A MEASURE OF CONFLICT INHIBITION IN TODDLERS:

THE ANIMAL-VEHICLE TASK

CİHAN ZÜLEYHA AYDIN ÖZDEMİR

BOĞAZIÇI UNIVERSITY

2015

A MEASURE OF CONFLICT INHIBITION IN TODDLERS:

THE ANIMAL-VEHICLE TASK

Thesis submitted to the

Institute for Graduate Studies in the Social Sciences

in partial satisfaction of the requirements for the degree of

Master of Arts
in
Psychology

by

Cihan Züleyha Aydın Özdemir

Boğaziçi University

2015

A Measure of Conflict Inhibition in Toddlers:
The Animal-Vehicle Task

The thesis of Cihan Züleyha Aydın Özdemir
has been approved by:

Prof. Dr. İ. Ercan Alp _____
(Thesis advisor)

Assoc. Prof. Dr. Ayşecan Boduroğlu _____

Assist. Prof. Dr. Deniz Tahiroğlu _____

January 2015

Thesis Abstract

Cihan Züleyha Aydın Özdemir, "A Measure of Conflict Inhibition in Toddlers: The Animal-Vehicle Task"

Despite the recent increase in the number of age-appropriate cognitive tasks for very young children, their paucity is still obvious. Inhibitory abilities emerge very early in life but the research generally focuses on the preschool years because of the deficiency of tasks that are appropriate for toddlers. The present study was motivated by the fewness of age appropriate conflict inhibition (CI) tasks. Although its validity was not fully supported, the Animal-Vehicle Task (AVT) was presented as a CI task for toddlers in an earlier study. This study was an attempt to replicate and extend the earlier investigation of the AVT by considering the limitations of that study. In the present study, multiple criteria were used to evaluate the validity of the AVT as a CI task. Its relation to CI, working memory (WM) and simple delay (SD) was investigated. The AVT involves training toddlers to 'hop' animals and 'push back-and-forth' vehicles in the first part of the task (the single part). In the second part (the mixed part), eight further exemplars from each category are presented, this time in a mixed-order (random presentation) fashion and their reaction times (RTs) and errors for each trial were measured. The AVT was expected to be negatively correlated with CI and WM while none or moderate relation between the AVT and SD was anticipated. Forty-eight toddlers aged between 22 to 36 months were included in the study. The results showed that (1) the main finding of the previous study, the CI relation to the AVT could not be replicated, (2) as expected, performance of children who have a higher working memory capacity is affected less by mixing the two category exemplars, and (3) SD was not correlated with the AVT performance. The results also confirmed finding of the previous study that there are switch and mixing cost regarding the errors in the AVT. In conclusion, the AVT seems to be viable cognitive tasks that can be employed with toddlers but its validity needs further investigation.

Tez Özeti

Cihan Züleyha Aydın Özdemir, "Hayvan-Taşıt Testi: Küçük Yaştaki Çocuklarda Çatışan Davranışı Ketleme Becerisi Ölçeği"

Son dönemlerde erken çocukluk döneminde bilişsel becerileri ölçen testlerin sayısında ciddi bir artış olsa da, bu ölçekler henüz ihtiyacı karşılayacak düzeye gelmemiştir. Kendini ketleme becerisi yaşamın ilk aylarında ortaya çıkmaktadır fakat bu yaş grubunda bu beceriyi ölçmek için oluşturulmuş testlerin yetersiz olmasından ötürü ketleme becerisi araştırmaları okul öncesi dönemden daha geriye gidememektedir. Bu çalışma erken çocukluk döneminde çatışan davranışı ketleme becerisini ölçen yeni bir testi değerlendirmek için yapılmıştır. Daha önceki bir çalışmada, Hayvan-Taşıt Testi 2-3 yaş çocuklarda çatışan davranışı ketleme becerisi ölçeği olarak sunulmuş fakat ölçeğin çatışan davranışı ketleme becerisi ölçeği olduğunu göstermesi umulan verilerin sadece bir kısmı bulunmuştur. Bu çalışma, önceki çalışmayı, eksikliklerini dikkate alarak tekrarlamayı amaçlamaktadır ve Hayvan-Taşıt Testinin çatışan davranışı ketleme becerisini ölçen bir test olup olmadığını test edilmektedir. Bu çalışmada Hayvan-Taşıt Testinin basit ketleme, çatışan davranışı ketleme ve çalışan bellek ile olan ilişkisi incelenmektedir. Hayvan-Taşıt Testinin ilk aşamasında çocuklara hayvanları zıplatmaları ve taşıtları ileri geri sürmeleri öğretilmiştir. İkinci aşamada ise her bir kategoriden 8 oyuncak olmak üzere toplam 16 oyuncak çocuğa karışık bir sıra ile sunulmuştur. Her bir tekrarda çocuğun tepkime süre farkı ve yaptığı hata sayısı kaydedilmiştir. Hayvan-Taşıt Test performansının düştüğü durumlarda çatışan davranışı ketleme ve çalışan bellek becerilerinin yükselmesi beklenmekteydi. Hayvan-Taşıt Testi ile basit ketleme arasında ilişki beklenmemekteydi. Bu çalışmaya yaşları 22 ile 36 ay arasında değişen 48 çocuk katılmıştır. Önceki çalışmanın en temel bulgusu olan, Hayvan-Taşıt Testinin çatışan davranışı ketleme becerisi ile olan ilişkisi bu çalışmada bulunamamıştır. Fakat çalışan bellekleri iyi olan çocukların Hayvan-Taşıt Testinin karışık kategori sunma bölümünde daha az hata yaptığı bulunmuştur. Beklendiği gibi basit ketleme becerisi ile Hayvan-Taşıt Test performansının arasında bir ilişki gözlemlenmemiştir. Önceki çalışmada olduğu gibi, çocukların Hayvan-Taşıt Testinin karışık kategori sunma aşamasında daha fazla hata yaptığı bulunmuştur fakat Hayvan-Taşıt Testinin iki aşaması arasında tepkime süresine dair bir fark bulunamamıştır. Bu sonuçlara dayanarak, Hayvan-Taşıt Testinin 2 yaş grubu çocuklarla uygulanabilecek bilişsel bir test olduğu fakat hangi bilişsel yapıyı ölçtüğünün araştırılması gerektiği söylenebilir.

ACKNOWLEDGEMENTS

I would like to express my deep gratitude to my thesis advisor, Prof. Dr. İ. Ercan Alp for his enduring supervision and continuous encouragement. He had been so generous about his time, patience, and understanding.

Furthermore I would like to thank Assoc. Prof. Dr. Ayşecan Boduroğlu for her understanding and her trust on me.

I am also grateful to Assist. Prof. Dr. Deniz Tahiroğlu for her valuable comments and positive attitude.

I owe special thanks to Prof. Dr. Diane Sunar for her guidance and encouragement. Without her insightful advices this thesis might not be completed.

I also owe special thanks to Ayşem Yorulmaz and Şule Selçuk for their friendship, continuous support and warm attitude.

I also want to thank to Nihan Sönmez for her profound contribution to the preparation and data collection processes. I also want to thank to Demet Ay, Ayşenur Çelik, İlayda Mutlu, İlayda Kalaycı, Name Kan and A. Betül Uzun for their contribution to coding processes and sincere support.

Also, I like to thank the families and their wonderful children for their time, energy and cooperation.

Finally, I am very much thankful to my husband for his permanent support and love. My biggest appreciation goes to my little son Ali, for being there always with a big smile in his face. Without his presence I will not be able to have the energy to finish this thesis.

This thesis is dedicated to my beloved husband Halim and my cheerful son Ali.

CONTENTS

TABLES

CHAPTER 1

INTRODUCTION

Inhibitory control, one of the most studied executive functions (EFs), is the capacity to deliberately perform a subdominant action when suppressing a dominant, automatic, or prepotent action (Garon, Bryson & Smith, 2008). Inhibitory control consists of two core operations: Firstly, holding on dominant response which is called as 'simple delay' (Selcuk, 2013) and secondly, performing subdominant response when holding a dominant response which refers to 'conflict inhibition' (Carlson, Moses & Breton, 2002). There is a functional difference between simple delay (SD) and conflict inhibition (CI). They also differ in term of their relation to working memory (WM): CI was found to be correlated with WM but SD did not.

Inhibitory abilities have a critical role in the development of EFs. Further, EFs are assumed to be dependent on a general inhibitory ability (Dempster, 1992). Among the other EFs components, inhibition attracted many researchers' attention because it has a prominent role in EFs (Conway & Stifter, 2012).

The contribution of inhibition to our adaptive behaviors starts from very early in life (Diamond, 2006). Preschool years are very critical for the development of inhibition (Diamond, 2001; Munakata, 2001; Zelazo, Qu & Muller, 2005). The ability to resolve conflict, which is an outcome of inhibitory ability, goes through rapid changes from 2 to 5 years of age (Gerardi-Caulton, 2000). Therefore, conflict inhibition is a core concept in developmental research. Exploration of complex inhibition in the early years of life appears to be very critical for understanding the nature of the development of cognitive processes in adulthood.

Despite the advances, inhibition studies in developmental research are hindered by lack of age appropriate tasks (Carlson, 2005; Hughes & Ensor, 2005). The scarcity of

pure age appropriate tasks resulted in widespread use of modified versions of adult EFs tasks. But the age appropriate versions of adult inhibition tasks are questioned for their appropriateness of testing the toddler's inhibitory abilities (Carlson, 2005).

The aim of the present study is to evaluate a new task called the Animal-Vehicle Task (AVT) as a potential CI task to be used with 2 years old and older children (unpublished data, Alp, Yorulmaz & Selcuk, 2013). The AVT is a cognitive task for 2 to 3 years old children. Alp et al. (2013) tested the AVT and their findings suggested that the AVT has the potential to be a valid measure of EFs but what aspect of the EF it is measuring was not clear.

The current study aims to replicate the finding with a compensation of the weaknesses of their study such as sample age distribution, age appropriate versions of the tasks etc. To sum up, the relation between WM, CI and SD was investigated with a focus on the AVT in 22 to 36 months old children in this study.

Executive Functions

Executive functions are the general control mechanisms that rule higher order cognition (Miyake, Friedman, Emerson, Witzki & Howerter, 2000). All our deliberate acts are operated by our EFs. The adaptation of human cognitive and socio-emotional life depends on the development of EFs (Espy, 2004) therefore EFs have a critical role in survival.

Most often postulated and studied EFs are (1) shifting between mental sets, (2) updating WM representations and (3) inhibition of prepotent responses (Miyake et al., 2000). These abilities are proposed to work in coordination in order to perform tasks that require higher order cognition.

The dominant theoretical conceptualization of EFs in adult literature is based on the findings of a study conducted by Miyake and his associates (2000). There have been two strong claims about the structure of the EFs: First and the dominant account was advocating unity of EFs components. This view was supported by clinical studies which focused on frontal lobe functions and impairment of frontal lobe diseases. Results from these studies show that there is a common source of impairments (e.g., Duncan, Johnson, Swales & Freer, 1997).

On the other hand, there were data suggesting that EFs may be best conceptualized as comprising of dissociable diverse components. For instance, in 2000, Miyake and his colleagues found that three EFs (shifting, updating and inhibition) were moderately correlated but also clearly distinguishable by using confirmatory factor analyses. They showed that the operations of EFs are linked as well as dissociable. Moreover, when EFs batteries are subjected to explanatory factor analyses, there were multiple factors (Miyake et al., 2000). In addition to this, selective deficit in control processes was found when frontal patients were tested with novel, combined and conflicting tasks (Godefroy, Cabaret, Petit-Chenal, Pruvo & Rousseaux, 1999).

