Effect of bilingualism on inhibitory control and theory of mind development

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To my "kuzu" …

Thesis Abstract

Tuğay İlyasoğlu, "Effect of bilingualism on inhibitory control and theory of mind development"

The aim of the present study was to investigate the effect of bilingualism on inhibitory control and theory of mind development of preschoolers between the ages of 3 and 5. Accordingly, 2 age groups of bilinguals and monolinguals (younger group between the ages 3 and 4; older group between the ages 4 and 5) performed following tasks; theory of mind tasks (location false belief, location false belief explicit, contents false belief, appearance-reality task), inhibitory control (DCCS, Grass/Snow and Day/Night Stroop task and color-object Stroop task), Peabody Vocabulary Test, and lastly pretend play. The results of the study revealed only significant effects of age on both theory of mind and inhibitory control; not language. The results of the study were discussed in the light of SES and parent education level of the participants.

Tez Özeti

Tuğay İlyasoğlu, "Effect of bilingualism on inhibitory control and theory of mind development"

Bu araştırmanın amacı 3 ve 5 yaş arasında iki dilli olmanın engelleyici kontrol ve zihin teorisi gelişimi üzerindeki etkilerini incelemektir. Bu doğrultuda, iki ve tek dilli çocuklar 2 yaş grubuna ayrılarak (3-4 yaş arası genç grup, 4-5 yaş arası yaşlı grup) çeşitli deneyler yapılmıştır; zihin teorisi deneyleri, engelleyici kontrol deneyleri, Peabody kelime testi ve mış gibi yapma testi. Araştırmanın sonuçlarına göre engelleyici kontrol ve zihin teorisi gelişiminde sadece yaş'ın istatistiksel olarak anlamlı bir etken olduğu, iki ya da tek dilli olmanın bir etkisi olmadığı ortaya çıkmıştır. Araştırmanın sonuçları sosyoekonomik statü ve ailelerin eğitim düzeyleri göz önüne alınarak tartışılmıştır.

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INTRODUCTION

Bilingualism is an individual's proficiency in two language systems. Although early studies on bilingualism focused on the negative effects of bilingualism such as weaker verbal abilities, poorer vocabulary; recent studies take bilingualism into consideration balanced bilinguals as they are equally proficient in both languages and this change in the sample revealed positive effects of bilingualism on cognitive development such as mental flexibility, concept formation and metalinguistic awareness (Lee, 1996).

Bialystok, Craik, Klein & Viswanathan (2004) proposed that as bilinguals routinely pay attention to abstract dimensions of language that are essentially transparent to monolinguals. Bilinguals children need to be aware at some level (not necessarily consciously) of the language that is needed in a particular situation or with a particular speaker and they rarely make mistakes in selection. On the other hand, most of the times tasks that bilinguals are advantageous are distinguished by the incidence of misleading, generally perceptual, information and the need to choose between competing response options. Tasks based more heavily on analytical knowledge presented without a misleading context are solved equally well by monolinguals and bilinguals. This difference corresponds to the difference between control and representational processes. Functions involve with control include selective attention to relevant aspects of a problem, inhibition of attention to misleading information, and switching between competing alternatives. Control processes in charge of regulation and inhibition of information, particularly in the presence of conflicting cues, are within the last cognitive abilities that come out in children.

Around 4 years of age, another important development change occur; theory of mind which is children's developing understanding that people might have different mental representations of the world and one can be wrong about it (Kloo and Perner, 2003). One possible factor in the emergence and expression of theory of mind is executive functioning, especially inhibitory control (Carlson & Moses, 2001). The results of the studies conducted in order to investigate the relation between theory of mind and inhibitory control reveal a strong correlation but the direction of the relation is not relevant and controversial (Kloo and Perner, 2003).

The aim of the current study is to investigate the relation between theory of mind and inhibitory control by comparing monolingual and bilingual preschool children, in order to shed light to the direction of the relation.

Bilingualism and Inhibitory Control

Previous research conducted with bilinguals indicated bilingual advantages across variety of domains such as; creativity, problem solving and perceptual disembedding (Kessler & Quinn, 1987 as cited in Bialystok, Craik, Klein & Viswanathan, 2004). Also bilingual disadvantages such as lexical decision task (Ransdell & Fischler 1989 as cited in Bialystok et. al. 2004). Bialystok, Craik, Klein & Viswanathan (2004) proposed that the contradictory findings can be compromised by taking into consideration the cognitive processes implicated in various tasks used to evaluate the effects of bilingualism. Most of the times, tasks that bilinguals are advantageous are distinguished by the incidence of misleading, generally perceptual, information and the need to choose between competing response options. Tasks based more heavily on analytical knowledge presented without a misleading context are solved equally well by monolinguals and bilinguals. This difference corresponds to the difference between control and representational processes. Functions involve with control include selective attention to relevant aspects of a problem, inhibition of attention to misleading information, and switching between competing alternatives. Whereas the functions contribute to representation include encoding problems in sufficient detail, accessing appropriate knowledge, and making logical inferences about relational information. Control processes in charge of regulation and inhibition of information, particularly in the presence of conflicting cues, are within the last cognitive abilities that develop in children which has been attributed to the late development of the frontal lobes that mediate these skills (Diamond, 2002 as cited in Bialystok, Craik, Grady, Chau, Ishii, Gunji & Pantev, 2005). On the other hand research conducted with bilingual children showed that although bilingual children develop control processes in faster rates than monolingual children, both of the groups improve at the same speed in the development of representational processes (Bialystok, 1993).

Investigations of the metalinguistic capacities of bilingual and monolingual children revealed different developmental patterns for these two groups. The representational changes are attributed to the development of two processing components; ability to represent increasingly explicit and abstract structures and to control which is the ability to selectively attend to specific aspects of a representation, especially in misleading situations. However these two processes are related and methodologically it is difficult to separate them, bilingualism presents an important base for this attempt. If the experience of learning more than one language in childhood changed the way in which one of these processes evolved, then it would be possible to observe their developmental effects individually (Bialystok, 1999).

Bialystok (1999) proposed some possible reasons for the bilingual advantage in tasks that contain misleading information. As bilinguals routinely pay attention to abstract dimensions of language that are essentially transparent to monolinguals. Bilingual children need to be aware at some level (not necessarily consciously) of the language that is needed in a particular situation or with a particular speaker and they rarely make mistakes in selection. Also they realize that names of things are arbitrary because they can call the same thing by different names.

Another reason for bilingual advantage lies in the recent studies which indicated that two languages of a bilingual remain constantly active while processing is carried out in one of them (Brysbaert, 1998; Francis, 1999; Gollan & Kroll, 2001; Kroll and Dijkstra, 2002; and Smith, 1997; as cited in Bialystok et. al. 2004). The dual activity of the two systems requires a mechanism for keeping the languages separate in order to achieve a fluent performance without distractions from the unused language. Green (1998, as cited in Bialystok et. al. 2004) proposed a model called Inhibitory Control which controls the activation of competing schemes. This system is based on the suppression of unused language by the same executive function used mostly to control attention and inhibition. Depending on this model, bilingual children exercise in inhibitory control very much, and which might be generalized across cognitive domains. Inhibitory Control model has implications for high-level cognitive processing because the relevant inhibition of the mechanism is situated in a central process.

Another model proposed for explaining inhibitory control is the Bilingual Interactive Activation model in which hierarchically organized representations of words from both languages are activated by input and they compete for selection (Dijkstra & Van Heuven, 1998; Van Heuven, 1998; as cited in Bialystok et. al.

2005). A layer of nodes indicates the language mark and represents the role of context in language use. Occurring competition between and within language is determined by lateral inhibition, adjacent representations inhibit each other, so that selection of a particular response decreases the probability of selecting the adjacent response. This model is an account of how semantic processing is carried out by bilinguals (Dijkstra & Van Heuven, 1998; Van Heuven, 1998; as cited in Bialystok et. al. 2005).

Bialystok et. al. (2005) argued that both the Bilingual Interactive and the Inhibitory Control Model take into consideration the organization of semantic systems in bilinguals and propose inhibitory mechanisms to determine the conflict produced if access to the lexicon is not language selective. Therefore the difference between the models is the nature and locus of inhibition. Depending on the Bilingual Interactive Model, properties of the stimulus is the local determinant of inhibition, whereas depending on the Inhibitory Control Model, inhibition is a central mechanism stemming from higher centers such as the frontal lobes. As the Bilingual Interactive Model is data driven, it is not possible to determine how the inhibition could be generalized across problems and skill areas. In contrast Inhibitory Control Model provides a basis for understanding how bilinguals could develop a generalized advantage in cognitive control.

