristic of bilingualism that may affect theory of mind in adults is valuable for understanding the mechanisms of bilingualism which are the main factors in creating these bilingual advantages and understanding how to study these differences in adults. There is also value in exploring what characterizes the bilingual processing of such tasks in adults, such as initiation time, and other areas that may implicate differences between monolinguals and bilinguals, in order to understand more about what part of the processing is different.

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Table 1

False Belief Video Task Results

	Language	N	*M*	*SD*	*t*	*p*	*d*
AUC	Monolingual	53	.282	.612	-.557	.579	.11
	Bilingual	49	.342	.473			
MD	Monolingual	53	.162	.251	-.533	.595	.12
	Bilingual	49	.187	.228			
RT (ms)	Monolingual	53	1720.05	846.92	-.679	.499	.14
	Bilingual	49	1882.55	1503.57			
FB – TB AUC	Monolingual	53	.086	.419	-1.625	.107	.32
	Bilingual	49	.232	.495			
FB – TB MD	Monolingual	53	.092	.194	-.693	.490	.15
	Bilingual	49	.120	.212			
FB – TB RT	Monolingual	53	397.33	736.90	-.766	.446	.16
	Bilingual	49	619.95	1906.32			

Table 2

Cognitive Cartoon Task Results

	Language	N	*M*	*SD*	*t*	*p*	*d*
AUC	Monolingual	53	.558	.973	.4	.692	.08
	Bilingual	50	.480	1.022			
MD	Monolingual	53	.159	.245	-.06	.955	.01
	Bilingual	50	.161	.212			
RT(ms)	Monolingual	53	2105.82	643.32	-1.92	.058	.38
	Bilingual	50	2245.21	566.65			
Initiation time	Monolingual	53	775.44	291.36	-2.12	.037	.42
	Bilingual	50	912.13	362.05			
Cog-Phys AUC	Monolingual	53	.104	.961	.0009	.999	.0002
	Bilingual	50	.031	1.122			
Cog-Phys MD	Monolingual	53	-.012	.203	.192	.848	.04
	Bilingual	50	-.020	.238			
Cog-Phys RT	Monolingual	53	-143.69	478.58	1.57	.119	.31
	Bilingual	50	-293.85	490.94			

Table 3

Affective Cartoon Task Results

	Language	N	*M*	*SD*	*t*	*p*	*d*
AUC	Monolingual	53	.591	.850	.798	.427	.157
	Bilingual	50	.474	.610			
MD	Monolingual	53	.207	.219	.019	.985	.004
	Bilingual	50	.206	.214			
RT	Monolingual	53	2234.11	572.25	-.619	.537	.122
	Bilingual	50	2462.07	872.87			
Initiation time	Monolingual	53	839.87	370.15	-1.17	.244	.23
	Bilingual	50	929.87	409.56			
Aff-Phys AUC	Monolingual	53	.137	.700	.910	.365	.179
	Bilingual	50	.025	.524			
Aff-Phys MD	Monolingual	53	.036	.204	.152	.880	.03
	Bilingual	50	.024	.192			
Aff-Phys RT	Monolingual	53	-15.39	486.50	.156	.876	.031
	Bilingual	50	-32.08	595.82			

Table 4

Composite IRI Perspective-Taking Results

	Language	N	M	SD	t	p	d
Comp IRI PT	Monolingual	53	19.57	4.19	-.224	.823	.044
	Bilingual	50	19.74	3.44			

Table 5

Accuracy on Tasks Results

	Language	N	M	SD	t	p	d
FB	Monolingual	53	93.63	7.82	-.1.016	.312	.201
	Bilingual	50	95.13	7.03			
Cog	Monolingual	53	97.74	5.77	-.241	.810	.047
	Bilingual	50	98.00	5.35			
Aff	Monolingual	53	89.25	7.756	.529	.598	.105
	Bilingual	50	88.20	11.90			

Table 6

Exploratory: Correlations Between Measures Using Pearson's r

	FB AUC	FB MD	FB RT	Cog AUC	Cog MD	Cog RT	Aff AUC	Aff MD	Aff RT	IRI PT
FB AUC	1	.859*	-.277*	.117	.071	.163	.438*	.317*	.044	-.108
FB MD		1	-.077	.076	.025	.117	.332*	.203*	-.030	-.077
FB RT			1	-.004	.016	-.065	-.069	-.122	.029	.166
Cog AUC				1	.787*	.240*	.551*	.346*	-.018	-.019
Cog MD					1	.125	.459*	.515*	-.058	.010
Cog RT						1	.035	.028	.615*	.022
Aff AUC							1	.816*	.063	-.070
Aff MD								1	.149	-.032
Aff RT									1	-.016
IRI PT										1