The EFs can be detected by the middle of the first years. The first sign of holding a representation in mind was seen at around 6 months of infants' life (Pelphrey & Reznick, 2002). Basic inhibitory performance can be first seen at around the same time and grow rapidly in the second half of the first year (Diamond, 1990). Further, the ability to shift between responses which is considered as an indication of the operation of both WM and inhibition is evident at around the beginning of the second year of life (Diamond, 2006; Garon et al., 2008). According to Diamond (1990), children's ability to regulate their responses in line with an abstract rule kept in mind also appears during

this period. The changes that occur during the first 5 years of life have a critical role in determining adult cognitive functioning (Garon et al., 2008).

Neural Basis of EF and Its Development

EFs are based on the prefrontal activity, especially in dorsolateral prefrontal cortex and ventrolateral prefrontal cortex (Diamond, 2006; Godefroy et al., 1999). Basic functions of prefrontal cortex (PFC) are to control perception, thoughts and behaviors by activating or inhibiting other brain areas (Knight & Stuss, 2002) such as amygdala (Likhtik, Pelletier, Paz, & Pare, 2005). Piaget (1954; as cited in Diamond, 2006) suggests that the early signs of EFs can be observed by the 8 or 9 months in infants which corresponds to the fourth sensorimotor stage where the infants start to show the sign of goal directed behaviors. In line with this observation, infant's prefrontal cortex goes through significant changes during the second half of the first year. Specifically, rapid growth in dorsolateral prefrontal cortex (Koenderink, Ulying, & Mrzljiak, 1994) and increase in dopamine neurotransmitter which have a critical effect on EFs task performance have been documented (Diamond, 2001). Resulting from these, it seems that the second half of the first year in infancy is the period in which the physiological background of EFs is formed.

Studies show that infants become able to recover an object that was hidden in their full view by 8 months (Diamond, 2006; Forssman, 2012). Infants are progressively getting better in remembering the hiding place of an attractive object for a longer time between 8 to 12 months (Diamond, 2006). This is an indication of a functioning WM (Reznick, Morrow, Goldman & Snyder, 2004). Moreover, infants' ability to hold the prepotent response which is to reach previously rewarded location in A not B task becomes evident during this period. This is a good indication of inhibitory control. Notwithstanding, the ability to hold an abstract rule in mind and act accordingly on a

WM or inhibition task develops only at around 2 years of age (Diamond, 2006). For example, Diamond (1990) found that until 20-21 months, toddlers cannot perform well on delayed nonmatching sample task (DNST). This task requires the toddlers to hold an abstract rule in mind for a while without any physical cue (Diamond, Towle & Boyer, 1994). Participants are shown an object and they are required to move the object to receive the reward hided underneath of the object. After a delay, a novel object is presented to the child together with the object used in the previous trial. At this session, reward is hidden under the novel object, not under the previously rewarded object. The abstract rule that the toddler has to keep in mind is that the reward is always under the new object. Thus, reaching the novel object is always rewarded. Therefore, the child is required to withhold the dominant response which is to reach the previously rewarded object and respond in line with the abstract rule that he or she learned. The result shows that second year of life is the beginning of using abstract rules to modify action while ignoring physical cues.

Measurement Problems of EFs

It is difficult to behaviorally measure a construct which consists of interrelated but dissociable components. EFs task performances depend on organization of different abilities. Nevertheless, the components of EFs are independent to some degree and we also need to create pure tasks that tap each component separately. Even though there are tasks to measure EFs in adults, there is a scarcity of developmentally appropriate EFs tasks for toddlers (Garon et al., 2008; Hughes & Ensor, 2007). Most of the tasks used in toddler's EFs research are modification of adult EFs tasks (e.g. Shape Stroop, Antisaccade). In order to make the tasks age appropriate, the complexity and difficulty of the tasks are reduced. But the modifications impair the validity of the tasks most of the time (Garon et al., 2008). The paucity of the age appropriate EFs tasks obscures the

research on toddlers' EFs. In other words, lack of age appropriate EFs tasks yields lack of toddlers' EFs research and these limitations obscure the work on children's mind. That is why there is a tendency to use adult EFs theory to understand the toddler's mind but we cannot be sure about the sameness of adult EFs and toddler EFs (Karmiloff-Smith, Scerif & Ansari, 2003). It is found that the early years EFs are somehow different than the adults' (Johnson, 2011). The components of EFs have been proposed to become integrated only after 3 years of age (Jones, Rothbart & Posner, 2003) and their developmental trajectory is not the same until this age (Karmiloff-Smith et al., 2003). It was found that children between 3 to 4 years old can have a good attentional focus accompanied by low attentional shifting (Jones et al., 2003). In the same study, inhibition was found to be negatively correlated with attentional shifting in 3 to 4 years old children. But older children's (3 to 7 years) attentional shifting and attentional focus scores loaded on a common EF factor which consist of inhibition and attentions scales (Rothbart, Ahadi & Hershey, 1994). Accordingly, contrary to adult samples where the performance of inhibition tasks (e.g., Antisaccade, Stop signal and Stroop) is the only predictor (Miyake et al., 2000), Seen et al. (2004) found that complex executive functions task (TOH) performances was predicted by WM and CI together model with the sample of preschoolers. Hence, these findings show that the relation between the components of EFs might change developmentally and the architecture of toddler's EFs might be different than adults' (Best & Miller, 2010). Nevertheless, the extent of the uniformity of adult and toddlers' EFs remains to be elucidated.

Differential Relations between Inhibition, WM and EFs

Inhibition has a critical role in EFs (Rothbart & Posner, 1985). This fact was investigated and supported by many studies (e.g. Diamond 2006; Miyake et al., 2000; Munakata, 2001). What is more, Friedman et al. (2008) found in their latent variable

analyses that there are shifting and updating specific variances although no separate inhibition variance (Friedman et al., 2008; Friedman, Miyake, Robinson & Hewitt, 2011). This finding shows that the commonality of EFs is about the inhibition dimension of EFs (Friedman et al., 2011). Thus, these studies highlighted the importance of inhibition for understanding the nature of EFs.

WM and inhibition are appreciated as the foundation of the correlation among EFs components (Dempster, 1992; Senn, Espy & Kaufmann, 2004). Even though WM and inhibition have dissociable developmental trajectories (Diamond, 2001; Carlson & Moses, 2001), it is mandatory to have a functioning WM and inhibition ability to perform well in EFs tasks (Senn et al., 2004). In fact, in their well-known two factors theory of cognitive control Kane and Engle (2003) highlighted the importance of WM which they described as maintenance of task goal in mind and CI which they described as the resistance to interference during EFs tasks. They also emphasized the inter-correlation of these two factors. Moreover, in a study conducted by Senn and her colleagues (2004), WM and CI scores were found to be the best predictors of complex executive task (e.g., Tower of Hanoi) performance in children aged from 32 months and on. After all, one might say that the integrated works of WM and inhibition has a prominent role in cognitive performances (Diamond, 2006).

The Nature of Working Memory

WM refers to the long term memory (LTM) representations that become activated above a threshold (Engle, Kane & Tuholski, 1999) plus controlled attention. Controlled attention maintains the activated representations in focused attention and inhibit the no longer relevant representations have a prominent role in WM operations (Engle et al., 1999). Similarly, Pascual-Leone's developmental theory that is, the Theory of Constructive Operators (TCO), also highlights the importance of activation and

inhibition processes (1970; as cited in Alp, 1994). Task relevant schemes among the already existing schemes become activated in order to perform successfully on a cognitive task according to TCO. Specifically, task performance depends on both (1) schemes which are the units of task relevant representations and (2) activation energy supplied by the silent operators that are conceptualized as the content free organismic resources. The TCO proposes that the number of schemes that can be simultaneously activated increases with age. Thus, more schemes can be activated and more complex performance can be displayed by the child age increased. The critical silent operator is the M capacity. Cognitive development is explained by age-related increases in M-capacity. Increases in M-capacity goes hand-in-hand with an increasing ability to deactivate (i.e., to inhibit) those schemes that are irrelevant with respect to the task at hand (Alp, 1994). In short, both WM theories emphasize the critical role of inhibition in successful WM operations.

The Relations between Working Memory, CI and SD

The relationships of WM to simple delay and complex inhibition are distinctive (Diamond, Kirkham & Amso, 2002). Simple delay (SD) which is to suppress an automatic or dominant response can be observed in children from the second half of their first year (Diamond, 1990; Diamond, Prevor, Callender & Druin, 1997). Regarding this period, we cannot observe any indication of CI. Therefore cognitive requirement of SD tasks seem to be less than that of CI tasks (Carlson & Moses, 2001; Diamond, Kirkham & Amso, 2002). In fact, CI consists of SD abilities plus the ability to perform less dominant or conflicting action in response to a given stimulus. So, the cognitive load, namely WM requirements are more prominent in CI tasks. Further, CI in early years predicts academic achievement of preschoolers which includes learning related

behaviors and math achievements (Blair & Razza, 2007) but SD was not among the predictors of future academic performances (Brock et al., 2009).

The critical relation of WM with CI has also been supported by psychophysiological studies. There is common cortex activation during both WM and CI tasks performances. Right inferior frontal gyrus gets activated during both WM and CI tasks (McNab, Leroux, Strand, Thorell, Bergman & Klingberg, 2008). In accordance with these findings Kane and Engle (2003) suggested that higher WM capacity promotes participants to maintain task relevant goal in an active state and these people can deal with the response competition which was derived from learned behaviors or habits. Similarly, individual differences in WM were found to be positively correlated with CI in adults (Engle, 2002) and preschoolers (Carlson et al., 2002). Further, Espy and Bull (2005) found that children from 42 months to 6 years with high and low WM performed differently on CI tasks but not on SD tasks. These findings show that WM capacity and CI work together.

Accordingly, Brock et al. (2009) suggest an alternative differentiation between CI and SD based on the cool and hot EFs categorization of Zelazo and Muller (2002). They have argued that SD tasks such as Snack or Gift Delay are measures of hot EF whereas CI tasks such as Stroop or the Bear & Dragon (Kochanska, Murray & Harlan, 2000) are cool EFs measures. Hot EFs refer to the capabilities of emotional problem solving whereas cold EFs refer to cognitive problem solving capabilities (Zelazo & Muller, 2002). So, the performance on SD tasks may require more emotional control compared to CI tasks. The classification of SD and CI as hot and cool EFs respectively, matches with the finding suggested that WM is correlated with CI but not with SD (Carlson et al., 2002; Engle, 2002). Thus, cognitive load is more in CI tasks compared to SD tasks and emotional load in SD tasks is more compared with CI tasks. On the

other hand, studies with children 6 years and above indicating that the development of cool EFs protracted compared to the cool EFs (e.g., Hooper, Luciana, Conklin, & Yarger, 2004). Considering the developmental trajectory of the SD and CI (SD might be observed before CI), this classifications might not be appropriate. In fact, the distinction between hot and cool EFs cannot be shown with studies with smaller ages such as 3 to 6 years (e.g., Allan & Lonigan, 2011) so, we might say that the differentiation is not prominent in the early years.

The distinction between SD and CI was also supported by the results of the studies on the antecedent analyses of these constructs. When the effect of maternal attention maintaining was tested in exuberant and inhibited children it was found that maternal attention maintaining is associated with only high levels of CI but not with SD (Conway & Stifter, 2012). Similarly, Carlson et al. (2002) have found that CI ability strongly predicts Theory of Mind (ToM) in preschoolers but there was no relation between ToM and SD.

The dissociation between SD and CI becomes more explicit when we analyze the tasks that tap each inhibitory process. In the SD task procedure the only requirement of the toddler is to hold his or her wish, desire or appetite by the power of instructions. To illustrate, in snack delay paradigm, which was launched by Kochanska et al., (2000) children aged between 22 to 33 months are expected to wait until the experimenter allow them to eat the attractive snack which was placed in front of the child. The dominant behavior for the child in this condition is to reach and eat the snack without any delay but the SD ability leads the child to wait until the time he or she is instructed to eat the snack.