In her study, Bialystok (1999) investigated whether bilingual advantage in control is found in a non-verbal task; dimensional change card sort (DCCS). DCCS task places two pairs of rules in conflict and requires children to pay attention to one of them at a time. Children are shown cards containing pictures of two targets. They are then given a set of cards consisting of cards and asked to sort them by one of the dimensions, color or shape. Following this, a new pair of rules reverses the relationship between the targets and the cards and children must sort the cards by the opposite direction. Until 4 or 5 years of age it is very difficult to be successful in the second phase when the sorting rule changes because they continue to use the first one.

According to Bialystok (1999) the demand for analysis is in the ability to understand the range of the sorting rule and the demand for control is in the ability to ignore the original rule and reconsider the cards in terms of the new instruction. The control demand is more difficult as most of the children make very few mistakes in the first phase of the task but bump into difficulty in the second phase. If this is correct than bilingual children should solve the dimension change card sort task better than monolingual children.

60 children participated to the study; within this children half of them were in the younger group whose ages ranged from 3.2 to 4.9, and other half were in the older group whose ages ranged from 5 to 6.3. And also half of the children were monolingual of English and other half were Chinese and English bilinguals. All of the participants were administered to PPVT-R, Form M, Visually-Cued Recall Task, Moving Word Task and Dimensional Change Card Sort.

The results of the study indicated that all of the participants had equivalent levels of receptive vocabulary and comparable capacity for working memory. Nevertheless, in tasks containing distracting information that made the solution difficult, bilinguals outperformed monolinguals. This result revealed that the ability of bilingual children to control over attention in a nonverbal problem that is based on different forms of problem solving than any previously used. Also this success of bilinguals indicated that two aspects of functioning (ability to represent increasingly explicit and abstract structures and to control) are distinct from each other as there is no reason to attribute more sophisticated representations to bilingual children which are also available for monolinguals. Also as the bilingual children demonstrated increased skill in executive functioning, bilingualism might have impact on the development of executive functioning (Bialystok, 1999).

In another study, Bialystok et. al (2004) question if the improvement of bilingual children is strong enough, bilingualism may continue to influence certain control processes throughout the lifespan. If the control processes used in the management of language systems described by Inhibitory Control model are the same processes used in the other nonverbal rationales, then the use of these processes during language use would provide an explanation for the enhanced performance of bilinguals on certain nonverbal cognitive tasks. This explanation leads to the hypothesis that bilinguals are more proficient than monolinguals in tasks requiring inhibitory control.

Depending on the assumptions of the Inhibitory Control Model, Bialystok et. al. (2004) questions whether the advantages found for young children in executive processes are also seen in adult bilinguals and whether such advantages are maintained in older adulthood and protect bilingual adults from the normal decline of these processes that occurs with age. Children's cognitive development is characterized by a growth in both control of attention and representational complexity, on the other hand aging leads to a decline in the efficiency of attentional control but not in the ability to exploit routine procedures and representational knowledge. Therefore, bilingual children experience an improvement in the development of types of cognitive processing that typically decline with aging.

Bialystok et. al. (2004) also questions whether the ability to attend to the stimulus and ignore the irrelevant location information reflects the same type of cognitive control that is enhanced in the development by bilingualism. If this is the case then the young bilingual children's performances should be less affected by the irrelevant spatial code of the target than the performance of comparable monolingual children; bilinguals should show a reduced Simon affect. Moreover if the effect of bilingualism on cognitive processes persists through adulthood then this advantage should also be found in adult bilinguals. Finally, if lifelong bilingualism provides a protection from the normal decline of these control processes, then older bilinguals should show less decrement in control as measured by the Simon task compared to monolingual older adults. The reason for using the Simon task is that; it is a powerful tool for revealing the effect of stimulus-response compatibility on performance. Also it is widely used task for investigating attentional processes and executive functions. In the task a stimulus which contains both position and response information are presented with a rule that requires participants to ignore the position and respond only to the relevant target aspect. When the stimulus appears on the same display side as the correct response key both position and the response information congregate on the correct response, this kind of a trial is called congruent trial. When the position contradicts with the correct response, the trials are called incongruent. The reliable increase in response time for the incongruent trials compared to the congruent ones is usually between 20 and 30 milliseconds and this is called Simon effect. The most common explanation for the Simon effect is that mirrors stimulus-response (S-R) incompatibility because of response-selection processes. The location is coded in spite of its irrelevance, creating longer reaction times when the stimulus location and the response key are incongruent (Lu & Proctor, 1995; as cited in Bialystok, 2006). In addition to the need to selectively focus on the target stimulus in the context of misleading position information, the Simon task includes other demands that recruit executive processing. Such as the task is presented to the participants in mixed trials which requires set dissipation, and response switching that are part of controlled or executive functioning. Performance in the Simon task contains processes involved with selective attention, inhibition and response switching (Bialystok, 2006).

In order to test these assumptions, monolingual and bilingual younger and older adults were exposed to different versions of the Simon task. In all of the experiments conducted monolinguals and bilinguals performed differently on the Simon task. Bilinguals responded faster to both congruent and incongruent trials. Bilinguals produced a smaller Simon effect which indicated that regardless of speech they were disrupted less by the incongruent items. The results also revealed that bilingualism reduced the age related increase in the Simon effect which indicated the lifelong experience of managing two languages eases the age related decline in the effectiveness of inhibitory processing. It was also shown that proportional increases from the congruent to the incongruent condition were superior for the older adults and for the monolinguals.

The results of the study supported the assumptions of whether the bilingual advantages in control processing observed for children would be maintained into adulthood and whether bilingualism would provide a defense against the decline of these executive processes that occurs with normal aging. The results of the study indicated that in all of the studies bilinguals performed more effectively compared to monolinguals and also the age related increase in the Simon effect was significantly less for the bilingual participants. The initial hypothesis of Bialystok et. al. (2004) which was bilingualism improves inhibitory control and therefore bilingualism would be associated with a small Simon effect and with a smaller age related increase in the Simon effect. The findings support the hypothesis. And depending on the results of positive effect of bilingualism on working memory costs Bialystok et. al. (2004) speculates the beneficial effects of bilingualism may be wider than its effect on inhibitory control. The effects may be on executive control functions mostly and may act to reduce the negative impact of aging on such functions.

It was also hypothesized that bilinguals would outperform monolinguals in the incongruent trials but the results indicted that they also outperformed monolinguals in the congruent trials, too. Bialystok et. al. (2004) proposed two possibilities for the reason of this; one is that the executive processes engaged in attention and selection across these conditions might be the same, and the components being enhanced by the lifelong experience of bilingualism might be central executive components rather than just inhibition. Another possibility is that as originally proposed influences only the inhibitory control and this more efficient inhibitory control is seen in some working memory tasks as well as in situations in which the need to inhibit misleading information is more obvious.

In another study, Bialystok et. al. (2005) proposed that examination of the areas of cortical activation during the Simon task may reveal the reason for the bilingual advantage and therefore examination of electrophysiological signals would be more informative than reaction times in establishing how participants solve the task. One of the aims of the study was to verify and clarify the differential pattern between monolinguals and bilinguals. Another purpose of the study was to understand why the bilingual advantage in reaction times came about for both congruent and incongruent trials in the study of Bialystok et. al. 2004. One possible reason is that if lifelong experience of bilingualism results in improved cognitive control, and this may be associated with an enhanced ability to represent task control in the left PFC (MacDonald et al., 2000; as cited in Bialystok et al. 2005). In turn, this greater task control may act in a top-down fashion to improve performance on both congruent and incongruent trials.

In the study of Bialystok et al. 2005, the questions stated above are investigated by examining two groups of bilinguals (French-English and Cantonese-English) and a group of English monolinguals in order to determine whether cortical activation during the Simon task was different in participants from different comparison groups. 30 volunteers, 10 from each group, participated to the study. Their mean age was 29. Participants were exposed to a questionnaire in order to classify them as bilinguals. While the participants were performing in the Simon task MEG data recording of these participants were done. All of the participants were assigned to congruent, incongruent and control trials of Simon tasks.

The results of the study indicated that three groups' performances were different in the Simon task. Reaction times of Cantonese-English bilinguals were faster compared to the other groups. In all of the groups differential response to congruent and incongruent trials was observed. Faster reaction times were associated with increased frontal activation in all of the groups. Specific cortical areas involved were largely the same for the two bilingual groups but different for the monolinguals. Even in the absence of reaction time differences between groups, brain activation data distinguished between monolingual and bilingual participants. Constant with the results of Bialystok et. al. (2004), the French-English bilinguals' reaction times were in the same speed of monolinguals on both congruent and incongruent tasks whereas Cantonese bilinguals were faster than both the French bilinguals and monolinguals. Still consistent with Bialystok et. al. (2004), Cantonese participants kept their speed advantage on both congruent and incongruent tasks. Faster reaction times of

Cantonese participants could be accounted for the sampling variety as the groups had small number of participants (Bialystok et. al., 2005).