Note. * = statistically significant, $p < .05$

Table 7

Exploratory: Monolingual and Bilingual Group Correlations using Pearson's r

	Monolingual (M) or Bilingual (B)	FB AUC	FB MD	FB RT	Cog AUC	Cog MD	Cog RT	Aff AUC	Aff MD	Aff RT	IRI PT
FB AUC	M	1	.911*	-.022	.266	.138	.063	.710*	.591*	.062	-.140
	B		.795*	-.435*	-.034	-.016	.273	.050	.006	.009	-.071
FB MD	M		1	-.060	.262	.138	.137	.589*	.516*	.097	-.115
	B			-.097	-.127	-.130	.078	-.066	-.172	-.148	-.026
FB RT	M			1	.189	.180	.036	.062	.029	-.044	.158
	B				-.086	-.064	-.127	-.170	-.205	.054	.205
Cog AUC	M				1	.820*	.415*	.498*	.424*	.004	-.196
	B					.759*	.054	.648*	.268	-.023	.201
Cog MD	M					1	.174	.406*	.491*	-.193	-.122
	B						.058	.560*	.546*	.043	.206
Cog RT	M						1	.141	.105	.568*	.106
	B							-.117	-.065	.682*	-.108
Aff AUC	M							1	.903*	.158	-.242
	B								.713*	.008	.243
Aff MD	M								1	.084	-.161
	B									.205	.138
Aff RT	M									1	.006
	B										-.044
IRI PT	M										1
	B										

Note. * = statistically significant, $p < .05$

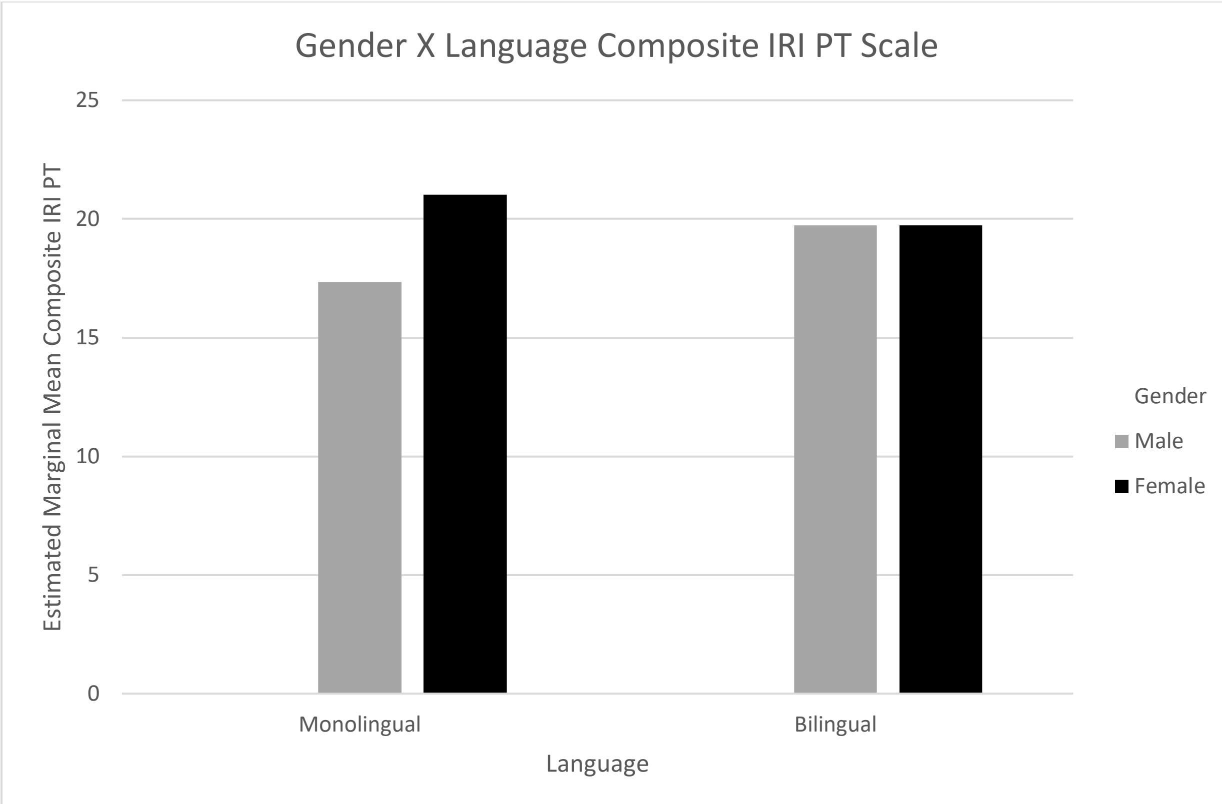

Figure 1: Gender and Language Interaction on Composite IRI PT Subscale

APPENDIX A

False Belief Task