On the other hand, CI tasks' requirements are clearly different than SD tasks. Shape stroop, one of the feasible CI tasks to use in children (Kochanska et al., 2000),

requires the child to point at a small fruit embedded on big fruit pictures (e.g. a picture of little banana presented on a big orange picture). The dominant behavior that the child is expected to withhold in this task is to ignore the dominant perceptual feature which is bigness. Furthermore, the child is expected to focus on the subdominant perceptual feature and respond according to this subdominant feature. Both tasks (snack delay and shape stroop) consist of withholding a dominant behavior (e.g. waiting in SD task and not pointing to the big picture in the CI task) but CI task (shape stroop) additionally requires the child to give a conflicting response while suppressing the dominant response.

The Present Study

In the present study, three tasks were employed to measure CI. Two of those were Reversed Categorization and Shape Stroop, which are already established measures of CI in very young children. The third task was the Animal-Vehicle Task. The major aim of the current study was to test whether the AVT is a valid measure of CI.

In the earlier study by Alp, Yorulmaz & Selcuk (unpublished data, 2013) the AVT was employed with 51 toddlers aged from 24 to 40 months selected from middle to high SES families. The results were mixed. On one hand, they found evidence for switch and mixing cost in Errors; that is, children made more errors in the Mixed Part compared to the Single Part and on Conflict trials compared to the non-conflict trials in the Mixed Part. On the other hand, there was no evidence for switch and mixing cost in RT; that is, RT did not increase in the Mixed Part compared to the Single Part nor on Conflict trials compared to the Non-Conflict trials in the Mixed Part. With respect to the independent variables of the study, they found evidence for a relation only between CI and the Errors: higher CI score was negatively correlated with both Error Switch and Mixing Cost; indicating that higher CI scores were associated with lower Error rates on

the AVT. There was no evidence for the predicted relation between CI and RT Switch and Mixing Cost. Moreover, WM was not related with any of the AVT scores.

In view of the results of that study, AVT appears to be a viable task that can be employed to measure CI in toddlers. Yet, there are a number of points that require further clarification. For one thing, their WM variable was assessed by only one task, Imitation Sorting Task, because the second task, Three Boxes, had to be excluded due the fact that the score derived from it failed to correlate with Age and IST scores (indicating that it was not an appropriate WM measure). For another thing, they also observed that children's errors increased with age. This unexpected finding suggested that the task might not be appropriate for children around 3 years. Yet, their sample was heavily skewed: there were only 13 children between 24 and 29 months, but 39 between 30 and 40 months. Moreover, they employed the cognitively more demanding version of the Reverse Categorization task (Carlson, Mandell, & Williams, 2004) where children are asked to sort 'baby' and 'mummy' animals as opposed to large and small boxes all of which were of the same shape and color. In fact, 28 participants could not pass the learning phase of the tasks among 52 participants.

In view of these limitations, a large enough group of younger toddlers to allow a realistic test of the hypotheses specific to the AVT performance were employed in this study. So, the current study replicated their study with a sample of children that is balanced in terms of number of children older and younger than 30 months and includes two different WM tasks (the IST and Spin the Pots) and age appropriate version of Reversed Categorization. The relation between WM, CI and SD was investigated with a focus on the AVT in 22 to 36 months old children in this study.

In the AVT, toddlers are required to do the right category related action with toys from two categories (animal and vehicle). Children have already acquired the

animal and vehicle categories towards the end of the first year (McDonough & Mandler, 1998). That is why toys from these categories are employed in the Animal-Vehicle Task (AVT). Children learn to match a category unique action with a toy that is a member of that category. The child is expected to learn an abstract rule: There are two different sets of toys from two different categories and each toy should be moved in accordance with that category related action. In the mixed part of the AVT, contrary to learning phase where toys from each category presented serially (the single part), the toys presented in a mix order. The child is required to think about the abstract rule and switch between the proper actions related to each toy in the mixed part.

Four dependent variables were derived from this task. First two were error and reaction time differences between the single part and nonconflict trials within the mixed part of the AVT which are error mixing cost (EMC) and RT mixing cost (RTMC). Repeating a task in an unchanging context for a while reduces the cognitive load of the participant which occurs in the single part (pure repetition context) of the AVT. That is, our actions become more automatic in a pure repetition context (Grange, & Houghton, 2014). The same action might require more attention when there is switch trials which is the condition of the mixed part of the AVT. In a context where switches occur participant stay concentrated. Not only switch trials (conflict trials), but also repeat trials (nonconflict trials) are affected by this context (Los, 1996). In the mixed part participants are required to switch between category related movement of the toys which means that they have to keep in mind the rule and also they have to deal with the interference occurred from the shifting between these two actions. As a result, the performances (RT and errors) in the nonconflict trials within the mixed part should be worse compared to the single trials (Mari-Beffa, & Kirkham, 2014).

Last two dependent variables are error and RT switch costs which is the comparison between switch (conflict) and repeat (nonconflict) trials. Even though the shifting affects both switch and repeat trials longer RTs and more errors are expected when the toy category is switched compared to continuous presentation of category related toys within the mixed part (Grange, & Houghton, 2014). Cognitive demand of conflict trials are greater than the nonconflict trials because participants are required to think about two category related action (Rogers & Monsell, 1995) and inhibit the preoccupation that occurred by the prior repeat trials. The decrease in the performance is an indication of conflict resolution (Mayr, 2002). Namely, children with good conflict inhibition ability are expected to have lower error and RT switch cost.

Two exemplars are used at the beginning of each session followed by 2 modelled trials and 2 learning trials in the single part of the AVT. The experimenter shows the right action and asked the child to repeat in the first two exemplars. Then, in the learning trials, 2 toys presented to the child to act by him/herself. So, the action becomes automatic by repetition and toddler performs progressively better in the later trials of the learning phase. The AVT single part scores derived from the last 4 toys of this part. This procedure is repeated with second toy category. In the mixed part of the AVT, the child is expected to think before action. For example, a vehicle presented after two animal presentations that were hopped, should be pushed. This mixed presentation of the toys is expected to increase attentional demand. In other words, the mixed presentation of toys is confusing for the child. The conflict caused by the contradiction between switch and repeat trials ends up with longer RTs and more errors. The more time the toddler needs to resolve the conflict, it is interpreted as less inhibitory abilities the child has. So, longer duration and more errors in the nonconflict trials compared to the single part demonstrate lower CI and WM. Similarly, longer duration and more

errors in conflict trials compared to the nonconflict trials within the mixed part demonstrate lower CI and lower WM capabilities.

In order to label AVT as a CI task, scores of the AVT should be related to other CI tasks. The relation of the AVT scores to SD and WM tasks should be in the same direction with other CI task.

So, based on the literature presented above, the following hypotheses are generated:

Performance on the Animal-Vehicle Task is;

(1) Related to performance of the Conflict Inhibition tasks: Mixing cost and Switch cost in both Errors and RT are negatively correlated with CI performance;

(2) Related to Working Memory performance: The higher the IST scores the smaller is the Mixing cost and Switch cost in Errors and RT.

(3) Weakly or not at all related to the performance on the Simple Delay tasks.

CHAPTER 2

METHOD

Participants

Families from middle to high SES (At least one of the parents is college graduate) were contacted through nursery schools and online play groups. The method and the aim of the study were described by a letter to the families. Toddlers of parents who accept to participate are seen twice in the nursery school setting or in the Developmental Research Laboratory at Boğaziçi University. Sixty normally developing toddlers are recruited. Six of the children were excluded from the analyses since they were either not so cooperative or did not want to continue to play. Two families did not bring the child for the second session within the 3 weeks because of the incompatibility of session's time. Three children from a nursery school cannot be reached for the second session because either their absence or health problems. A 28 months old female participant excluded due to her high error rate in the AVT.

Therefore, analyses were conducted with the remaining 48 children. The age range of the participants was 22 to 36 (M = 28.27, SD = 3.21). Each month of age represented with more than 1 participant except from the lower and higher months (One participant in 22 and 36 months). There were 23 female (M_{age} = *28*.50, SD_{age} = *3*.464) and 25 male (M_{age} = *28.12*, SD_{age} = *2.948*) participants (see Table 1 in Appendix A). Age was normally distributed, with skewness of .15 (SE = .34) and kurtosis of -.38 (SE = .67).

Measures

Conflict Inhibition Measures

Animal-Vehicle Task (Alp, Yorulmaz & Selcuk, 2013)

This task is assumed to measure CI in toddlers from 2 years on. It comprises two parts: single category presentation and mixed category presentation. In the first part of the AVT, which is *single category presentation*, toys from two different categories (vehicles and animals) presented separately to the child demonstrating the appropriate action that goes with each category. Vehicles are presented first and animals are presented later. The right action that was taught to the child is to *hop* all the animals and *push* all the vehicles. Both categories include 8 exemplars each; therefore eight trials are run with each category. The first two trials start with a demonstration with the toy; on the remaining 6 trials, the child is presented with the object concealed from his/her view and the child is instructed to act as soon as possible when the object is visually revealed to him/her. First 3 of the 6 trials are considered as the practice trials. Single category presentation part of AVT includes a total of 16 trials: 4 demonstrations (2 for vehicles and 2 for animals), 6 practice (3 for vehicles and 3 for animals) and 6 single score trials (3 for vehicles and 3 for animals). After the first part of the AVT is conducted, the mixed category presentation part of the task is run. In this part, 16 toys consisting of 8 animals and 8 vehicles are presented to the child in a mixed fashion (see Appendix B for the list of the toys). The child is asked to do the right action with each toy as quickly as possible.

Thirty two pieces of toys used in this study in total including two sets of animal and two sets of vehicle. The size range of vehicles used in the AVT is between 1.5 to 4.5 cm, in width and 6 to 8 cm, in length. The size range of animals is 3 to 3.8 cm, in width and 3 to 7 cm, in length.

Two of the AVT scores are taken from the RT measures so, the time spent in each trial should be controlled and time related confounding effects should be eliminated. In order to obtain a clear RT, the child reaching area is standardized by two interventions: First, the arm length of each child is fixed by placing a sign on the table where the child can readily reach. Second, the child is asked to put his/her hands on his/her knees until the experimenter presents the new toy. Therefore, the distance between the hands and the toys kept constant. Children are reminded to put their hand on their knees at the beginning of each trial.

Before the single category presentation, two bigger sized toys (duck and truck) with each being a representative of each category presented to the child for the instruction. Experimenter demonstrates the right action with each toy, namely hop the duck and push the truck. After this demonstration, the first part of the AVT, which is single category presentation, begins.

At the beginning of the single category presentation phase, 8 vehicles placed on the table one by one and the child is encouraged to explore the toys. The familiarization phase is repeated at the beginning of each part because the familiarization to the toys is critical. If the child cannot be familiarized with the toys, their attention might be distracted by the novelty of objects during the task and this might distort the RT. When the experimenter makes sure that the toys are familiarized s/he removes all the toys from the table and then, asked the child to put his/her hand on the knees. Toys from the first set are presented to the child one by one. The experimenter shows the right action with the first two sample toys and asks the child to imitate quickly. After the two practices, experimenter stops modeling the appropriate action. The experimenter says 'Let us see whether you can remember what to do with this!' while hiding the toy in his or her palm. Before raising his or her hand, experimenter says '*1, 2, 3!'* and displays the

toy. Both, reminding the child to be quick and entertaining the child is very critical in the AVT. It is also very important to appreciate good performance of the child by saying 'W*ell done!'.* The wrong actions should not be punished. If the child cannot perform the right action, the experimenter models the right action and supports the child to do the right action. Second set of toys which includes animal toys are presented in the same way after the vehicle category presentation is finished. The presentation of the order (vehicles first and animals second) is fixed. This is the end of the single category presentation part of the AVT.