The question proposed by Bialystok et. al. (2005) concerning the distinction between the bilinguals and monolinguals was supported. Faster reaction times were associated with increased activity generally in the left hemisphere regions and slower responses with increased activity in the right hemisphere regions. These activation patterns might partly reflect response speed, as the fastest Cantonese bilinguals expressed this pattern to a lesser extent. The monolinguals and bilinguals differed in the activation results. For the bilinguals faster responding was hinted by increased activation of the right temporal and left frontal and cingulate areas and slower responding by activity in occipital and parietal regions which is an indicator of engagement of inhibitory processes. Faster reaction times of Cantonese group might be the consequence of additional activation expressed by these participants that distinguishes them from the French bilinguals (Bialystok et. al., 2005).

Another aim of the study was to investigate whether data from neural activation could assist finding the reason of the reaction time differences between groups that apply to both congruent and incongruent tasks that was found in Bialystok et. al. (2004). The results indicated some regions activated in congruent and incongruent task trials which was characterized in both bilinguals and monolinguals. Bialystok et. al. (2005) proposed that although bilingualism may vary facets of processing used to perform Simon task, it does not appear to affect the way trials are distinguished as congruent and incongruent.

The results facilitated that faster responding in bilinguals was related to activation in cingulate, superior frontal, and inferior frontal regions (the same areas that are engaged in the management of two language systems) whereas fast responding in monolinguals are associated with middle frontal, all in the left hemisphere. Both groups showed faster responding with increased activation in the left frontal areas but with different specific regions. It is possible that bilingualism enhances those control processes in the left frontal lobe and makes them available for other inhibitory tasks even nonverbal ones which is consistent with Green's hypotheses of Inhibitory Control. Slower responding in both bilinguals and monolinguals however was related to activation of substantially different areas. For the bilinguals slow responding was went along with by increased activation in the visual cortex and for the monolinguals by activation in the motor cortex largely in the right hemisphere in both cases (Bialystok et. al., 2005).

Some recent researchers argue that cortical centers that control these attentional processes are plastic and may be modified through experience (Marzenich &Jenkins, 1993; as cited in Bialystok, 2006). Posner and colleagues (as cited in Bialystok, 2006) also propose that training might also determine the course of development for these attention networks. Experiences that use the processes employed in attentional control may modify those processes and modify their function for other purposes. This outcome would have implications for the generalizability, interactivity and plasticity of central cognitive processes. The aim of the Bialystok's (2006) study was to investigate effect of two such experiences on Simon task performance; bilingualism and playing computer video. Bialystok (2006) proposed that if Inhibitory Control model of Green (1998) and Posner's ideas are correct then bilinguals should reveal more efficient selective attention and ability to ignore distraction than monolinguals because of their regular use of general executive functions in the management of two languages.

The need to constantly switch between languages may also strengthen the ability to execute response switches in other domains, an ability that may be helpful in performing the Simon task. Although there is no research investigating the response switches performances of bilinguals in comparison with monolinguals, there is some evidence of task switching skill of bilinguals. In the study of Hernandez and Kohnert (1999; as cited in Bialystok, 2006) task switching performances of adult and older adult bilinguals were investigated. The results of the study indicated that however both types of switch blocks increased reaction times evenly for younger and older adults, the predictable switch blocks that contained more within trial switches were more difficult for older adults compared to younger adults. According to this study Bialystok (2006) proposed that if bilingualism protects the decline of executive function with age, then bilingualism might also protect the skill of carrying out response switching and increases performance in paradigms like Simon task.

Another experience that might influence the participants' executive processes in the Simon task is practice with computer video games. Bialystok (2006) hypothesized that experiences that share some of the same executive processes that are involved in the Simon task will adapt those processes and end in measurable changes in performance in that task. The experiences of bilingualism and computer video game have different relations to Simon task. Bilingualism is connected to executive functioning (Green, 1998) and influence performance on Simon task in some age groups (Bialystok et. al., 2004), but is obviously not connected to the task. Whereas video game playing is more alike to the speeded processing demands of the Simon task, so these skills may transfer across tasks. It was expected that these two experiences would have different effects on the task performances of the participants.

Two versions of the Simon task were recruited in the study; the first one required working memory to remember the stimulus-response association and resembles the demands of video games in which random rules associate stimulus and response. On the other hand second one required inhibitory control to determine the conflict between two spatial codes in the incongruent trials and resembles the perceptual conflict tasks that the bilinguals are successful. Also the high switch condition for both tasks investigated the effect of increased monitoring and response switching on processing. 97 participants whom half was monolinguals and other half was bilinguals; and half was experienced video game players and other half was not, took part in the study. Language and computer game experiences were determined by questionnaires administrated to the participants. The two versions of the Simon tasks were administrated in a counterbalanced order.

The results of the study indicated that participants with different experiences (bilingualism or computer video game) performed differently in different tasks; videogame players demonstrated strong speed advantages whereas bilinguals demonstrated more slight processing advantages; such as bilingualism increased performance in the high switch condition of the arrow task which is the most demanding condition and produced the longest reaction times. And the effect of these experiences were not additive, they were distinctive; both the video game players and bilinguals performed better in tasks that was similar to their experiences. There were no interaction between the direction or intensity of the Simon effect and group. The conditions in which bilinguals or video game players performed better, participants maintained that advantage in both congruent and incongruent trials which is consistent with the previous findings of Bialystok et al.(2004).

The results of the study also revealed that two versions of the Simon task produced different results which suggested different executive processing components involving in different versions. Although the two tasks seem very alike, they produced different response patterns and were solved better by participants who have different experiences. In both of the versions of the task, the stimuli need to be understood and linked to a response that is a decision sometimes required switching from a previously executed response. Apart from the common demands, each task is focused on a different component of executive performance and the results support this proposal.

In another study, Bialystok, Martin & Viswanathan (2005) questioned whether the processes that are improved in development of bilingual children continue to be efficient in bilingual adults and the identification of control of attention, containing inhibition and selectivity, as the major focus of influence for bilingualism on children's cognition. As older adults have less control over the content of working memory and less executive control in general than the young adults, if bilingualism facilitates this function than bilingualism may be a defense against normal decrease of cognitive control over attention.

In the first study of Bialystok et al. (2005), French-English bilingual children's and English monolingual children's performances were compared in the Simon task. The bilingual children responded significantly faster than monolinguals in both the congruent and incongruent trials which was a surprising result. In order to replicate the same study with a bigger sample size more bilinguals and monolinguals were recruited for the second study. The results of the second study revealed that although the difference between the bilinguals and monolinguals decreased the difference was still significant. If the Simon task relies only on inhibition of attention than bilinguals advantage seen also in congruent trials is a bit puzzling. It might be possible that bilinguals were just faster than monolinguals and they might have not any advantaged access to control of attention. In order to test this, control condition that did not include conflict created by the Simon task was added to the study. Another difference made in the third study was the participants; bilinguals and monolingual university students were recruited. The bilingual students who met the bilingualism standards were children or grandchildren of immigrants. The results of this study indicated that incongruent items took significantly more time than congruent and control trials. Monolingual and bilingual participants performed exactly the same in all of the conditions. The task requests the use of computer for rapid controlled responding which is a kind of skill that has been mastered by most of the university students. Depending on this assumption, all of the participants filled out a questionnaire about computer video game playing. The results indicated that computer video game players had a reliable advantage in the task. The ability to respond more quickly improved performance on the trials where executive processing was more in demand, in incongruent and congruent trials not in the control trial. The forth study compared the performances of bilinguals and monolingual older adults with bilingual and monolingual middle adults in order to investigate whether the bilingual advantage reappears in the lifespan. The results of the study indicated that consistent with the effects of aging middle adults performed faster than older adults and bilinguals were faster than monolinguals in both congruent and incongruent trials. In the fifth study a control condition were added to the study again with the same participants who have same demographic information of the forth study's. Again middle aged adults were faster than older adults in all of the trials. In the control trial there were no differences between bilinguals and monolinguals whereas in the congruent and incongruent trials bilinguals were faster than monolinguals. Another interesting finding was that there were no reaction time differences of bilingual middle aged participants in incongruent and congruent trials (Bialystok, Martin & Viswanathan, 2005).

The control trials added to some of the studies indicated that better performances of bilinguals in both the congruent and incongruent trials were not just a simple reaction time difference. Bialystok, Martin & Viswanathan (2005) interpret this finding as executive demands of the Simon task broaden to the need to carry out local switches between randomly presented items, and this aspect of processing is also more efficient in bilinguals indicating an advantage in both types of trials. In conclusion Bialystok, Martin & Viswanathan (2005) proposed that language is not isolated from general cognitive processes instead it is tied to it. The need to manage two active language systems and to manipulate attention to both during language use is carried out by the same general executive functions responsible for managing attention to any set of systems or stimuli. Experiencing of exercising these attentional systems enhances their function, and the benefit can be seen whenever control of attentional processing is required. “It is incontrovertible that bilingualism enriches the life by opening the individual to other forms of knowledge, other cultures, and other types of thought. It is a serendipitous bonus that it may also bestow the individual with an enhanced skill in executing a fundamental cognitive process.” (p.117, Bialystok, Martin & Viswanathan, 2005).

