THE DEVELOPMENT OF EPISODIC COGNITION AND MENTAL TIME TRAVEL IN TURKISH PRESCHOOLERS: WHAT, WHERE, AND WHEN

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Submitted by **GÜLTEN ÜNAL** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Cognitive Science, Middle East Technical University** by,

Prof. Dr. Nazife Baykal ______________________
Director, **Informatics Institute**

Prof. Dr. Cem Bozşahin ______________________
Head of Department, **Cognitive Science**

Assoc. Prof. Dr. Annette Hohenberger ______________________
Supervisor, **Cognitive Science, METU**

Examining Committee Members:

Prof. Dr. Cem Bozşahin ______________________
Cognitive Science, METU

Assoc. Prof. Dr. Annette Hohenberger ______________________
Cognitive Science, METU

Prof. Dr. Sibel Kazak Berument ______________________
Psychology, METU

Prof. Dr. Deniz Zeyrek ______________________
Cognitive Science, METU

Assist Prof. Dr. Saime Tek ______________________
Psychology, Bilkent U.

Date: 08.05.2014

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name : Gülten Ünal

Signature : ____________________

ABSTRACT

THE DEVELOPMENT OF EPISODIC COGNITION AND MENTAL TIME TRAVEL IN TURKISH PRESCHOOLERS: WHAT, WHERE, AND WHEN

Ünal, Gülten
Ph.D., Department of Cognitive Science
Supervisor: Assoc. Prof. Dr. Annette Hohenberger

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The goal of the present study is to investigate the development of episodic cognition and mental time travel and their relation with Working Memory, language ability, and counter-factual thinking in Turkish preschoolers (age range: 3 to 5 years). Overall, in order to investigate these concepts, we developed two main tasks: (1) a what-where-when (www) memory task that tests episodic memory of the past, (2) a future prediction task that tests episodic future thinking (mental time travel) and five additional tasks as possible predictors: (3) a story telling task which measures the development of the usage of the future-tense, (4) the Day-Night Stroop Task, (5) the Corsi Block Tapping Task, (6) a counter-factual thinking task, and (7) a questionnaire asking incidental episodic memory questions about the events related to the testing session. The results indicated that the main tasks and additional tasks developed significantly by age. The regression results showed that the www task depends mainly on executive functioning and episodic memory for younger children, while these predictors disappear for older children. For the future-prediction task, while the performances of 3-year-olds seem to depend on executive functioning and visuo-spatial abilities, none of the additional tasks seem predictive for the 4-year-olds indicating a process of re-organization. As for the 5-year-olds, linguistic abilities become more predictive indicating that episodic future thinking might later depend more on linguistic sources.

Keywords: episodic cognition, mental time travel, future thinking, cognitive development, what-where-when task

ÖZ

OKUL ÖNCESİ TÜRK ÇOCUKLARINDA OLAYSAL BİLİŞ VE ZİHİNSEL ZAMAN YOLCULUĞUNUN GELİŞİMİ: NE, NEREDE VE NE ZAMAN

Ünal, Gülten
Doktora, Bilişsel Bilimler Bölümü
Tez Yöneticisi: Doç. Dr. Annette Hohenberger

Mayıs 2014, 128 sayfa

Bu çalışmanın amacı, okul öncesi Türk çocuklarında (yaş aralığı: 3-5) olaysal biliş ve zihinsel zaman yolculuğunun gelişimini ve bunların işler bellek, dil yeteneği ve karşıolgusal düşünme ile ilgisini incelemektir. Bu kavramları inceleyebilmek için iki ana deney ((1) geçmişe ait olaysal zamanı test edebilmek için bir ne-nerede-ne zaman deneyi, (2) olaysal gelecek düşüncesini (zihinsel zaman yolculuğu) ölçmek için bir geleceği tahmin etme deneyi) ve olası öngörücüler olarak beş ek deney ((3) gelecek zaman kullanımının gelişimini ölçen bir hikâye anlatma deneyi, (4) Gündüz-Gece Stroop Testi, (5) Corsi Blok Tıklama Testi, (6) bir karşıolgusal düşünme deneyi ve (7) test seansı ile ilgili olaylar hakkında tesadüfi olaysal zihin soruları içeren bir anket) geliştirilmiştir. Sonuçlar, ana ve ek deneylerin yaşla beraber anlamlı bir şekilde geliştiğini göstermiştir. Regresyon sonuçları küçük çocuklar için ne-nerede-ne zaman deneyinin daha çok işler belleğe ve olaysal bilişe dayandığını, fakat yaşça büyük çocuklar için bu etkinin kaybolduğunu göstermiştir. Geleceği tahmin etme deneyinde ise, 3 yaşındaki çocukların performansı işler belleğe ve görsel-mekansal becerilere dayanıyor gibi gözükürken, ek deneylerin hiçbiri 4 yaşındaki çocuklar için öngörücü değildir ki bu, bu yaş grubunda bir reorganizasyon süreci olabileceğini gösterebilir. 5 yaşındaki çocuklarda ise, dilsel beceriler daha çok öngörücü hale gelir, bu da olaysal gelecek düşüncesinin daha sonraları dilsel kaynaklara daha fazla dayanabileceğini gösterebilir.