In the mixed category presentation, new exemplars of vehicle and animal categories are presented to the child prior to the test trials to familiarize the child with the toys. The separate presentation of each category helps the child to notice the distinction between categories. The toys are then presented to the child one by one in a mix design (e.g. two vehicle presentations precede an animal presentation). The mix design presentation order was fixed for all children to get the same toys in the same order. Fixed order is: V1, A1, V2, V3, A2, A3, A4, V4, A5, A6, V5, V6, A7, V7, V8, A8 (V for toys from vehicle category and A for toys from animal category). Following this order, 16 trials are run in exactly the same way as in the single presentation part of the task.

The task was videotaped and coded with the help of special computer program called 'VirtualDub'. All videos were watched in a frame base (20 milliseconds was a frame) with the program. In order to compute the reaction time score of the task, all trials with errors (Hopping the vehicles or pushing the animals) are discarded. Trials in which children refuse to play also removed. Three reaction time (RT) scores in seconds are derived from the remaining trials from single and mixed part. First, $RT_{see\text{-}touch}$ corresponds to the time between the initial visual contact with the toy and initial manual

contact with it. Second, $RT_{touch\text{-}move}$ refers to the time between the child's initial manual contact with the object and the initiation of the target action. Third, RT_{full} is the sum of $RT_{see\text{-}touch}$ and $RT_{touch\text{-}move.}$ RT_{full} was the basic score that was used for calculating the two dependent variables related to RTs. RT mixing cost score was calculated by subtracting the RTs in the single part from the RTs of the nonconflict trials from mixed part. Second RT variable which referred to RT Switch Cost is calculated by subtracting the RTs of the nonconflict trials from the RTs of the conflict trials of the mixed part.

Two Error scores were derived from the task: First, Error Mixing Cost (ErrorMC) was calculated by subtracting the errors of the single part from the errors of nonconflict trials of the mixed part. Second, the Error Switch Cost (ErrorSC) was the differences between the number of errors made in conflict and nonconflict trials.

Each participant's average RTs in the single and the mixed part was calculated. And then, three coders coded all the videos and a master coder coded 25% of the total data. Intraclass correlation coefficient (ICC) for RTs was between .99 and 1 based on the 25% of the total data.

Shape Stroop (Kochanska et al., 2000)

Six cards that consist of 3 large size pictures of a banana, an orange and an apple and 3 small size pictures of the same fruits are shown to the child. After the introduction of the cards with large fruits, the other 3 cards with the picture of small sized fruits are described to the child. The names and the sizes (large or small) of the fruits are expressed by the experimenter while the card is shown to the child. After the presentation the cards with small fruits are taken away and the experimenter asked the child to point each big fruit sequentially. This called the first part of the task. Following this part, new cards including picture of large fruit that has a different small fruit embedded in (e.g., a small apple embedded in a large banana) shown to the child. The

experimenter asks the child to point the small fruit which is embedded in larger size of different fruit. This called the testing part. Correctness of the responses is coded in the following way. Pointing to the small fruit, score = 3; pointing to the large fruit but correcting oneself at once by moving the finger towards the small fruit, score = 2, and pointing to the large fruit, score = 1 (see Appendix C).

All the videos were coded by a trained coder and her codes compared with the master coder. Interrater reliability, Cohen's Kappa, was .98 based on the 25% of all the data.

Reversed Categorization (Carlson et al., 2004)

The task consists of two different sizes of canisters and 12 blocks (Half of the blocks are smaller than remaining). The child is required to put the small blocks in the small canister and big blocks in the big canister on the learning phase of the task. After the learning phase the experimenter tests the child. Twelve blocks in mixed order are given to the child and the child sorts each block in the right canister. If the child passes this phase by making only one or none error the second part of the task starts. The experimenter warn the child about the following game that it has a silly rule which is to put small blocks into the big canister and the big blocks into the small canister. And then, six blocks from small and big groups are given to the child sequentially and the child is required to sort the blocks in line with the new silly rule of the new game. The number of correct sorts out of the first and second six trials is scored respectively for the pre-switch and post-switch task scores. Children who failed in the learning phase get a score of 0 for the test phase. The number of correct sorts was the score of the child in the test phase which can be ranged between 0 and 12 (see Appendix D). A trained coder coded all the data and a master coder coded randomly selected 25% of the total data. Interrater reliability (Kappa) was 1 for this task.

Performance on the two CI tasks (Reversed Categorization and Shape Stroop) were correlated significantly with each other, r = .44, 95% BCa CI [.122, .715], p = .00. That is, these scores were standardized and averaged to compose a CI composite score.

Simple Delay Measures

Snack Delay (Kochanska et al., 2000)

Children are seated at the table and a candy or cracker which is covered with a transparent cup is on the table in the visual field of the child. The experimenter asks the child to wait for varying delays before the child can eat this appetitive stimulus. This task requires the child to inhibit the reaching response when an attractive snack is attainable. Further, waiting before acting in the face of appetitive snack is tested. The child is asked to keep his or her hand on the table, by the covered snack in order to make the task more difficult. The child can eat the snack only when the experimenter rings the bell and the delay before the bell rang was ranged between 0 second to 40 seconds (delays in sequential order: 5 seconds, 10 seconds, 0 second, 20 seconds, 0 seconds, and 40 seconds). The child performance was rated between 4 (Waits until the bell rang) to 0 (eats the snack before the bell rang). Latencies of impatience during the delay also recorded (see Appendix E). After the correlation between trials was settled, the scores in each trial are standardized and averaged to get a composite Snack Delay score. Higher scores indicate lower impatience.

Cohen's Kappa (interrater reliability) was 1 based on the 15% of the total data for the Snack Delay scores and ICC for latency of impatience was .98.

Gift Delay (Kochanska et al., 2000)

In this task, children are required to hold their tendency to look or touch which arises from their curiosity for an intriguing stimulus. This task has two sections. In the first section the experimenter informs the child about an unwrapped gift for him or her. The

child is instructed not to look while the experimenter wraps the gift for him or her at the back side of the child. Intentional wrapping noises made by the experimenter during 1 minute. At this point, children's curiosity rises up and it is very difficult for many children to inhibit the peeking response.

In the second part of the task, the experimenter put the wrapped gift by the child and asked him or her to wait until the experimenter brings a bow for the gift from outside. The child stay alone in the room for 3 minutes and his or her inhibition related behaviors are coded (see Appendix F).

Behaviors that are indicative of the child's interest in the gift, in the first section, are coded. If the child does not peek or do nothing but waits for the experimenter, gets 5 points. If the child peek over his or her shoulder gets 3 points. Further, if the child continuously peeks and turns towards to the experimenter gets 1 point. The latencies of children's peeking and turning are also coded. In the second section, the approach behaviors towards to the gift are coded. Latencies of touching, lifting or opening the gift wrap are scored. The extent of the children's approach behavior are ranged between 1 *(opens gift)* to 4 *(does not touch).* A trained coder coded all the data and a master coder checked the randomly selected 25% of the data. The interrater reliability for the latencies was .97 and for the behavioral scores was .95 (Kappa).

The SD composite score was computed in the following way. All the behavior scores and latencies of behavior that indicates impatience were standardized for the Snack Delay task. The correlation between these standardized scores was high and the average of these two scores was the Snack Delay Score. In the case of Gift Delay task a similar procedure was followed. Behavior codes for peeking/turning, touching and sitting and latencies of these behaviors were standardized and their intercorrelations were checked. Because they were highly correlated a single Gift Delay composite score

was composed by their average. The two composite scores (Snack Delay and Gift Delay) were correlated, $r = .26$, 95% BCa CI [.030, .473], $p = .02$, so they are aggregated to arrive at a composite score of SD.

Working Memory Measures

Imitation Sorting Task (Alp, 1994)

Imitation Sorting Task (IST) is a toddler's measure of WM from 1 year on. It requires the child to sort toys between two canisters in imitation of the experimenter. The task has eight levels (from LEVEL 1 to LEVEL 8). The level numbers indicate the number of toys to be sorted. At each level there are three sets of toys. At the beginning of the task, LEVEL 1, experimenter drops one toy into the canister placed in front of the child. Later, the second canister is introduced and LEVEL 2 trials begin. Now, the toy sets include two toys and each canister receives one. In the following levels, the number of toys in each set increases by one. A correct imitation involves putting the same toys together in the respective canisters; whether the child reproduces the same order of toy placement and/or uses the same canister as the experimenter for the respective subset of toys are not taken into account. Passing a level requires correct imitation with at least two out of the three sets of toys. Upon failure with a set at any level, a second demonstration is held and a second trial is run. A pass is recoded even if the child passed on the second trial.

The task ends when the child fails to pass two consecutive levels and the highest level passed by the child is his/her IST score.

Spin the pots (Hughes & Ensor, 2005)

This task is a modified version of Diamond et al.'s (1997) scrambled multi-location search task. It includes 7 similar boxes in different colors. These boxes are fixed on a lazy Susan rotating tray. There are 3 levels and 3 sets at each level. In the first level, the

experimenter places 3 of the boxes on the tray and hide one sticker in one of the boxes. And then the tray was covered by a scarf and spun around 90° by the experimenter. Then the tray is shown to the child and the child is asked to find the stickers. The child is required to find the stickers in maximum 1 plus level number (level number+1) trials (e.g., The child is required to find the sticker in 2 searches in the first level). Two and three stickers will be hidden in 5 and 7 boxes respectively in the second and third levels. The task ends when the child cannot find any sticker within three sets at that level. Total number of stickers that were found by the child is the score of the child (see Appendix G).

A trained coder coded the videos. The interrater reliability, interclass correlation coefficient, was 1 when compared with a master coder in the 25% of the data.

These two working memory measures were employed in this study in order to create a WM composite score. Unfortunately, no correlation was found between these two tasks ($p > .1$). IST scores, replicating earlier findings (e.g. Alp, 1994, 1996), correlated with age, $r = .38$, 95% BCa CI [.165, .604], $p = .01$, but Spin the Pots did not ($p > .1$). In fact, this task did not correlate with any of the study variables such as CI and age ($p > .1$). Therefore only IST scores were used as a WM measure.

Procedure

This study was approved by the Institutional Review Board for Research with Human Subjects (İnarek) of Boğaziçi University. Families are contacted by the nursery schools and online play groups. Written consent forms were collected from the parents who accept to participate (see Appendix H). Appointments were made by phone. Children were seen in two sessions within a maximum of two weeks in between. The sessions are held in a designated room in the day care centers or in the Developmental Research Laboratory at Boğaziçi University. In each session, after the child gets acquaintance

with the experimenter, the first game was introduced to the child. There were seven measures. In the session A the AVT (CI), Spin the Pots (WM), Shape Stroop (CI), and Snack Delay (SD) sequentially presented to the child. The IST (WM), Reversed Categorization (CI), and Gift Delay (SD) were sequentially presented in the session B. Thirty four participants (M_{age} = 28.20, *SD = 3*.20), received the 'session A' first and 14 of the participants (M_{age} = 28.57, *SD = 3*.35) received 'session B' first because of the some logistic problems. There was no effect of the presentation order on the study variables (all *p*s >.1).

In some cases (N=12) the presentation sequence within the session A has changed because of the child refuse of the prior tasks. In these cases, the AVT presented at the end of the session (Spin the Pots, Shape Stroop, Snack Delay and the AVT). The effect of the task presentation on the study variables was examined in the results.

Tasks that measure the same construct are presented in different sessions in order to reduce the effect of situational factors such as mood, health issues. Each session lasted approximately in 40 minutes. At the end of the sessions a gift was given to the child for his/her participation.