In another study conducted by Martin & Bialystok (2003), they classified the task as bivalent and univalent. Bivalent tasks are the ones that have two pieces of conflicting information present simultaneously and one can lead the participant to be lost. One example of these tasks is the Simon task in which both location cues and misleading location cues must be ignored. Univalent tasks are the ones in which there is one piece of information associated with a familiar response that must be suppressed and replaced with a conflicting response. One example of these kind of tasks is the Stroop task in which the participant must overcome the usual tendency to name the color and say the opposite. Martin & Bialystok (2003) hypothesized that there would be a bilingual advantage in the univalent Simon task whereas bilinguals and monolinguals would perform equally well in the Stroop task. The results of the study supported their hypothesis, bilingual children performed faster than monolingual children in the Simon task, while on the other hand bilinguals and monolinguals performances were equal in the Stroop tasks for both the reaction time and accuracy. Martin & Bialystok (2003) explain this result as bilinguals need to manage two activated language systems which might be done by controlling attention to one of them and inhibiting the other, this skill might have led them to outperform the monolinguals in the Simon task which activates two competing representations and resolving the competition involves attending to one representation and ignoring the other. On the other hand univalent tasks just activate one representation and are not based on these practiced control processes and this might be the similar performances of bilinguals with monolinguals.

On the other hand, Morton & Harper (in press) proposed that previous studies which examined the bilingual advantage in Simon task did not consider the effect of socio-economic status and ethnicity. In order to eliminate this, Simon task was administered to bilingual and monolingual children with same ethnic and socio-economic status. 34 monolingual and 17 bilingual children with a mean age of 6.88 participated to the study. All of the bilingual children were from o local French school.

Simon task, vocabulary measures (Peabody Vocabulary Test), and a test of non-verbal intelligence (Matrix Analogies Test) were administered to all of the participants. Also parents of the participants completed background information questionnaire (Morton & Harper; in press).

The results of the study revealed that bilingual and monolingual children performed similarly however performances of children from higher SES families were more advantageous compared to performances of children from lower SES families(Morton & Harper; in press).

Theory of mind and executive functions

Around 4 years of age, children develop an ability to understand other people's minds, they start to acquire that people might have different mental representations of the world and one can be wrong about it is known as the theory of mind (Wimmer & Perner, 1983; as cited in Flynn, O'Malley & Wood; 2004). One possible factor in the emergence and expression of theory of mind is executive functioning which includes the processes that monitor and control thought and action such as self-regulation, planning, behavior organization, cognitive flexibility, error detection and correction, response inhibition and resistance to interference. Regarding of emergence, without some competence to distance themselves from current stimuli, they would not be able to reflect on representation of those stimuli. And regarding of expression in order to be successful in theory of mind tasks, children requires overriding prepotent predispositions to reference reality. Within the processes of executive functioning, inhibitory control is central in the relation between theory of mind and executive functioning. Like theory of mind, inhibitory control also develops around 4 years of age. There are two kinds of inhibitory control tasks; the first one measures children's ability to delay or suppress an impulsive response when a task requires it and the other one includes tasks that require children to react in a certain way in a highly salient, conflicting response alternative, in this kind of conflict tasks children must also provide a novel response. Apart from developing around the same ages, there are some other links between theory of mind and inhibitory control. Brain imaging studies indicate the same brain regions being activated while doing both of the tasks; frontal lobes. Studies conducted with autistic children revealed that they are deficient in both of the tasks (Carlson & Moses, 2001). On the other hand, the causal relation between theory of mind and executive function is very controversial (Kloo & Perner, 2003).

In order to investigate this relation Hughes (1998) conducted a study. Fifty preschool children whose first language at home was English participated to the study with a mean age of 3 years and 11 months. Apart from the assessments of children's verbal and non-verbal abilities, two working memory tasks (pin the pots visual search task and noisy book auditory sequencing task), two inhibitory control tasks (detour-reaching box and fist and finger hand game), EF tasks (two attentional flexibility tasks a simple color/shape set-shifting task and a magnets pattern-making task) and ToM tasks (false-belief predictions, false-belief explanation and deception task) were administered to the participants.

The results of the study indicated that preschoolers' performances on EF and TOM tasks were associated. Even after age related effects were partialled out, significant correlations were found between working memory and false belief prediction and between inhibitory control and both deception and false belief explanation. When age, verbal and non-verbal ability were partialled, both inhibitory control and attentional flexibility were significantly correlated with scores for deception which indicated that EF and TOM could not be explained by verbal and non-verbal ability. The results of the study also revealed that age-related improvements in deception could be explained by co-occurring improvements in inhibitory control which supported the growing strategic rather than representational abilities. The results indicated that age related improvements on standard false belief prediction tasks were not being mediated by covarying increases in EF and changes in children's meta-representational skills could not explain age related changes in EF performance. Rather a fractioned model of EF were supported, further indicating that deception, explanation and prediction of false belief showed different patterns of association with different aspects of executive control. In general, the results indicated that children's theory of mind are multifaceted constructs and involve several different types of skills. Strong age related changes in EF was observed in the preschool children and patterns of association observed between different aspects of EF and ToM did not support the modular view of the two domains, rather supporting that they are multifaceted constructs with specific instead of general relationships between the two domains.

The aim of the study of Carlson & Moses (2001) was to examine the relation between the preschool children's inhibitory control skills and their theory of mind. 107 preschool children, sixty-two 3 year olds and forty-five 4 year olds were tested in two sessions. They all completed inhibitory control and theory of mind batteries, measure of verbal ability, mental state control tasks and motor sequencing task. Also parental data of children's IC, data of children's pretend play and number of siblings were collected. Theory of mind battery consisted of location false belief, contents false belief, deceptive pointing and appearance-reality tasks. Mental state control tasks were contents and location. Inhibitory control battery tasks were day/night, grass/snow, spatial conflict, bear/dragon, card sort, pinball, gift delay, tower building and KRISP.

The results of the study indicated that executive functioning developments are closely linked to changes in children's theory of mind in the preschool period. Four year old participants outperformed three year olds in TOM tasks which are interrelated over and above age, gender, and verbal ability factors. The results also revealed that inhibitory control skills improved in the preschool years. The TOM battery was significantly correlated to each of the collective IC tasks, and also to all of the individual behavioral measures of IC. Both IC and TOM were related to age, gender and verbal ability. The correlations still remained significant after other factors held constant. Inclusion of Mental State Control Task was a major advantage of the study because although the task taped inhibitory control skill, the IC-TOM relation was still significant in the subset of children who performed perfectly in this task. Although both the delay and conflict tasks of inhibitory control were found to be significantly correlated with TOM tasks, conflict scale was a better predictor of TOM which indicated that ability that was measured by conflict task might be more central to TOM reasoning. The authors stated that working memory was the differentiating factor between these tasks. In the delay tasks children were expected to inhibit their responses whereas in the conflict tasks they were required to inhibit an inappropriate response and activate a conflicting novel response. This additional processing requirement might suggest that more working memory demands are involved in conflict tasks. In conclusion executive functioning, especially inhibitory control is causally implicated in TOM development but the direction of causality is not clear (Carlson & Moses, 2001).

Depending on the study of Carlson & Moses (2001), Carlson, Moses & Breton (2002) claimed that working memory is a more specific cognitive skill which is believed to support most executive skills and it could be possible that inhibitory control relate to TOM only in light of working memory demands. Alternatively, both inhibition and working memory might contribute to TOM. To be able to investigate the relative contributions of inhibitory control, general intelligence and working memory to the preschoolers' ToM performances Carlson et. al (2002) conducted a study. Batteries of TOM, inhibitory control and working memory were administered to 47 children with a mean age of 4. The TOM battery included appearance reality and false belief tasks, the inhibitory battery included both conflict inhibition and delay inhibition tasks and working memory battery included spam tasks and dual processing tasks.

The results of the study indicated that inhibitory control was significantly related to false belief performance task performances' of preschool children. The relation was persevered even when age and measure of intelligence were controlled. It was also found that when working memory was held constant inhibitory control still predicted false belief task performance. Working memory failed to relate to false belief over and above inhibitory control. The previous findings of Carlson & Moses (2001) which revealed conflict inhibition tasks were related to false belief task not delay inhibition was replicated in this study. On the other hand for the appearance reality task the results were different, conflict inhibition control and working memory were significantly related to this task in bivariate correlations but these correlations disappeared when age and IQ were controlled (Carlson et. al 2002).

Carlson, Moses & Claxton (2004) conducted another study to examine the relative contributions of inhibitory control and planning ability which is one of the executive skills, to preschooler children's theory of mind. In order to investigate this issue, Carlson et al. (2004) administered TOM, inhibitory control and planning batteries as well as receptive vocabulary tasks to 49 preschool children (24 3-year-olds and 25 4-year-olds). TOM battery included false belief and appearance reality tasks. Inhibitory control included Bear/Dragon, Whisper and Gift Delay whereas planning included Tower of Hanoi, Truck Loading and Kitten Delivery.