Anahtar Kelimeler: olaysal biliş, zihinsel zaman yolculuğu, geleceği düşünme, bilişsel gelişim, ne-nerede-ne zaman deneyi

To my three loved “Mustafa”s

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LIST OF ABBREVIATIONS

www	what-where-when
EM	episodic memory
MTT	mental time travel
WM	working memory
AI	Artificial Intelligence
GWT	Global Workspace Theory

CHAPTER 1

INTRODUCTION

Human memory is a central research area within the field of cognitive science. It is mainly classified as long term memory and short term memory, regarding the duration of information held in memory (Baddeley, 2012). According to Squire's taxonomy (1987, p. 169; see also Terry, 2006, p. 202) long term memory is divided into implicit and explicit memory in terms of retrieval of information. While implicit memory refers to recalling information without being aware of it, explicit memory refers to conscious retrieval of information. Explicit memory ramifies further into semantic and episodic memory. The most important distinction in long-term memory is between declarative and non-declarative memory (Tulving, 1972; Squire, 1987). While declarative memory is consciously available and verbally declarable memory, non-declarative memory is defined by the absence of these features. It comprises procedural memory, priming, habits and classical conditioning (see also Terry, 2006, p. 207). Declarative memory comprises episodic and semantic memory. Semantic memory is knowledge of facts in the world, i.e., encyclopedic knowledge, for which it does not matter where, when and how this information had been acquired. The notion of episodic memory was first introduced by Tulving (1972). He stated that episodic memory "receives and stores information about temporally dated episodes or events, and temporal-spatial relations among these events" (p. 385). Later, Tulving changed his definition to emphasize the autonoetic ("self-knowing") aspect of episodic recall (Tulving, 1985).

The development of episodic memory has also been studied extensively. There are several studies regarding (1) mental time-line experiments (e.g., Friedman, 2000; Busby Grant & Suddendorf, 2009; Busby & Suddendorf, 2005; etc.), (2) episodic future thinking/mental time travel tasks (e.g., Russell, Alexis, & Clayton, 2010; Russell, Cheke, Clayton, & Meltzoff, 2011; Atance & Meltzoff, 2005; Atance & O'Neill, 2005; Atance, 2008a; etc.), and (3) non-episodic memory tasks (Suddendorf and Busby, 2005; Atance and Meltzoff, 2006; etc.). The main results of these studies indicated that, in children, episodic memory develops between 3-5 years of age with past events being somewhat earlier and better understood than future events.

Recently, a new term, episodic future thinking, the future counterpart of episodic memory has been put forward (Tulving, 2005). Together, episodic memory and episodic future thinking constitute the concept of episodic cognition. A critical aspect of episodic cognition is mental time travel, which is the ability to mentally experience events in the future or in the past (Suddendorf & Corballis, 2007). Episodic memory, episodic future thinking, and mental time travel are typically tested with mental time-line experiments where children have to imagine, discriminate, and verbalize events in the near/far past or future, hide-and-seek tasks that test for what-where-when aspects of episodic memory, and future prediction tasks, where children have to predict items that they would need in an imagined future event (Atance & Meltzoff, 2005; Russell, Alexis, & Clayton, 2010). However, obvious relations between the episodic cognition system (including mental time travel) and the executive component of working memory with the episodic buffer as its storage (Baddeley, 2000, 2003, 2012) have not been explicitly investigated yet.

The goal of the present study is to investigate the development of episodic cognition and mental time travel and their relation with Working Memory (episodic buffer, central executive, spatio-temporal sketchpad), linguistic encoding of temporal categories and counter-factual thinking in Turkish preschoolers (age range: 3 to 5 years). The general aim of this study is to investigate the development of the time conception in the broader framework of cognitive science experimentally *via* various related experiments with children.