All of the applications are videotaped and coded from these video records. Three coders for the AVT and one each coder for each task are trained with the pilot data. In order to achieve data independency, each task coded by different coders who were blind to the aim of the task. A master coder coded randomly selected participants of each task video to examine the reliability between coders.

CHAPTER 3

RESULTS

Descriptive Statistics of the Study Variables

Descriptive statistics of the variables are shown in Table 2 (Appendix A). Most of the variables were non normally distributed as indicated by Shapiro-Wilk test: RTMC (S-W= .93, df = 46, p = .01), EMC (S-W= .78, df = 46, p = .00), ESC (S-W= .89, df = 46, p = .00) and IST (S-W= .80, df = 46, p = .00). Because the distributions were nonnormal, bias-corrected and accelerated (BCa) bootstrap was calculated (Efron, 1987) with those variables. All three independent variables increased with Age; IST, r = .38, 95% BCa CI [.165, .604], p = .01; CI, r = .33, 95% BCa CI [.120, .563], p = .03; and SD, r = .42, 95% BCa CI [.116, .644], p = .00. On the other hand none of the dependent variables (ESC, EMC, RTSC, and RTMC) were related to age (See Table 3). Age controlled correlations among all the study variables (Table 4) are shown in the Appendix A. There were no sex differences for any of the variables.

Preliminary Analyses

Results of the earlier studies with respect to the independent variables of the present study were mostly replicated. First, the CI composite correlated with the WM score, r = .47, 95% BCa CI [.117, .710], p = .00 and this is true in the case of both CI tasks; $r_{reversed\ cat\text{-}IST}$ = .49, 95% BCa CI [.071, .763], p < .01, $r_{shape\ stp\text{-}IST}$ =.39, 95% BCa CI [.087, .619], p = .01. Second, SD composite did not correlated with WM score, $r_{SD\text{-}IST}$ = -.15, 95% BCa CI [-.360, .064], p = .33. This was true for each of the SD tasks; $r_{snack\text{-}IST}$ = -.15, 95% BCa CI [-.392, .063], p = .33, $r_{gift\text{-}IST}$= -.09, 95% BCa CI [-.314, .148], p = .54. Third, the SD composite did not correlate with CI composite; $r_{SD\text{-}CI}$ = .03, 95% BCa CI [-.282, .328], p = .45 and this was true for both CI tasks; $r_{SD\text{-}CI\ shape}$ = .05, 95%

BCa CI [-.238, .344], p = .74 and $r_{SD\text{-}CI\ reversed\ cat.}$ = .07, 95% BCa CI [-.253, .357], p = .70.

Main Analyses

Children made more errors in the mixed part (M = 2.54, SD = 2.20) of the AVT, than in the single part, (M = .21, SD = .54), r = -7.36, 95% BCa CI [-2.97, -1.70], p = .00. Out of 48 children only seven children made any error in the single part. Four of them made only one error and the others made 2 errors each. In the mixed part, there were more errors on the conflict trials (M = 2.19, SD = 1.88) compared to the nonconflict trials (M = .38, SD = .67), r = -7.30, 95% BCa CI [-2.31, -1.31], p < .01. These results show that (1) the mixed part of the AVT was harder than the single part and (2) conflict trials were harder than the nonconflict trials.

Similarly children took longer to act in the mixed part (M = 1.42, SD = .62) than in the single part (M = 1.28, SD = .95), however these mean differences did not reach significance (p > .1). The mean RTs of conflict (M = 1.35, SD = .59) and nonconflict (M = 1.50, SD = .82) trials within the mixed part also didn't differ (p > .1).

There was a negative correlation between mixing and switch cost in RTs, r = -.50, 95% BCa CI [-.775, -.210], p = .00, indicating that participants who showed higher mixing cost spend comparably less time in conflict trials. That is, when the reaction time differences between single and nonconflict trials increased, the difference between nonconflict trials and conflict trials decreased within mixed part.

The Relations between the Independent Variables and the AVT Scores

The relationship between AVT and CI was checked by correlation analyses in order to test the first hypothesis. There were no relations between CI performance and any of the AVT scores; $r_{CI\text{-}EMC}$ = .08, 95% BCa CI [-.261, .428], p = .44; $r_{CI\text{-}ESC}$ = -.04, 95% BCa CI [-.417, .387], p = .99; $r_{CI\text{-}RTMC}$ = .02, 95% BCa CI [-.284, .258], p = .38, except the

relation between reaction time switch cost (RTSC) and CI: there was an unexpected positive correlation between RTSC and CI; $r_{CI\text{-}RTSC}$ = .34, 95% BCa CI [.022, .601], p = .02. In short, Hypothesis 1, suggesting that there would be negative correlation between the AVT and CI, was not confirmed.

To test Hypothesis 2, the relations between the IST and the AVT scores were investigated. Only switch cost in error (ESC) correlated with IST; $r_{ESC\text{-}IST}$ = -.33, 95% BCa CI [-.493, -.090], p = .03. None of the others correlated with IST; $r_{RTSC\text{-}IST}$ = .18, 95% BCa CI [-.121, .430], p = .09; $r_{RTMC\text{-}IST}$ = .08, 95% BCa CI [-.170, .298], p = .11; $r_{EMC\text{-}IST}$ = .01, 95% BCa CI [-.245, .332], p = .95. That is, when switching to a new category in the mixed part, children with higher WM capacity made fewer mistakes. Therefore the second hypothesis suggesting negative correlation between the AVT and WM was partially supported.

SD composite score did not correlate with any of the AVT scores, $r_{RTSC\text{-}SD}$ = .22, 95% BCa CI [-.083, .460], p = .69; $r_{RTMC\text{-}SD}$ = -.13, 95% BCa CI [-.379, .137], p = .93; $r_{ESC\text{-}SD}$ = .12, 95% BCa CI [-.192, .366], p = .42, and $r_{EMC\text{-}SD}$ = -.23, 95% BCa CI [-.459, .027], p = .13. This was true for both SD tasks individually (p >.1). The results were consistent with Hypothesis 3.

Further Analyses

Whether or not the two categories (animals and vehicles) included in this study elicited a differential response by the children was checked. The results of the t-test analyses revealed no differences between these two categories either in the single part, t (47) = .55, p = .58 or in the mixed part, t (47) = .75, p = .46. Thus, the results reported above do not seem to be affected by the choice of the categories employed.

In the case of 12 children the standard task sequence could not be followed because these children did not cooperate with the experimenter on the AVT which was

the first task administered in Session A. In the case of these children, testing began with the second task and AVT was administered as the last task. Children for whom the task sequence had to be changed were compared with those for whom the regular order was followed. The former children were younger (M = 26.67, SD = 2.93) than the latter (M = 28.81, SD = 3.15), t (46) = 2.07, p = .04. Also, WM scores of the former (M = 2.55, SD = .68) were significantly lower than those of the latter (M = 3.29, SD = 1.55), t (46) = 2.22, p = .03. Their CI scores (M = -.32, SD = .53) were also lower than those of the children with whom the regular order was followed (M = .16, SD = .57), t (46) = 2.53, p = .02. All of these children were home cared and only occasionally attended institutional education services.

CHAPTER 4

DISCUSSION

The AVT was reevaluated in the present study as a potential executive functions task. The results showed that there were mixing and switch costs in errors; that is, children made more mistakes on the nonconflict trials of the mixed part compared to the single part and on conflict trials compared to nonconflict trials within the mixed part. In the single part, where toys of a category are presented one after another, children respond more correctly compared to the mixed part when they could not predict the category membership of each new toy. Similarly, within the mixed part, when category membership of the toys changes from one category to another, the probability of making an error increases. These results show that when prepotency of a response has to be counteracted to perform the correct response, children make more errors. Therefore, the AVT appears to have promise to be used in the study of cognitive development in toddlers.

The prediction of the present study was that the AVT would qualify as a conflict inhibition task and hypotheses were put forward to show that it did. Thus, Hypothesis 1 stated that AVT scores be related with CI. Because WM and CI are typically found to be positively correlated, a positive correlation between AVT scores and WM was also hypothesized (Hypothesis 2). The results showed that none of the four AVT scored correlated with CI. However, switch cost in errors correlated with working memory as measured by IST (Hypothesis 2). Although Hypothesis 3, that the SD composite is unrelated to the AVT scores, was also supported, the results of the present study failed to confirm, in a straight forward way, the expectation that the AVT would qualify as a conflict inhibition task.

The results of the earlier study with respect to the switch and mixing cost in errors are replicated in this study. In the earlier study, the majority of the children were 30 months and older whereas in the present study the opposite was true; the majority of the children were younger than 30 months. Therefore, the AVT emerges as a viable cognitive task for toddlers across the second year up to 40 months.

Although the differences were in the expected direction, the results pertaining to switch and mixing cost in RT failed to reach significance, again replicating the earlier study. This seems to be due to the few numbers of trials that can be run with children this young.

The results of earlier study suggested that the AVT might qualify as a CI task yet the current results did not confirm that expectation. In this study, ESC was found to be correlated with WM. Higher working memory capacity was associated with fewer errors on conflict trials compared to nonconflict trials. In the earlier study, however, both switch and mixing costs in errors were found to be related with CI. Higher CI scores were associated with fewer errors both in the single part compared to nonconflict trials and nonconflict compared to conflict trials. At first blush, the two sets of results appear to be inconsistent. A closer look at the methodologies of the respective studies suggests, however, that they may not be inconsistent after all. In the earlier study a cognitively more demanding version of the reversed categorization task was employed, in which 'baby' and 'mommy' animal were categorized. In the present study, the easier version was employed, in which small and big blocks were categorized and the blocks were of the same shape and color. Thus, CI measurement in the earlier study was more demanding with respect to WM. Moreover, although not significant, the correlations between switch and mixing cost in errors were in the expected direction (i.e., negative).

The curious result pertaining to the positive relation between RTSC and CI deserves further discussion. Studies show that children who are cognitively more advanced employ strategies to deal with more demanding tasks and these children take longer to respond in some cases (Geary & Brown, 1991; Geary, Brown, & Samaranayake, 1991; Sternberg & Davidson, 1982). That is, children who perform better may not necessarily be always faster (Reams, Chamrad, & Robinson, 1990). If this were the issue, children with higher CI performance should have made fewer errors in the AVT, but this was not true for this sample. That is, further investigation of the relation between the AVT and CI is needed.

Limitations and Future Directions

Prior research with children in this age range showed that their attention span and motivation are limited. Studies in which attractive stimuli were employed to keep toddlers motivated during prolonged testing sessions have failed to do so (e.g., Gerardi-Caulton, 2000). Gerardi-Caulton (2000) reported a high attrition rate in her 24 months old group. Even though in the present study a relatively small number of trials and relatively small sample size were employed, still 6 participants were excluded because of their reluctance to cooperate. However, this small number of trials precluded a sound RT measurement. So, it can be said that RT data collection from a sample of toddles under 3 years old is doubling the difficulty of the research and the analyses (Senn et al., 2004). The errors, not the RT measure, emerge as the critical AVT variable. In further studies, error rates should be considered as the basic dependent variable of the AVT.