The results of the study indicated that conflict inhibition tasks; Bear/Dragon and Whisperer were significantly correlated to children's TOM performances over and above the age and receptive vocabulary variables replicating previous findings. On the other hand there was no relation between planning ability and TOM.

Flynn, O'Malley and Wood (2004) investigated the relation between emergence of false belief understanding and inhibition skills and examined the sequence of development between these two concepts. Luria lights task and Luria hand-game task were administered in order to tap inhibitory control of the children. In the Luria hand-game task, a child is trained to make two different hand gestures and during testing the child must make the gesture that is different to the gesture made by experimenter. In the Luria lights, the child has to squeeze a rubber ball when a screen was blue, but not squeeze the ball when the screen was red. Children's false belief understanding was examined by using unexpected transfer task and deceptive box task. Apart from these, children's verbal ability was tested in the first and last phases of testing. Children who were 3 years 1 month to 3 years 10 months, were tested in these tasks every four weeks for six phases of testing. The results of the study indicated that children were able to perform well on a test of executive inhibition before they show an understanding of false beliefs which is consistent with the theories which suggested that the development of good inhibition skills precedes the development of an understanding of a false belief.

Chinese preschoolers are expected to master impulse control as young as two years old by their parents and impulse control is more promoted in Chinese preschool settings which might have led Chinese preschoolers to exercise executive functioning. Depending on this assumption Sabbagh, Xu, Carlson, Moses and Lee (2006) questioned whether executive functioning is more advanced in Chinese preschoolers compared to U.S. preschoolers and whether a relation between executive functioning and theory of mind exists for Chinese preschoolers regardless of cultural differences. One hundred and nine Chinese preschoolers, ages from 36 to 59 months, participated to the study with the same procedures of Carlson and Moses (2001) in order to make the samples comparable.

The results of the study indicated that ontogenetic link between executive functioning and theory of mind also exists for Chinese preschoolers. Although Chinese preschoolers demonstrated more mature executive functioning compared to U.S. preschoolers, there were no differences between Chinese and U.S. preschoolers' verbal ability and theory of mind scores. Maturity of Chinese preschoolers' executive functioning indicated that there are some cross cultural underlying mechanisms that contribute to the theory of mind development. On the other hand no differences of theory of mind scores of Chinese and U.S. preschoolers demonstrated that achieving a particular level of executive functioning is not enough for strong theory of mind development. Chinese children's low theory of mind scores might be because of their less exposure to the kinds of experiential factors that have been shown to be important for theory of mind development. Nevertheless, because domain general executive factors interact with domain-specific experiential factors within each culture, individual differences in executive functioning predict individual differences in theory of mind. Another factor to be considered is that Chinese preschoolers had no siblings by law, and might have fewer opportunities to discuss about their mental states compared to U. S. preschoolers (Sabbagh et. al, 2006).

The aim of the first study of Kloo and Perner (2003) was to investigate whether there was or not an immediate training effect of the easier card-sorting versions on the standard DCCS task. Another aim was to confirm that modifications of DCCS task would eliminate the difficulties of the standard task to feel more confident that children have difficulties because they must redescribe the cards. And lastly, investigate the relation between performance on standard DCCS task and mastery of false-belief task. Sixty 3-year-old children whose ages were between 2 years 11 months and 4 years, participated to the study. There were three experimental conditions; one condition consisted of two false belief prediction tasks separated by a standard DCCS task. The other two groups consisted of a false-belief prediction task then a non-standard DCCS task (either a reversal shift or a task using target characters) followed by a second false-belief prediction task and standard DCCS. The results of the first study indicated that performance on the card sorting task was correlated with the ability to pass the second false belief, but no the first one. The reason for this might be the children's unfamiliarity with the experimenter and the testing procedure. Non-standard card sorting tasks were much easier than the traditional card sorting task.

Although children who were exposed to easier versions of the card sorting task before being exposed to traditional DCSS performed a little bit better in the DCSS, this effect was insignificant.

In their second study of Kloo and Perner (2003) questioned whether a more thorough, explicit training would improve children's performance. Seventy-four children whose ages were between 3 and 4.7, participated to the study. In the experiment condition, children were provided verbal feedback and explanations during the DCCS task in two training sessions over 2 weeks whereas in one of the control condition, children were trained on false-belief tasks and in the other control condition, they were trained either on relative-clauses or on number-conservation tasks. The results of this second study revealed that card sorting training with feedback and explanations improved children's performances on the DCCS compared to the control condition. Nevertheless, false-belief training led to a significant increase in the performance of card-sorting. Also, card sorting training significantly increased children's performance on the false-belief task, but not significantly more than control training.

The present study

Depending on the previous studies conducted, one of the aims of the study is to investigate the effect of bilingualism on inhibitory control and inhibitory control, consequently shed light to the direction of the relation between theory of mind and inhibitory control.

Monolingual and bilingual children who participated to the study were chosen from a sample of 3 and 4 year olds. The reason for this is previous studies indicated that both inhibitory control and theory of mind are cognitive processes that develop around 4 years of age. And also after an age inhibitory control differences between monolingual and bilingual children start to decrease and reach to a constant level till older ages (Bialystok). By including 3 year olds to the study, it would be possible to tap bilingual advantage more clearly.

Moreover, previous studies of Bialystok revealed that bilinguals outperform monolinguals in both Simon task and DCCS. Simon task is very difficult and time consuming to perform with 3 and 4 year olds because of two reasons; unfamiliarity with computers and quick disruption in attention. Depending on this only DCCS is used in the previous study.

In the study of Bialystok and Martin (2003), they compared Day/night Stroop task with Simon task and although there was a bilingual advantage in the Simon task, bilinguals and monolinguals performed likely in the Day/night Stroop task. As there are various findings which draw attention to the similarities that these two tasks assess, this result was very surprising. As Simon task is not used in this study, correlation between DCCS and Day/Night Stroop task will be examined.

Another issue to be considered is Day/Night Stroop task might not be underpinning the same processes as the Stroop color-word task. Saying day and night is not as heavy loaded as saying the color of the ink written in another color name. In order to control this color-object Stroop task of Prevor and Diamond (2005) is used in this current study. In the color-object Stroop there were four sets; color-object congruent (red apple), color-object incongruent (purple carrot), color-object neutral (brown book) and abstract shapes drawn in different colors. Half of the children are expected to say the color of the objects and other half of children were expected to say the name of the object. In the study of Prevor and Diamond (2005), color-object Stroop performances of children were similar to adults' color-word Stroop performances. So by adding color-object Stroop task to the study, correlation between color-object Stroop, Day/Night Stroop and DCSS will be examined. Hypotheses of the present study are as follows;

1. Regardless of language group, it is expected that 4 year olds will outperform 3 year olds in all of the tasks.
2. It is expected that bilingual children younger (3 year olds) and older (4 year olds) will outperform monolingual children of both age groups in DCCS, color-object Stroop and in ToM tasks whereas both language groups will perform similarly in Day/Night and Grass/Snow Strop tasks.
3. It is expected that DCCS will correlate with color-object Stroop task whereas both of them will not correlate Day/Night and Grass/Snow Stroop task.
4. It is expected that bilingual children's earlier developed inhibitory control will lead to earlier developed theory of mind.

METHOD

Participants

31 bilingual and 40 monolingual preschool children were administered to the study. In the bilingual group, 15 children were in the younger age group with a mean age of 3,53 and 16 children were in the older age group with a mean age of 4,40. Half of the monolingual children were in the younger age group with a mean age of 3.54 and other half was in the older age group with a mean age of 4.34. Within the bilingual group, there were 14 males and 17 females whereas there were 14 males and 17 females in the monolingual group.

All of the children were chosen from private nursery schools. Monolingual children who participated to the study were all Turkish and could speak only Turkish. Bilingual children were chosen from nursery schools that educate in English, and the languages they could speak were Turkish and English. At least one of the parents of bilingual children was non-Turkish.

By choosing children from nursery schools which have equivalent levels of fees, socioeconomic statuses of children were more or less equalized.

Design and procedure

Children were tested individually in their own school's laboratory. All of children were administered to Peabody Vocabulary Test, ToM tasks (appearance reality, location & contents false belief), DCCS, Day/Night and Grass/Snow Stroop task, pretend play and finally color-object Stroop task. Also a questionnaire to be filled by the parents of the children was collected by sending the questionnaires to children's houses.

All of the Turkish speaking monolingual children and half of the Turkish-English speaking bilingual children took the tasks in Turkish. The other half of the Turkish-English speaking bilingual children took the tests in English. Both Turkish and English versions of the tasks were administered by the same experimenter.