Overall, in order to investigate these concepts, two main tasks have been developed: (1) a "what where when" (www) memory task that tests episodic memory of the past, and (2) a "future prediction task" for testing episodic future thinking and mental time travel. Apart from the main tasks, we also developed some additional tasks: a story-telling task, a counter-factual thinking task, the Day-Night Stroop task, and the Corsi-Block Tapping task, as well as a classical episodic memory questionnaire. The story-telling task was devised to measure the relation between episodic future thinking and linguistic expression of future tense. The counter-factual thinking task was devised for observing the effects of counter-factual thinking on episodic future thinking. The Day-Night Stroop task and Corsi-Block Tapping task are executive and spatial working memory tasks which were used to investigate the relations between episodic cognition, mental time travel and these aspects of working memory. Lastly, the classical episodic memory questionnaire was devised so as to observe the relation between the episodic memory task (www experiment) and some incidental questions related to the testing session.

The www task, the future-prediction task, the story-telling task, and the classical episodic memory questionnaire were adapted or developed by Gülten Ünal and Annette Hohenberger. The www task was similar to that of Hayne & Imuta (2011) with respect to hiding toys (what) in particular places (where) at certain times (when). The future-prediction task was based on the study of Russell, Alexis, & Clayton (2010). Other than these, the story-telling task and the classical episodic memory questionnaire were originally created by Gülten Ünal and Annette Hohenberger.

Our sample consisted of preschool children from different districts of Ankara (totally 94 children). The study aims to be a comprehensive study on the development of episodic cognition and mental time travel and their grounding in working memory, language and counterfactual thinking. In addition, this study takes a developmental perspective and tries to answer the question how this ability (i.e., episodic cognition and mental time travel) develops in preschool children. There should be an interaction between the various cognitive abilities that we study, e.g., a facilitatory relation such that one ability may increase (further) when the others have increased to a certain level also, so we study them developmentally in order to see in what ways these abilities are related to each other. Although the best methodology is carrying out the experiments longitudinally, we just examined the children cross-sectionally, as different age groups because of temporal restriction of the study. There are also other alternatives to study episodic cognition such as animal studies (e.g., Clayton, Griffiths, Emery, & Dickinson, 2001), and brain imaging studies with adults (e.g., Addis, Wong, Schacter, 2007). These studies will be reviewed in the Literature Overview in section 1.2 and 1.3.

<u>A Cognitive Science Framework to Episodic Cognition and Mental Time Travel</u>

In the following, the relevance of the current thesis with respect to Cognitive Science is pointed out. Cognitive Science may be used as a framework that helps asking important over-arching, interdisciplinary questions that could not be formulated from the perspective of any single discipline and which may allow us to integrate research domains that have not been brought to bear on each other previously. These domains include (but are not restricted to) cognitive psychology, developmental psychology, connectionism, the Bayesian model of belief updating, and Artificial Intelligence. In the following, the relevance of these domains will be outlined.

Future episodic cognition, which is a relatively new topic in cognitive science, is related to older, more traditional studies in child development. Deferred imitation is an area of study in developmental cognitive psychology which helps us to understand the mechanism of looking ahead into the future in children. According to Hopper (2010) deferred imitation is the ability to imitate an act or a behavior which one has already seen some time ago (but was not allowed to imitate at that time). Hopper (2010) refers to Piaget (1962) who states that for an infant the development of mental representations allows encoding of internal representations of an object or an act.

These internal representations could be retrieved later for the sake of imitating the action. Meltzoff (2002, p. 30) gives a summary of how long a delay children at various ages can tolerate in a deferred imitation task. Six- to 9-month-old infants can imitate after a 1-day long delay, 12-month-old infants after a 4-week delay, and two year-olds after a 4 months delay or longer. The results of these studies indicate that over time infants, toddlers, and children form stronger representations of events that help them to track and predict those events and reason about them across increasing temporal distances. Likewise, in one of our experiments, i.e. in the future-prediction task (see Methods chapter), we try to study the development of this predictive ability across temporal distances.

There also exist some studies on prospective memory development which give us some clues about the temporal durations that children at various age can look ahead into the future and plan for future action. For example, McDaniel & Einstein (2007) mention that in Kreutzer, Leonard, & Flavell's (1975) study, it was found that older children (third- and fifth-graders) were better at prospective tasks than younger ones (kindergarteners). This result might show that children's ability to think ahead develop while they grow up. Thus, studying further this kind of development in our study will give us the opportunity to observe the details of looking ahead into the future more closely.