One of the limitations of this study was the configuration of the conflict and nonconflict trials within the mixed part. Originally in the AVT random seriation was used to create predisposition (V1, A1, V2, V3, A2, A3, A4, V4, A5, A6, V5, V6, A7, V7, V8, A8). Since Jersild (1927) used the first configuration of task switch (e.g.,

ABABAB…) the configuration went through different revisions based on the limitation of his configuration. This configuration consists of only conflict trials and it was anticipated very difficult by the participants. Roger and Monsell (1995) suggested that the burden affects the switch cost therefore they created new configuration which consist of conflict and nonconflict trials together (e.g., AABBAABB…) in order to have pure switch cost. In this configuration the seriation was predictable and both conflict and nonconflict trials equally affected by the mixed presentation. This configuration also has its limitations. Nonconflict trials might be easier because they were practiced and this repeat benefit might affect the switch cost. Based on this limitation, random seriation of the conflict and nonconflict trials was used (Shaffer, 1965). But in this case, uncertainty on the mixed part increased. Therefore, the cognitive demand needed on the mixed part also increased. By this configuration the differences between the single part to the mixed part increased but switch cost decreased. In the AVT context where random seriation was used, switch cost and mixing cost are concerned. Therefore, the configuration of Roger and Monsell (1995) could be the best choice (e.g., AABBAABB…) of use. In addition, the age range that we assume the AVT was suitable, have limited cognitive capacity so; the predictability of the mixed configuration might help them by reducing the difficulty of the task.

The difference between conflict and nonconflict trials within the mixed part was not significant based on the RT data. Although not significant, the RTs of the nonconflict trials were longer than the conflict trials. This might be due to the proportion of the conflict trials. There were 10 conflict trials whereas the nonconflict trials were only 6. Participants encountered more conflict than nonconflict trials. The comparably more repetition of conflict trials might create a repetition benefit on the

conflict trials and reduce the effect of switch. By using equal numbers of conflict and nonconflict trials in the mixed part might provide us purer switch cost results.

The hypotheses were put forward on the preposition that the AVT was a cool EFs task. The context is very critical when assessing cool and hot EFs. Brock (2009) suggested that any cool EFs task might turn out to be a hot EFs task by giving feedback. In this study, feedback was given on each trial of the AVT and this might have distorted the validity of the measurement. In future studies, the effect of feedback on the results should be investigated.

Internal verbalization is the general strategy that people use when countered with cognitively demanding tasks (Vygotsky, 1962). But this strategy was not used when the response is automatic or the task demand is small (Baddeley et al. 2001). The mixed part of the AVT might be categorized as demanding therefore, children's verbal abilities might affect the switch and mixing cost (Bryck & Mayr, 2005). Considering the variation of the children's verbal levels around the 2 years old, future research on the AVT might measure the verbal abilities of the participants.

Conclusion

It is interesting that the preliminary analyses replicated the established findings regarding the relations among the independent variables included in this study. First, as expected, WM, CI, and SD increased with age. Second, in accordance with earlier studies, CI was found to be correlated with WM whereas there was no correlation between SD and WM (e.g., Carlson, Moses, & Breton, 2002; Diamond et al., 2002). These results preclude any concerns about the choice of the tasks employed to measure the independent variables in the present study. Similarly, they also refute the possibility that the children who participated in the study were unusual in any respect. Furthermore, the evidence for clear mixing and switch costs in the AVT indicated that

the task worked as predicted. Yet, practically none of the independent variables predicted performance on the AVT except WM. That is, the results failed to show that AVT qualifies as a CI task for toddlers. Given the soundness of the task, further investigations are in order.

APPENDICES

APPENDIX A: Tables

Table 1. Descriptive of the participants

	N	M	SD	Min.	Max.
Child age (months)	48	28.27	3.21	22	36

Child gender by age period

	22-29 months	30-36 months	Total
Female	15	8	23
Male	16	9	25
Total	31	17	48

Table 2. Descriptive Statistics of the Study Variables

	N	Minimum	Maximum	Mean	Std. Deviation
EMC	48,00	-1,00	3,00	0,20	0,81
ESC	48,00	-1,00	8,00	1,82	1,76
RTMC	48,00	-3,72	1,98	0,21	1,01
RTSC	48,00	-1,55	0,63	-0,14	0,53
IST	46,00	1,50	6,50	3,11	1,42
Spin the Pots	48,00	0,00	3,00	1,63	0,73
CI	48,00	-1,46	1,46	-0,03	0,89
SD	48,00	-1,07	0,98	0,01	0,55
Reverse Categorization	37,00	0,00	13,00	5,22	5,20
Shape Stroop	48,00	3,00	9,00	6,04	2,08
Snack Delay	48,00	-1,12	1,21	0,01	0,62
Gift Delay	48,00	-1,12	1,19	0,02	0,73

Note. EMC = AVT Error Mixing Cost, ESC = AVT Error Switch Cost, RTMC = AVT Reaction Time Mixing Cost, RTSC = AVT Reaction Time Swicth Cost, IST = Imitation Sorting Task, CI =Conflict Inhibition Composite Score, SD = Simple Delay Composite Score.

Table 3. Child Age Correlations with AVT, WM Task, CI, and SD

			EMC	ESC	RTMC	RTSC	IST	SP	CI	SD
Age	Pearson Correlation		,130	,086	,123	,112	,380**	-,120	,331*	,416**
	BCa 95% CI	Lower	-,139	-,125	-,122	-,136	,165	-,427	,120	,116
		Upper	,403	,291	,390	,354	,604	,257	,563	,644

Note. EMC = AVT Error Mixing Cost, ESC = AVT Error Switch Cost, RTMC = AVT Reaction Time Mixing Cost, RTSC = AVT Reaction Time Swicth Cost, IST = Imitation Sorting Task, SP = Spin the Pots, CI =Conflict Inhibition Composite Score, SD = Simple Delay Composite Score.

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4. Partial Correlations between the AVT, CI, SD and WM

Control Variables			1	2	3	4	5	6	7	8	9	10	11
Age	1.EMC		-	-,032	,080	-,103	,010	,079	-,230	,066	,113	-,190	-,178
	BCa 95% CI	Lower		-,290	-,202	-,446	-,245	-,261	-,459	-,264	-,264	-,444	-,380
		Upper		,249	,318	,276	,332	,428	,027	,467	,495	,139	,039
	2.ESC			-	-,170	,122	-,327	-,044	,122	-,073	,002	,164	,041
	BCa 95% CI	Lower			-,397	-,094	-,493	-,417	-,192	-,361	-,381	-,219	-,247
		Upper			,022	,356	-,090	,387	,366	,261	,430	,458	,281
	3.RTMC				-	-,493	,083	,019	-,127	-,047	,069	-,280	,048
	BCa 95% CI	Lower				-,775	-,170	-,284	-,379	-,289	-,262	-,519	-,252
		Upper				-,210	,298	,258	,137	,195	,328	,025	,284
	4.RTSC					-	,179	,341	,219	,253	,259	,228	,129
	BCa 95% CI	Lower					-,121	,022	-,083	-,054	-,052	,002	-,194
		Upper					,430	,601	,460	,509	,541	,416	,434
	5.IST						-	,466	-,150	,493	,394	-,150	-,094
	BCa 95% CI	Lower						,117	-,360	,071	,087	-,392	-,314
		Upper						,710	,064	,763	,619	,063	,148
	6.CI							-	,025	,866	,878	,006	,033
	BCa 95% CI	Lower							-,282	,775	,773	-,305	-,242
		Upper							,328	,938	,942	,351	,326
	7.SD								-	,067	,051	,753	,834
	BCa 95% CI	Lower								-,253	-,238	,620	,745
		Upper								,357	,344	,842	,899
	8.Rev. Ct.									-	,437	,052	,053
	BCa 95% CI	Lower									,122	-,258	-,256
		Upper									,715	,378	,376
	9.Shp. Str.										-	,016	,061
	BCa 95% CI	Lower										-,291	-,249
		Upper										,329	,354
	10.Snc. Dly.											-	,264
	BCa 95% CI	Lower											,030
		Upper											,473
	11.Gift Dly.												-

Note. Rev. Ct. = Reversed Categorization, Shp. Str. = Shape Stroop, Snc. Dly. = Snack Delay, Gift Dly. = Gift Delay

APPENDIX B: The Original Exemplars

Learning Phase

	Single Animal Presentation	Single Vehicle Presentation
1	Sheep	Helicopter
2	Rooster	Lorry
3	Polar Bear	Police Boat
4	Kangaroo	Minibus
5	Fox	Van
6	Bear	Boat
7	Tiger	Police Car
8	Hippopotamus	Wagon

Test Phase

	Mix Presentation
1	Plane*
2	Bird*
3	Red Car*
4	Speedy Boat
5	Horse*
6	Turtle
7	Lion
8	Pink Wagon*
9	Anteater*
10	Elephant
11	Jeep*
12	Sled
13	Deer*
14	Helicopter*
15	Police Car
16	Hippopotamus*

Note: Presented in the original order

* indicates conflict trials

APPENDIX C: Shape Stroop Coding Sheet

Shape Stroop Kodlama Sayfası

Kodlayıcı:	Katılımcı No:

Birinci aşama	Kod Tanımları	Gösterme frame	Direk gösterdi (3) /Kendini düzeltti (2)/Yanlış Gösterdi (1)
	Bana elmayı göster		
	Bana portakalı göster		
	Bana muzu göster		
Kodlama Skoru	Kodlama Puanı	Adeti (Kaç kere bu puanı aldığı)	Ortalaması (Bu kodlama puanını alan gösterme framelerin ortalaması)
	Direk gösterdi (3)		
	Önce büyük meyveyi gösterip sonra küçüğü gösterdi (2)		
	Büyük meyveyi gösterdi (1)		
İkinci aşama	Kod Tanımları	Gösterme frame	Kodlama puanı
	Bana küçük elmayı göster		
	Bana küçük portakalı göster		
	Bana küçük muzu göster		
Kodlama	Kodlama Puanı	Adeti (Kaç kere bu puanı aldığı)	Ortalaması (Bu kodlama puanını alan gösterme framelerin ortalaması)
	Direk gösterdi (3)		
	Önce büyük meyveyi gösterip sonra küçüğü gösterdi (2)		
	Büyük meyveyi gösterdi (1)		

APPENDIX D: Reversed Categorization Coding Sheet

Reverse Categorization Kodlama Sayfası

Katılımcı No:

Sınıflandırma

	Büyük Kova	Küçük Kova
1) Küçük Blok	_____	_____
2) Büyük Blok	_____	_____
3) Küçük Blok	_____	_____
4) Büyük Blok	_____	_____
5) Büyük Blok	_____	_____
6) Küçük Blok	_____	_____
Toplam # doğru: _____	_____	% doğru: ____

Ters Sınıflandırma

Kural Kontrol:

Büyükler hangi kutuya gidiyor? # doğru oluncaya kadar deneme:____

Küçükler hangi kutuya gidiyor? # doğru oluncaya kadar deneme:____

	Büyük Kova	Küçük Kova
1) Küçük Blok	_____	_____
2) Büyük Blok	_____	_____
3) Küçük Blok	_____	_____
4) Küçük Blok	_____	_____
5) Büyük Blok	_____	_____
6) Küçük Blok	_____	_____
7) Büyük Blok	_____	_____
8) Küçük Blok	_____	_____
9) Büyük Blok	_____	_____
10) Büyük Blok	_____	_____
11) Küçük Blok	_____	_____
12) Büyük Blok	_____	_____
Toplam # doğru: _____	_____	% doğru:____

APPENDIX E: Snack Delay Coding Sheet

Snack Delay Kodlama Sayfası

Katılımcı No: Kodlayan:

Kod Tanımları:	Kodlar
Ç zili çalmadan yer	0
Ç zili beklemeden alacakken süre biter	1
Ç zili çalmadan bardağa/tabağa vb. dokunur ama yemez	2
Ç zili bekler ama elini istenilen şekilde tutmaz (örn: kağıt aracılığıyla tabağa dokunur)	3
Ç elini kağıtta istenilen şekilde tutar ve zil çalana kadar bekler	4

	Başlama Zamanı (A nın yiyeceği bıraktığı an)	Kodu (Yukarıdaki listeden seçilir)	Kodun zamanı (Kodu almayı gerektiren davranışı gösterdiği an)	Beklediği süre (Kodun zamanı-başlama zamanı)	Sabırsızlık gösterdiği an (Yukarıdaki davranışları gösterdiği an)	Sabrettiği süre (Başlama zamanı-Sabırsızlıkgösterdiği an)
Deneme 1(5)						
Deneme 2(10)						
Deneme 3(0)						
Deneme 4(20)						
Deneme 5(0)						
Deneme 6(40)						

Not1: Çocuğun aldığı en düşük puan, kodu olur.