Instruments

Peabody vocabulary test

Standardized Turkish version of the Peabody vocabulary test was used in order to test all participants' Turkish level. Peabody Vocabulary Test was used to measure receptive vocabulary of participants. In the standard Peabody vocabulary test, there are 4 pictures in every page. Experimenter tells name of one picture and asks the participants to point the relevant picture out of four.

Theory of mind measures

Appearance-reality and false belief tasks were administered as theory of mind measures. In the appearance reality task, each child was shown an object with misleading appearance which involved a discrepancy between real and apparent identity. In this study a tomato shaped pencil sharpener was used. Then children were shown how the object looked and the true identity of the object then they were asked "When you look at this right now, does it look like a tomato or does it look like a pencil sharpener?" and the reality question "What is this really and truly?".

False belief task consisted of three questions two from a Contents False Belief task and one from a Location False Belief tasks. In the contents false belief task, children were shown a chewing gum box and asked what they thought was inside. After the child discovered the box is full of buttons instead of gums, they were asked what they thought was inside the box, when they first saw it. Then the children were told that their teacher never saw what's inside the box and they were asked about their teacher's thoughts about the materials inside the box. Lastly they were asked what is really inside the box.

In the location false belief task, children watched a short film in the computer; in the film two puppets were playing with a ball and then one of them put the ball into the pencil case and left. Then the other puppet took the ball out of the pencil case, played with it and put it into the white container instead of the pencil case. When the first puppet returned to the room, wanting to play with the ball children were asked abut the false belief question; "Where does the puppet think the ball is?" and then the reality question "Where is the ball really?".

Addition to the film another location false belief task was also used which is called explicit location false belief. This time children were shown a picture of a boy called "Can" who wanted to find his kitten. Children were told that the kitten was really in the closet (showing a picture of a closet door) but Can thought that his kitten was under the bed (showing a picture of a bed). Then children were asked abut the false belief question; “Where does Can think his kitten is?” and then the reality question “Where is the kitten really?”.

Inhibitory control measures

Day-night and Grass/Snow Stroop task, dimensional card change sort task (DCCS) and color-object Stroop task were administered to all of the children as inhibitory control measures. Only conflict inhibition type of inhibitory control measure was used in this study as the previous studies indicated that it is the only one correlated with ToM batteries.

In Day-night Stroop task, experimenter first verified that children associated the sun with daytime and the moon with nighttime and they were instructed children to say “day” when a card with moon and stars on it was shown, and say “night” when a card with sun was shown. 2 test trials and 10 experiment trials were performed. 10 In Grass/Snow Stroop task, children were instructed to point green when the experimenter said grass and point white when the experimenter said snow. 2 test trials and 10 experiment trials were performed

Dimensional card change sort task (DCCS) task places two pairs of rules in conflict and requires children to pay attention to one of them at a time. There were 10 cards consisting of 5 red and 5 blue cards and 5 triangle and 5 circles. Children were shown one blue triangle and one red circle and told that we will sort the cards in their hands depending on the shape. After this children were told to switch the rule and sort the cards depending on their color.

In the color-object Stroop there were four sets; color-object congruent (red apple), color-object incongruent (purple carrot), color-object neutral (brown book) and abstract shapes drawn in different colors. 10 congruent/incongruent objects were used in the study; heart, lemon, carrot, leaf, watermelon, frog, banana, teddy bear, strawberry and bee and 10 neutral objects used in the study were car, candy, glass, balloon, umbrella, pencil, scissors, telephone, slippers and ball. Half of the bilingual and monolingual children were asked to say the color of the objects and other half of children were expected to say the name of the object. In the object naming group abstract objects were not used. Lastly all of the participants were shown color boards (green, yellow, red, brown, purple, orange, blue) and asked to say the color in order to confirm whether participants could name colors. In order to avoid exercise, this phase of the test was not done at the beginning.

Pretend play

In pretend play, first the experimenter demonstrated pretend sleeping and asks children to pretend the following actions; brush teeth with a toothbrush, comb your hair with a comb, drink with a cup and put on sunglasses. For each of these actions, children's responses were coded as involving either a body part or a symbolic object. Their scores were calculated by the times out of four they used imaginary object.

RESULTS

Peabody Vocabulary Test performances of the participants were compared, only a significant effect of age group $F(1,36) = 53.87$, $p<.001$; older participants scoring significantly higher ($M=44.89$) than younger participants ($M=39.37$) regardless of their language group and gender.

Within the bilinguals participants, in order to investigate whether experimenter language had an effect one-way analyzes of variance were computed for all of the tasks they been exposed but there wasn't ant significant differences between two experimenter languages.

As all of the theory of mind tasks were tapping the same construct, a ToM score was calculated for all of the participants by adding up each ToM task score and dividing them to four. In order to validate all of the four tasks and the general ToM score were tapping the same construct, correlations between these tasks were calculated and as shown in Table x, all of them were significantly intercorrelated.

Table 1 around here

Using univariate analyses of variance, examination of the effects of age, language, gender, and having siblings on ToM scores revealed a significant effect of age and having sibling. Mean score of older group being significantly higher than younger group, $F(1,63) = 24.79$, $p<.001$; mean score of participants having siblings being significantly higher than participants without siblings; $F(1,63) = 9.34$, $p<.001$

and main effect of parent education F(3,63) = 3,477, p<.05. Effect of language barely missed significance F(1,63) = 3.36, p=.07.

In order to determine parent education post hoc analyzes were conducted; Tamhane's T2 post hoc test demonstrated that the mean scores of participants whose parent education level was master were significantly higher than participants whose parent education level was high school graduate (p<.05). On the other hand, descriptive statistics yielded a certain pattern master degree (M=.82, SD=.37), university degree (M=.53, SD=.40), high school graduate (M=.34, SD=.32) and junior high school (M=.25, SD=.35).

Previous studies of theory of mind focused on the age of sibling, when one-way ANOVA was conducted to examine whether having older or younger siblings had an effect, the analyzes revealed no significant differences between having older or younger siblings.

Different univariate analyses of variances have been run for each of the ToM tasks. When the effect of age, language and having siblings on appearance-reality task score was examined, the results revealed a significant effect of age F(1,63) = 38.885, p<.001, older children scoring higher; language F(1,63) = 7.73, p<.05, bilinguals scoring higher; and having siblings F(1,63) = 4.22, p<.05, children with siblings scoring higher on appearance-reality task.

Examination of the effect of age, language and having siblings on contents false belief task score revealed a significant effect of age F(1,63) = 7.69, p<.05, older participants scoring higher and having siblings F(1,63) = 6,43, p<.05, participants with siblings scoring higher.

When the effect of age, language and having siblings on explicit location false belief score was examined, the results revealed a significant effect of age

$F(1,63) = 14.16$, $p<.001$; having siblings $F(1,63) = 6.76$, $p<.05$ and an interaction of age-language-having siblings $F(1,63) = 6,16$, $p<.05$. Older bilingual children having siblings scoring higher on explicit location false belief task.

When the effect of age, language and having siblings on location false belief task score was examined, the results revealed a significant effect of age $F(1,63) = 9.217$, $p<.05$, older participants scoring higher; having siblings $F(1,63) = 4.01$, $p<.05$, participants with siblings scoring higher, and interaction of age and having siblings $F(1, 63) = 8,86$, $p<.05$ and parent education level $F(3,63) = 4.95$, $p<.05$. Tamhane T2 post hoc tests revealed significant mean score differences between junior high school and university ($p=.000$) and junior high school and master degree ($p<.005$). Descriptive statistics yielded the following pattern, master ($M=.71$, $SD=.18$), university ($M=.37$, $SD=48$), high school ($M=.08$, $SD=.28$) and junior high school ($M=.00$, $SD=.00$).

Inhibitory control tasks

<u>DCCS task</u>

According to previous studies, %80 of correct performance in DCCS means the participant has passed the test. When DCCS performances of participants were coded categorically as passed or failed, all of the participants passed the test. In order to analyze data thoroughly, DCCS performances were coded numerically.

When the effect of age, language, gender, parent education and having siblings on DCCS performance was examined using univariate analyzes of variance, the results revealed a significant effect of gender, females scoring higher than males $F(1,50) = 8.242$, $p<.05$; parent education $F(3,50) = 2.891$, $p<.05$; and age group, older participants scoring higher than younger ones $F(1,50) = 4.89$, $p<.05$.

<u>Day/Night-Grass/Snow Stroop tasks</u>

There were no significant effects of language, age, gender and parent education on participants' performances on Day/Night and Grass/Snow Stroop tasks. Actually, all of the participants passed day/night and grass/snow Stroop tasks.

<u>Color-object Stroop task</u>

Prevor & Diamond (2005) proposed that children's prepotent response was to name the object rather than naming the color. When the means of color naming (M=1.79, SD=.40) versus object naming (M=1.65, SD=.31) were compared, analyses revealed significant differences between these two means (color naming $t(34) = 26.566$, $p<.001$ and object naming $t(35) = 31,979$, $p<.001$), supporting Prevor & Diamond's assumption.

Effects of age, language, gender, having siblings and parent education on participants' overall reaction times were examined using univariate analyzes of variance, only effect of age was significant, $F(1,63) = 12.606$, $p=.001$; older participants with lower reaction times.

Within the color naming and object naming groups bilingual and monolingual participants' performances were compared, but the results revealed no significant results.

Participants' color naming performances on congruent, incongruent, neutral and abstract pictures were compared but no significant differences revealed. Although not significant participants fastest to slowest color naming performances were as follows; abstract, congruent, neutral and incongruent. When the participants' object naming performances on congruent, incongruent and neutral pictures were compared, there was a significant difference; Wilks's Lambda =.76, $F(2,34) = 5.34$, $p<.05$. Paired sample t-test results revealed a significant difference between incongruent and abstract pictures; $t(35) = -2.74$, $p<.05$.

When monolingual participants' color naming performances on congruent, incongruent and neutral pictures were compared, there were no significant differences between any of them. Although not significant, color naming rate from fastest to slowest was abstract, congruent, neutral and incongruent.

Examination of bilinguals' performances in color naming by comparing congruent, incongruent, abstract and neutral objects revealed no significant differences. Although not significant reaction times from fastest to slowest were incongruent, congruent, abstract and neutral.

When monolingual participants' object naming performances on congruent, incongruent and neutral pictures were compared, there were no significant differences between any groups of pictures. Although not significant monolinguals' object naming performances from fastest to slowest were congruent, neutral and incongruent.

When bilingual participants' object naming performances on congruent, incongruent and neutral pictures were compared, there was a significant difference between congruent and incongruent pictures, Wilks's Lambda = .57, $F(2,14) = 5.34$, $p<.05$. Bilinguals' object naming performances from fastest to slowest were congruent, neutral and incongruent.

Comparisons of language groups in the color naming and object naming groups separately revealed no significant differences between performances of bilinguals and monolinguals. Although not significant, monolinguals were faster than bilinguals within each group.

Lastly, participants' performances on naming the colors of boards were examined. There were no significant effects of language, age, gender or color object Stroop group.

General inhibitory control score

A general inhibitory control score was calculated by adding DCCS score and color-object score of participants and dividing them to two. Day/Night and Grass/Snow Stroop tasks were not included as all of the participants passed these two inhibitory control tasks. In order to confirm general inhibitory control score reflect the same construct with DCCS and color-object Stroop, correlations between these there scores were computed. As seen in the table 2 although color-object Stroop score was correlated with general IC score and DCCS correlated with color-object Stroop, DCCS score was not correlated with IC.

Table 2 around here

Inhibitory control and theory of mind tasks

In order to examine the relation between inhibitory control tasks and theory of mind tasks all of the ToM, IC tasks and Peabody Vocabulary Test scores were put into a correlation matrix. As previously observed ToM tasks and general ToM score were intra correlated and some IC tasks and general IC score were intra correlated but any of the ToM tasks were correlated with any of the IC tasks. On the other hand Peabody Vocabulary Test scores were correlated with all of the tasks except contents false belief task and general inhibitory control score, as seen on Table 3.

Table 3 around here

DISCUSSION

The aim of the study was to explore the effect of bilingualism on inhibitory control and theory of mind development of 3 to 5 years old preschoolers. The results of the study revealed no significant language effects neither on inhibitory control nor theory of mind performances of the participants. 6; in turn point to balanced bilingualism (Lee, 1196) as addressed in previous studies.

Comparisons of bilinguals and monolinguals general theory of mind tasks performances revealed that although bilinguals scored higher than monolinguals the difference did not reach significance. On the other hand older participants, the ones with siblings and parent education had significant effects on higher on ToM scores. Especially thre was a significant difference between the performances of children of junior high school degree parents and master degree parents. Although the difference between other education levels of parents were not significant, as the education level increased, participants' ToM mean ToM score also increased. The effects of age and siblings are very common in the ToM literature (McAlister & Peterson, 2007) and the last effect could be due to as parental education and financial resource access increases parental emotional support and cognitive stimulation increases which in turn increase attention development of children (Morton & Harper, in press). On the other hand every high educated parent do not increase attention development of children by increasing parental emotional support and cognitive stimulation but all of the participants in this study had higher SES levels as the nursery schools they were attending were among the Turkey's most expensive nursery schools which were focusing intensely on children's attention development. So these children could be advantaged in attention development in two ways; direct contribution of parents by parental support and cognitive stimulation or indirect contribution of support parents by sending their kids to nursery schools that focus on these concepts. Also, previous ToM literature focuses on the effect of pretend play on ToM performance, in the current study pretend play data of the participants were collected, too but as all of the participants passed this test, there was not a significant effect of it on ToM performance.

When the participants ToM tasks performances were examined one by one, the effects age and having siblings were significant in all of ToM tasks whereas also the effect of language was significant on appearance reality task-bilinguals outperforming monolinguals; the effect of interaction of age, language and having siblings were significant on explicit location false belief task and the effect of parent education was significant on location false belief task.

Within the inhibitory control tasks, Dimensional Card Change Sort task performances of the participants were very high compared to literature. According to previous studies before 4 years of age generally participants can not succeed in the post switch phase of the task (Bialystok, 1999) However in the current study all of the participants managed to pass both the pre and post switch phases in all of the age groups. As all of the participants passed the test, the data were analyzed numerically not categorically. The examination of the effect of age, gender, language and parent education revealed interesting results; the effect of age, gender and parent education were significant but not language. Females scored higher than males, older participants scored higher than younger ones and the ones with high educated parents scored higher than low educated parents.

Like DCCS, all of the participants also passed Day/Night and Grass/Snow Stroop tasks, regardless of age, gender, language group or parent education. No differences between two language groups were familiar with Martin & Bialystok's (2003) study which compared bilingual and monolinguals' performances on Simon and Day/Night and Grass/Snow Stroop tasks. As argued in some studies (Martin & Bialystok's, 2003; Prevor & Diamond, 2005) Day/Night and Grass/Snow Stroop tasks are not as automatic as color-word Stroop tasks and these two tasks should not be within conflict inhibition tasks.

Examination of the color-object Stroop performances confirmed Prevor and Diamond's (2005) assumption that children's prepotent response was to name the object rather than naming the color, in the current study participants named objects faster than color. Also, parallel with Prevor and Diamond's study older participants were significantly faster than younger participants.

Within the color naming group; congruent, incongruent, neutral and abstract object performances of participants were compared but there were no differences between these four performances. Although not significant participants fastest to slowest color naming performances were as follows; abstract, congruent, neutral and incongruent. On the other hand within the object naming group, comparisons of congruent, incongruent and neutral object revealed a significant difference between congruent and incongruent objects. Although not significant neutral objects were in the middle. These two results were consistent with Prevor and Diamond's (2005); the reason for this asymmetry is that as the prepotent response is to name the object rather than naming the color, object's meaning interferes with color while trying to name the color but object's color does not interfere with object's meaning in object naming group. This kind of an asymmetry is also observed in classical adult version of color-word Stroop task.

Interestingly when the analyzes were conducted by considering language groups different results came up. Examination of bilinguals' performances in object naming by comparing congruent, incongruent and neutral objects revealed a significant difference between congruent and incongruent objects. Although not significant neutral objects were in the middle, just like general performances of participants. Examination of bilinguals' performances in color naming by comparing congruent, incongruent, abstract and neutral objects revealed no significant differences. Although not significant reaction times from fastest to slowest were incongruent, congruent, abstract and neutral which is a pattern inconsistent with general performances of participants. Examination of monolinguals' performances revealed no significant differences neither in color naming nor object naming. Although not significant object naming performances of monolinguals from fastest to slowest were congruent, neutral and incongruent which is a pattern parallel to general performance whereas color naming performances were abstract, congruent, neutral and incongruent which is also consistent with general performance of participants.

Comparisons of language groups in the color naming and object naming groups separately revealed no significant differences between performances of bilinguals and monolinguals but monolinguals were faster than bilinguals within each group. Similarly again not significant but bilinguals had slower reaction times in saying the color of boards. Although bilinguals and monolinguals performed similarly in Peabody Vocabulary Test, previous studies indicated that lexically bilinguals are disadvantageous compared to monolinguals (Lee, 1996), this disadvantage might have lead bilinguals' slower performances in color-object Stroop task which is built up on lexical knowledge.

Overall, there was not a main effect of bilingualism on DCCS or color-object Stroop score which are inhibitory control measures. In the study of Bialystok (2006) bilingual and monolingual university students' inhibitory control scores were compared and the results revealed no differences of performance between these two groups. Bialystok et. al (2005) had argued that inhibitory control rises and falls in bilinguals, rises in the preschool years then monolinguals reach bilinguals and the gap closes; and when people reach their 50's the gap again starts to widen. Going to school could be the reason for disappearing of the gap and as all of the children who participated to the study were going to nursery schools in regular terms, the gap might have been disappeared sooner than expected.