Not2: Sabırsızlık Gösterisi: Zilin çalmasını beklerken kıpır kıpır olmak, kağıdı tabağı direk ya da dolaylı olarak itmek/dokunmak, durum hakkında konuşmak (hadi demek vb.)

Not3: Sabırsızlık gösterisi yoksa sabrettiği süreye 41 yazılır.

APPENDIX F: Gift Delay Coding Sheet

Hediye Paketleme Kodlama Sayfası

Paketleme Süreci:	Zaman	Süre
Başlama Zamanı:	____	____

Sabırsızlık gösterisi: (Tanım: Bakmadan ya da yerinden kalkmadan sabırsızlık gösterme, ör. durum hakkında konuşmak, hadi demek, kıpır kıpır olmak vb. (Ç sabırsızlık göstermediyse 61 sn verilir).

Bakma/oturma	Kod	Zaman	Süre
Ç arkasına döner ve tekrar önüne dönmez.	1	____	____
Ç arkasına döner/kalkar ama sonra önüne döner/oturur.	2	____	____
Ç hediyeyi görebileceği şekld omzunun üzrnden bakar.	3	____	____
Ç kafasını 90 dereceden daha az yana çevirir.	4	____	____
Ç bakmaya çalışmaz	5		

Aldığı en düşük bakma/oturma kodu: (Ç hiç bakmadıysa/kalkmadıysa = 60 sn)

Not: Aldığı en düşük bakma/oturma puanı için kod yazılır. 5'ten düşük gözlemlenen her bakma/oturma puanı için zaman yazılır ve süreler hesaplanır, yazılır. Hiç göstermediği davranışlar için süre 60 olarak yazılır.

Kurdele bekleme süreci:	Zaman	Süre
Başlama Zamanı:	____	____

Sabırsızlık gösterisi: Dokunmadan ya da yerinden kalkmadan sabırsızlık gösterme, ör. durum hakkında konuşmak, hadi demek, kıpır kıpır olmak vb. (Ç sabırsızlık göstermediyse 180 sn verilir)

Oturma Kodu:	Kod	Zaman	Süre
Ç süre bitmeden kalktı.	0	____	____
Ç süre bitene kadar oturdu.	1		

Dokunma Kodu:	Kod	Zaman	Süre
Ç hediyeyi açar.	1	____	____
Ç hediyeyi kaldırır/alır.	2	____	____
Ç hediyeye dokunur fkt kaldırmaz.	3	____	____
Ç hediyeye hiç dokunma	4	____	

(Hiç dokunmadıysa 180 sn verilir)
Aldığı en düşük dokunma kodu:

Not: Aldığı en dokunma puanı için kod yazılır. 4'ten düşük gözlemlenen her dokunma puanı için zaman yazılır ve süreler hesaplanır, yazılır. Hiç göstermediği davranışlar için süre180 olarak yazılır.

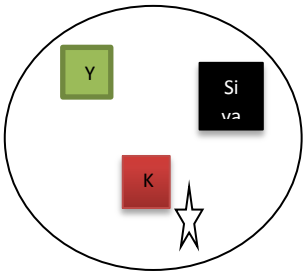
APPENDIX G: Spin the Pots Coding Sheet

Spin the Pots Kodlama Sayfası

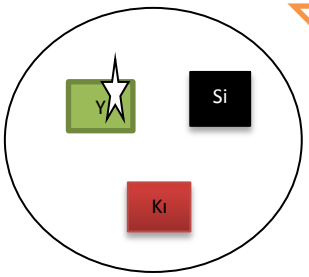
Çocuk Adı:

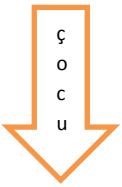
LEVEL1

SET1

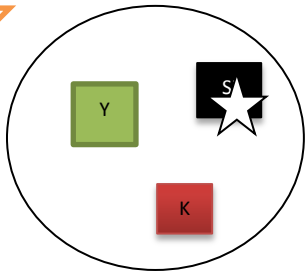


SET 2

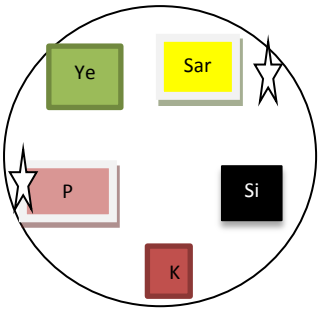


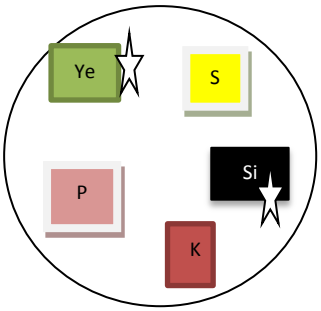


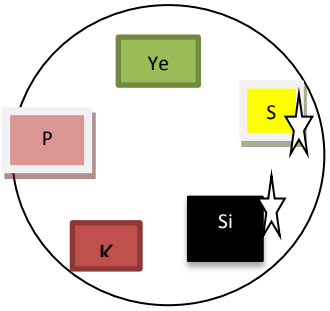
SET 3



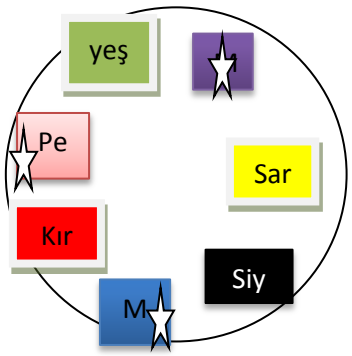
LEVEL2

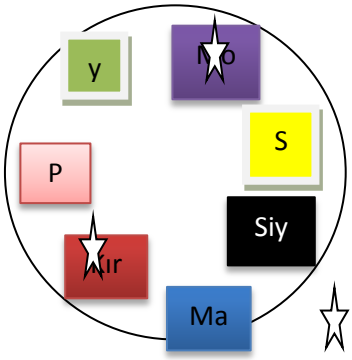


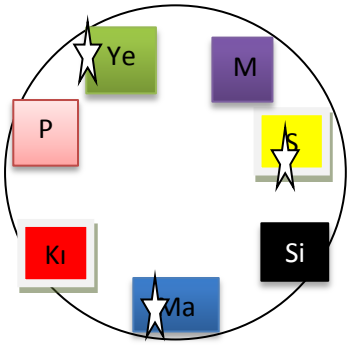




LEVEL3







APPENDIX H: Consent Form

KATILIMCI BİLGİ FORMU

Sayın Veli,

Çocukların zihinsel ve duygusal gelişimi ile ilgili yeni bir çalışmaya başlamış bulunuyoruz. 'İki yaş grubundaki çocuklarda yürütücü fonksiyonlar: Çalışan bellek, inhibe etme ve mizaç arasındaki ilişkiler' başlıklı bu çalışmada, 23-36 ay arasındaki çocukların 1) aynı anda kaç şeyi akılda tutabildiklerinin, 2) kendilerini denetleme becerilerinin ve 3) belirli mizaç özelliklerinin kendi aralarında ne gibi ilişkiler olduğunu ve bunların, bu yaş aralığında nasıl değiştiğini inceleyeceğiz.

Ufak yaştaki çocuklar dikkatlerini uzun süre en üst düzeyde tutamadıkları için bu oyunlar, yaklaşık bir hafta ara ile iki ayrı günde iki seans olarak oynanacaktır. Her seans yaklaşık olarak 45 dakika sürmektedir. Herhangi bir sebepten dolayı oyuna başlamadan, ya da oyun sırasında, çocuk oyuna katılmak istemezse veya siz/öğretmeni çocuğunuzun devam etmesini istemezseniz, seans durdurulacaktır.

Her çocuk ile ayrı ayrı oynanacak olan bu oyunlar video-kasete kaydedilecek ve kasetler daha sonra kodlanacaktır. Ancak, ne kasetlerin kendileri, ne de kodlanmış veriler, araştırmada çalışan yetkili kişiler dışında hiçbir kişinin ulaşımına açık olmayacaktır. Araştırma bitiminden bir süre sonra video kayıtları tamamen silinecektir. Herhangi bir sebeple çocuğunuzun oyuna devam etmesini istememişseniz ve seans yarım kalmış ise, kayıtlar en kısa zamanda silinecektir. Araştırma sonunda çıkacak yayınlarda, çocukların isimleri hiçbir biçimde kullanılmayacaktır. Gerekirse, kendilerine verilecek olan katılımcı numarası ile anılacaklardır. Çalışmanın sonunda elde edilen araştırma bulguları, bireysel herhangi bir değerlendirme yapılmaksızın ve katılımcı çocukların kimlik bilgileri kesinlikle verilmeden, bilimsel kongre ve sempozyumlarda sunulabilecektir.

Bu araştırmada kullanılan oyunlar, biz ve başka araştırmacılar tarafından daha önceki çalışmalarda uygulaması yapılmış ve kesinlikle çocuklara herhangi bir zarar vermediği bilinen oyunlardır. Bu oyunların hiçbiri zeka testi değildir. Bu çalışmada, kuramsal düzeyde bazı sorulara cevap aranmaktadır ve incelenen davranışların kendi aralarındaki ilişkilere ve yaş ile nasıl değiştiklerine bakılacaktır. Zaten bu aşamada, incelediğimiz beceri ve özellikler hakkında dahi, kişisel düzeyde herhangi bir çıkarım yapılması olanaksızdır.

Çocuğunuzun bu çalışmaya katılmasına ilişkin onayınızı lütfen bir sonraki sayfada yer alan Onam Formunda işaretleyiniz. Dilerseniz bizi aşağıdaki telefon numaralarından arayarak veya e-posta adreslerimize mesaj göndererek daha ayrıntılı bilgi alabilirsiniz.

İlginize teşekkür ederiz.

Prof. Dr. İ. Ercan Alp
Boğaziçi Üniversitesi
Psikoloji Bölümü
Bebek, İstanbul 34342
Tel: (212) 359 70 54
e-posta: alpe@boun.edu.tr

Cihan Züleyha Aydın Özdemir
Boğaziçi Üniversitesi
Psikoloji Bölümü
Bebek, İstanbul 34342
GSM: 0535 279 22 39
e-posta: cihanzuleyha@gmail.com

Bilgilendirilmiş Onam Formu

‘İki yaş grubundaki çocuklarda yürütücü fonksiyonlar: Çalışan bellek, inhibe etme ve mizaç arasındaki ilişkiler’ başlıklı çalışma ile ilgili bilgileri okudum ve anladım. (Anlamadığım kısımlar hakkında araştırmacıdan gerekli bilgileri aldım.)

Çocuğum ……’in bu araştırmaya katılmasını onaylıyorum/onaylamıyorum.

Ebeveynin Adı: Tarih:

İmzası:

Çocuğun Doğum Tarihi:

Telefon:

REFERENCES

Allan, N. P., & Lonigan, C. J. (2011). Examining the dimensionality effortful control in preschool children and its relation to academic and socioemotional indicators. *Developmental Psychology, 47,* 905–915.

Allport, D. A., & Wylie, G. (1999). Task-switching: Positive and negative priming of task-set. In G. W. Humphreys, J. Duncan, & A. Treisman (Eds.), *Attention, space, and action: Studies in cognitive neuroscience* (pp. 273–296). Oxford: Oxford University Press.