Another reason for this fail in bilingualism effect could be due to SES levels of the participants as previously argued. In the studies of Bialystok (1999), the participants were recruited from nursery schools in middle-class urban areas. The level of education these children are exposed to should be different from the children in the current study. In a circumstance that does not facilitate children's cognitive stimulation bilingualism might have an effect but when children cognitive stimulation is facilitated both bilinguals and monolinguals can succeed these tasks (Bialystok et al 2005; Bialystok, 2006).

Lastly, in order to shed light to the relation between inhibitory control and theory of mind, all ToM task (including general ToM score), all IC tasks (except Day/Night and Grass/Snow Stroop tasks, including general IC score) and Peabody Vocabulary Test as an indicator of verbal ability were examined. Correlation matrix revealed that although all of the ToM tasks and IC tasks were intercorrelated but any of the ToM tasks were correlated with any of the IC tasks. On the other hand Peabody Vocabulary Test was correlated with all of the ToM and IC tasks except contents false belief and general IC score.

Intercorrelation of DCCS and color-object Stroop task was important for the scope of the study because common tasks that were used by Bialystok and her colleagues to tap inhibitory control were DCCS and Simon task. But this study aimed to examine 3-5 year olds but it was very difficult to recruit Simon task with this sample because of quick disruption of attention and unfamiliarity with computer so instead of Simon task color-object Stroop task was recruited. There are plenty of previous brain imaging studies that claim Simon and Stroop tasks tap the same construct (i.e. Peterson, Kane, Alexander, Lacadie, Skudlarski, Leung, May, Gore; 2002) and child version of the Stroop task could be color-object Stroop developed by Prevor and Diamond (2005) because the results of their study indicated similarities between adult version of Stroop task and color-object Stroop task. On the other hand correlation with Day/Night and Grass/Snow Stroop tasks was not expected as also observed in one of Martin and Bialystok (2003) studies and also the results of the current study confirmed this expectation.

In summary, consistent with the first hypothesis regardless of language group, 4 year olds outperformed 3 year olds in all of the tasks except Day/Night and Grass/Snow Stroop tasks. Inconsistent with the second hypothesis there wasn’t a direct effect of bilingualism on theory of mind or inhibitory control performances of the participants. Consistent with previous literature age and having siblings were constant main effect on theory of mind performance. An interesting finding of this study was parents’ education on theory of mind performance. Controversially, all participants passed DCCS when classified as passed or failed but when classified numerically unlike Bialystok's (1999) studies there was no effect of language; there were effects of age, gender and parent education. Like DCCS, also all of the participants passed Day/Night and Grass/Snow Stroop tasks. Color-object Stroop revealed that participants named objects faster than colors, regardless of language group, parent education, age and gender, consistent with Prevor and Diamond's (2005) study. Although not significant monolinguals were faster than bilinguals which could be due to bilingual disadvantage in lexically tasks. Consistent with the hypothesis DCCS correlated with color-object Stroop task but not with Day/Night and Grass/Snow Stroop tasks. Last but one of the most important findings of the study was there were no correlations between theory of mind and inhibitory control.

Bilingualism studies are very important as bilinguals are people with a very special talent. Their cognitive advantages and disadvantages should be examined more thoroughly and they should be educated accordingly. This study should be replicated with a larger sample size as theory of mind performances of bilinguals were about to outperform bilinguals, with a larger sample size more interesting results could come up. Another very interesting finding that this study revealed is the effect of going to nursery school and development of attention. These two effects should be examined more thoroughly and systematically in further studies.

REFERENCES

Bialystok, E. (1999). "Cognitive complexity and attentional control in the bilingual mind." *Child Development*, 70: 636-644.

Bialystok, E. (2006). "Effect of bilingualism and computer video game experience on the Simon task." *Canadian Journal of Experimental Psychology*, 60: 68-79.

Bialystok, E., Craik, F.I.M., Klein, R., & Viswanathan, M. (2004). "Bilingualism, aging, and cognitive control: Evidence from the Simon task." *Psychology and Aging*, 19: 290-303.

Bialystok, E., Craik, F.I.M., Grady, C., Chau, W., Ishii, R., Gunji, A., Pantev, C. (2005). "Effect of bilingualism on cognitive control in the Simon task: evidence from MEG." *Neuroimage*, 24: 40-49.

Bialystok, E., Martin, M. M., Viswanathan, M. (2005). "Bilingualism across the lifespan: The rise and fall of inhibitory control." *International Journal of Bilingualism*, 9: 103-119.

Carlson, S. M., & Moses, L. J. (2001). "Individual differences in inhibitory control and children's theory of mind." *Child Development*, 72: 1032-1053.

Carlson, S. M., Moses, L. J, & Breton, C. (2002). "How specific is the relation between executive function and theory of mind? Contributions of inhibitory control and working memory. " *Infant and Child Development*, 11: 73-92.

Carlson, S. M., Moses, L. J, & Claxton, L. J. (2004). "Individual differences in executive functioning and theory of mind: An investigation of inhibitory control and planning ability." *Journal of Experimental Child Psychology*, 87: 299-319.

Flynn, E., O'Malley, C., & Wood, D. (2004). "A longitudinal, microgenetic study of the emergence of false belief understanding and inhibition skills." *Developmental Science*, 7: 103-115.

Hughes, C. (1998). "Executive function in preschoolers: Links with theory of mind and verbal ability." *British Journal of Developmental Psychology*, 16: 223-253.

Kloo, D., & Perner, J. (2003). "Training transfer between card sorting and false belief understanding: Helping children apply conflicting descriptions." *Child Development*, 74: 1823-1839.

Lee, P. (1996). "Cognitive development in bilingual children: A case for bilingual instruction in early childhood education." *The Bilingual Research Journal*, 20: 499-522.

McAlister, A., & Peterson, C. (2007). "A longitudinal study of child siblings and theory of mind development." *Cognitive Development,* 22: 258-270.

Martin, M. M., & Bialystok, E. (2003). "The development of two kinds of inhibition in monolingual and bilingual children: Simon vs Stroop." Poster presented at the third biennial meeting of the Cognitive Development Society, Park City, UT, October 2003.

Morton, J. B., & Harper, S. N. (in press). "What did Simon say? Revisiting the bilingual advantage" *Developmental Science.*

Peterson, B. D., Kane, M. J., Alexander, G. M., Lacadie, C., Skudlarski, P., Leung, H., May, J. Gore, J. C. (2002). An event related functional MRI study comparing interference effects in the Simon and Stroop tasks.

Prevor, M. B., & Diamond, A. (2005). "Color-object interference in young children: A Stroop effect in children 3 ½ - 6 ½ years old" *Cognitive Development,* 20: 256-278.

Sabbagh, M. A., Xu, F., Carlson, S. M., Moses, L. J., & Lee, K. (2006). "The development of executive funtioning and theory of mind. A comparison of Chinese and U.S. preschoolers." *Psychological Science*, 17: 74-81.

Table 1: Correlations among the Theory of Mind measures

TASKS	Location false belief	Location false belief explicit	Contents false belief	Appearance reality	ToM score
Location false belief		.559**	.534**	.364**	.758**
Location false belief explicit	.559**		.607**	.442**	.817**
Contents false belief	.534**	.607**		.633**	.869**
Appearance reality	.364**	.442**	.633**		.762**
ToM score	.758	.817**	.869**	.762**	

Note: N=71
** p< .01

Table 2: Correlations among the Inhibitory Control measures

TASKS	DCCS	Color-object Stroop	IC score
DCCS		-.267*	.328**
Color-object Stroop	-.267*		-.787**
IC score	.328**	-.787**	

Note: N=71
* p< .005
** p< .001

Table 3: Correlations between ToM and IC tasks

TASKS	Location false belief	Location false belief explicit	Contents false belief	Appearance reality	ToM score	DCCS	Color-object Stroop	IC score	Peabody
Location false belief		.559**	.534**	.364**	.758**	.093	-.105	-.021	.270**
Location false belief explicit	.559**		.607**	.442**	.817**	-.048	.056	.032	.324**
Contents false belief	.534**	.607**		.633**	.869**	-.031	.052	-.126	.229
Appearance reality	.364**	.442**	.633**		.762**	-.021	-.030	-.100	.493**
ToM score	.758**	.817**	.869**	.762**		-.004	-.005	-.068	.409**
DCCS	.093	-.048	-.031	-.021	-.004		-.267*	.328**	.248**
Color-object Stroop	-.105	.056	.052	-.030	-.005	-.267*		-.787**	-.243**
IC score	-.021	.032	-.126	-.100	-.068	-.98	-.78**		.133
Peabody	.270*	.324**	.229	.493**	.409**	,248*	-.24*	,133	

Note: N=71
** p< .01
* p< .05