Alp, I. E. (1994). Measuring the size of working memory in very young children: The Imitation Sorting Task. *International Journal of Behavioral Development, 17,* 125–141.

Alp, I. E., Yorulmaz, A. & Selcuk, S. (2013). Measuring conflict inhibition in toddlers with the Animal-Vehicle Task (Unpublished data). Boğaziçi University, Istanbul, Turkey.

Best, J. R., & Miller, P. H. (2010). A Developmental Perspective on Executive Function. *Child Development, 81,* 1641–1660.

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development, 78,* 647–663.

Bryck, R. L., Mayr, U. (2005). On the role of verbalization during task-set selection: Switching or serial order control? *Memory and Cognition, 33,* 611–623.

Brock, L. L., Rimm-Kaufman, S. E., Nathanson, L., & Grimm, K. J. (2009). The contributions of ‘‘hot’’ and ‘‘cool’’ executive function to children’s academic achievement, learning-related behaviors, and engagement in kindergarten. *Early Childhood Research Quarterly, 24,* 337–349.

Carlson, S. (2005). Developmentally sensitive measures of executive function in preschoolers. *Developmental Neuropsychology, 28,* 595–616.

Carlson, S. M., Mandell, D. J., & Williams, L. (2004). Executive function and theory of mind: Stability and prediction from age 2 to 3. *Developmental Psychology, 40,* 1105–1122.

Carlson, S., & Moses, L. (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.

Conway, A., & Stifter, C. A. (2012). Longitudinal antecedents of executive functions in preschoolers. *Child Development, 83,* 1022–1036.

Dempster, F. (1992). The rise and fall of the inhibitory mechanism: Toward a unified theory of cognitive development and aging. *Developmental Review, 12,* 45–75.

Diamond, A. (1990). The development and neural bases of memory functions as indexed by the AB and delayed response tasks in human infants and infant monkeys. In A. Diamond (Ed.), *The development and neural bases of higher cognitive functions* (pp. 267–317). New York: Academy of Sciences Press.

Diamond, A. (2001). A model system for studying the role of dopamine in prefrontal cortex during early development in human. In C. Nelson & M. Luciana (Eds.), *Handbook of developmental neuroscience* (pp. 433–472). Cambridge, MA: MIT Press.

Diamond, A. (2006). The early development of executive functions. In E. Bialystock & F. I. M. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 70–95). Oxford, England: Oxford University Press.

Diamond, A., Kirkham, N., & Amso, D. (2002). Conditions under which young children can hold two rules in mind and inhibit a prepotent response. *Developmental Psychology, 38,* 352–362.

Diamond, A., Prevor, M. B., Callender, G., & Druin, D. P. (1997). Prefrontal cortex cognitive deficits in children treated early and continuously for PKU. *Monographs of the Society for Research in Child Development, 62,* 1–205.

Diamond, A., Towle, C. & Boyer, K. (1994). Young children's performance on a task sensitive to the memory functions of the medial temporal lobe in adults: The delayed nonmatching-to-sample task reveals problems that are due to non-memory-related task demands. *Behavioral Neuroscience, 108,* 659–680.

Duncan, J., Johnson, R., Swales, M., & Freer, C. (1997). Frontal lobe deficits after head injury: Unity and diversity of function. *Cognitive Neuropsychology, 14,* 713–741.

Efron, B. (1987). Better Bootstrap Confidence Intervals. *Journal of the American Statistical Association, 82,* 171–185.

Ellefson, M. R., Shapiro, L. R., & Chater, N. (2006). Asymmetrical switch costs in children. *Cognitive Development, 21,* 108 –130.

Engle, R. W. (2002). Working memory capacity as executive attention. Current *Directions in Psychological Science, 11,* 19–23.

Engle, R. W., Kane, M. J., & Tuholski, S. W. (1999). Individual differences in working memory capacity and what they tell us about controlled attention, general fluid intelligence, and functions of the prefrontal cortex. In A. Miyake & P. Shah

(Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 102–134). New York, NY: Cambridge University Press.

Espy K. A. (2004). Using developmental, cognitive, and neuroscience approaches to understand executive control in young children. *Developmental Neuropsychology, 26,* 379–384.

Espy, K. A. & Bull, R. (2005). Inhibitory processes in young children and individual variation in short-term memory. *Developmental Neuropsychology, 28,* 669–688.

Forssman, L. (2012) Unpublished doctoral thesis. *Attention and the early development of cognitive control.* Uppsala University, Sweden.

Friedman, N. P., Miyake, A., Young, S. E., DeFries, J. C., Corley, R. P., & Hewitt, J. K. (2008). Individual differences in executive functions are almost entirely genetic in origin. *Journal of Experimental Psychology: General, 137,* 201–225.

Friedman, N. P., Miyake, A., Robinson, J. L., & Hewitt, J. K. (2011). Developmental trajectories in toddlers' self-restraint predict individual differences in executive functions 14 years later: a behavioral genetic analysis. *Developmental Psychology, 47,* 1410–1430.

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin, 134,* 31–60.

Geary, D. C., & Brown, S. C. (1991). Cognitive addition: Strategy choice and speed of processing differences in gifted, normal, and mathematically disabled children. *Developmental Psychology, 27,* 398–406.

Geary, D. C., Brown, S. C, & Samaranayake, V. A. (1991). Cognitive addition: A short longitudinal study of strategy choice and speed-of-processing differences in normal and mathematically disabled children. *Developmental Psychology, 27,* 787–797.

Gerardi-Caulton, G. (2000). Sensitivity to spatial conflict and the development of self-regulation in children 24–36 months of age. *Developmental Science, 3,* 397–404.

Godefroy, O., Cabaret, M., Petit-Chenal, V., Pruvo, J.-P., & Rousseaux, M. (1999). Control functions of the frontal lobes: Modularity of the central-supervisory system? *Cortex, 35,* 1–20.

Grange, J., & Houghton, G. (2014). Task switching and cognitive control. New York: Oxford University Press.

Hughes, C., & Ensor, R. (2005). Theory of mind and executive function in two-year-olds: A family affair? *Developmental Neuropsychology, 28,* 645 – 668.

Hughes, C., & Ensor, R. (2007). Executive function and theory of mind: Predictive relation from ages 2 to 4. *Developmental Psychology, 43,* 1447 – 1459.

Hooper, C. J., Luciana, M., Conklin, H. M., & Yarger, R. S. (2004). Adolescents' performance on the Iowa Gambling Task: Implications for the development of decision-making and ventromedial prefrontal cortex. *Developmental Psychology, 40,* 1148–1158.

Jersild A.T. (1927). Mental set and shift. *Archives of Psychology, 89,* 5–82.

Johnson, M. H. (2011). Interactive specialization: A domain-general framework for human functional brain development? *Developmental Cognitive Neuroscience, 1,* 7–21.

Jones, L., Rothbart, M., & Posner, M. (2003). Development of executive attention in preschool children. *Developmental Science, 6,* 498–504.

Kane, M. J., & Engle, R. W. (2003). Working memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General, 132,* 47–70.

Karmiloff-Smith, A., Scerif, G., & Ansari, D. (2003). Double dissociations in developmental disorders? Theoretically misconceived, empirically dubious. *Cortex, 39,* 161–163.

Kirkham, A. J., Breeze, J. M., & Marí-Beffa, P. (2012). The impact of verbal instructions on goal-directed behaviour. *Acta Psychologica, 139,* 212–9.

Knight, R., & Stuss, D. (2002). Prefrontal cortex: The present and the future. In D. Stuss & R. Knight (Eds.), *Principles of frontal lobe function* (pp. 573–597). New York: Oxford University Press.

Koch, I. (2005). Sequential task predictability in task switching. *Psychonomic Bulletin & Review, 12,* 107–112.

Kochanska, G., Murray, K. T., & Harlan, E. T. (2000). Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. *Developmental Psychology, 36,* 220–232.

Koenderink, M. J., Ulyings, H. G., & Mrzljiak, L. (1994). Postnatal maturation of the layer III pyramidal neurons in the human prefrontal cortex: A quantitative Golgi analysis. *Brain Research, 653,* 173–182.

Likhtik, E., Pelletier, J. G., Paz, R., & Pare, D. (2005). Prefrontal Control of Amygdala. *The Journal of Neuroscience, 25,* 7429–7437

Los, S. A. (1996). On the origin of mixing costs: Exploring information processing in pure and mixed blocks of trials. *Acta Psychologica, 94,* 145–188.

Mari-Beffa, P., & Kirkham, A. (2014). The mixing cost as a measure of cognitive control. In J. Grange & G. Houghton (Eds.), Task switching and cognitive *control* (pp. 74–100. New York: Oxford University Press.

Mayr, U. (2002) Inhibition of action rules. *Psychonomic Bulletin & Review, 9*, 93–99.

Mandler, J. M., & McDonough, L. (1998). On developing a knowledge base in infancy. *Developmental Psychology, 34,* 1274–1288.

McNab, F., Leroux, G., Strand, F., Thorell, L.B., Bergman, S., & Klingberg, T. (2008). Common and unique components of inhibition and working memory: An fMRI, within subject investigation. *Neuropsychologia, 46,* 2668–2682.

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

Munakata, Y. (2001). Graded representations in behavioral dissociations. *Trends in Cognitive Sciences, 5,* 309–315.

Pelphrey, K., & Reznick, J. (2002). Working memory in infancy. *Advances in Child Development & Behavior, 31,* 173–227.

Piaget, J. (1954). The construction of reality in the child. New York: Basic Books.

Reams, R., Chamrad, D., & Robinson, N. (1990). The race is not necessarily to the swift: Validity of the WISC-R bonus points for speed. *Gifted Child Quarterly, 34*, 108–110.

Reznick, S., Morrow, J. D., Goldman, B. D., & Snyder, J. (2004). The onset of working memory in infants. *Infancy, 6*, 145–154.

Rogers, R.D., & Monsell, S. (1995). The cost of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology: General, 124,* 207–231.

Rothbart, M. K., Ahadi, S. A., & Hershey, K. L. (1994). Temperament and social behavior in childhood. *Merrill-Palmer Quarterly, 40,* 21–39.

Rothbart, M.K., & Posner, M.I. (1985). Temperament and the development of self-regulation. In L. Hartlage & C.F. Telzrow (Eds.), *The neuropsychology of individual differences: A developmental perspective* (pp. 93–123). New York: Plenum.

Selcuk, S. (2013). Differential relationship of simple delay and conflict inhibition with working memory and exuberance in toddlerhood (Unpublished master's thesis). Boğaziçi University, Istanbul, Turkey.

Senn, T. S., Espy, K. A., & Kaufmann, P. M. (2004). Using path analysis to understand executive function organization in preschool children. *Developmental Neuropsychology, 26,* 445–464.

Shaffer, L. H. (1965). Choice reaction with variable S-R mapping. *Journal of Experimental Psychology, 70,* 284–288.

Sternberg, R. J., & Davidson, J. E. (1982). The mind of the puzzler. Psychology Today, 16, 37–4.

Vygotsky, L.S. (1962). Thought and language. Cambridge, MA: M1T Press.

Zelazo, P., & Muller, U. (2002). Executive function in typical and atypical development. In U. Goswami (Ed.), Handbook of childhood cognitive development (pp. 445–469). Oxford, England: Blackwell Publishers.

Zelazo, P., Qu, L., & Muller, U. (2005). Hot and cool aspects of executive function: Relations in early development. In W. Schneider, R. Schumann-Hengsteler, & B. Sodian (Eds.), *Young children's cognitive development: Interrelationships among executive functioning, working memory, verbal ability, and theory of mind* (pp. 71–93). Mahwah, NJ: Erlbaum.