Updating of mental representations as involved in object permanence is yet another developmental topic relevant to this thesis, although this ability is already acquired at somewhat younger ages (around 1 year of age). To illustrate the importance of this subject, Mareschal, Plunkett, & Harris' (1995) study can be referred to. They developed a connectionist model in order to simulate an object permanence task originally created by Baillargeon (1993). In this task, a situation occurred in which an object was occluded by a screen during the movement of the object. The child perceiving the object disappear behind the occluder on one side and reappear on the other side must be able to maintain its representation during the disappearance of the object when no sensory information about the object is received. Likewise the connectionist model: In the model developed by Mareschal et al., the object is represented even during the occlusion interval. Consequently, in a mental time travel experiment where the requested objects are not visible to the subject, the mental representations should continue to exist in the subject's mind and form the basis of their responses. If children are able to update their beliefs about the objects in their minds, they may do so in terms of their episodic cognition. In order to answer the experimental question they may follow the Bayesian models of belief updating which require that a rational agent should update its beliefs when encountering new data on the basis of the beliefs about the current problem and the previous knowledge gathered by the agent (Griffiths, Kemp, & Tenenbaum, 2008).

Moreover, the relevance of time representation to Cognitive Science can be discussed – whether children form them explicitly or implicitly. Given that time is rarely represented explicitly in the cognitive system, except when "objective" physical devices such as clocks are used, other, more indirect ways of representing time in cognition can be explored. Time is represented implicitly in connectionist networks in such a way that the output of previous processing is given as input to the system again, as in simple recurrent networks. Therefore, the result of the previous processing can have an effect on the intermediate results of the current processing (Elman, 1990; Servan-Schreiber, Cleeremans, & McClelland, 1991) which means that time is represented implicitly by the task itself. For instance, such recurrent networks, i.e., networks in which the activation of so-called "context" nodes is fed back to the hidden nodes at the next time step, have a "memory" that allows them to deal with temporal tasks such as predicting the next letter or word in a string (Plunkett & Elman, 1997). The representation of time in the child's mind could also be similar to that of connectionist networks, namely indirect. As children develop they may be able to form more explicit representations of time, probably supported by language (temporal words, tense markers, etc.). These various forms of temporal mental representations can be discussed in the context of this study.

Lastly, there could be a possible convergence between the notion of "context" in episodic cognition and the notion of "frame" as in the "frame problem" in artificial intelligence (AI). What both have in common is that some representational content is embedded in some frame (AI) or context (Episodic Cognition) and can be individuated and tracked, with respect to that frame or context. The frame problem in artificial intelligence can be defined as the difficulty of problem solving in a rich complex environment for a rational agent (Hayes, 1971). The agent must determine which of the many states that are embedding a certain variable as a frame are not affected by a change in that particular variable such that they do not need to be enumerated explicitly. Rather, they may stay in the background and may be assumed to not have changed. For episodic cognition the notion of context is very important since in order for a memory to become episodic it should occur in some spatio-temporal context (Tulving, 1972). This context information, although not directly relevant to the (core semantic) content of the memory itself, nevertheless helps retrieve the memory, track and update its content, for the cognizer. It individuates the memory for the cognizer, in terms of space and time. Crucially, self-consciousness is another aspect of episodic memory (Tulving, 1985). The spatio-temporal frame locates the content of the memory in the private spatio-temporal coordinate system of the individual. Overall, the notions of space, time and self are central notions in Cognitive Science whose development in the context of episodic cognition is looked at from a developmental perspective in this thesis.

Also, recently, the frame problem has been recognized in a different context by Shanahan & Baars (2005), namely in Global Workspace Theory. This theory suggests that consciousness could be the basic way for adapting new information in the world and various unconscious systems of the brain could shape the content in our working memory (see Discussion and Conclusion chapter for more information and discussion of the tasks in the light of the Global Workspace Theory). In the present thesis, the frame problem presents itself to the subjects when they are asked to retrieve information from their episodic memory, as in the www task and to embark on a mental time travel into the near future in the future prediction task. In each case they have to determine the changes in the frames/contexts and update their current representations accordingly. In particular in the future prediction task, a solution to this updating may not be to explicitly represent the spatio-temporal changes in the state of affairs but to simulate them through mental time travel – which are two different mechanisms. Pointing out this possible parallelism between the frame problem in AI and the notion of context in Episodic Cognition may help integrate these two domains better within the Cognitive Sciences.

The remainder of this thesis is organized as follows: In chapter 1, a comprehensive literature overview over the research on the various concepts used in this study, in particular, "Episodic Future Thinking", will be provided. In chapter 2, the methods including information on the sample, the various tasks used, the procedure, and the research questions and hypotheses will be presented. In chapter 3, the results of the statistical analyses will be presented and discussed. The dissertation will be closed by chapter 4 which includes a general discussion and conclusion chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Episodic Memory and Episodic Cognition

Tulving (1972, 2000) proposed multiple memory systems. For long term memory, there are two fundamental distinctions: non-declarative (implicit) memory and declarative (explicit) memory. While non-declarative memory is related to stored information in the brain without one's awareness of its acquisition coordinates in space and time, declarative memory may include the awareness of one's personal experience (Tulving, 1993). Declarative memory has also been divided into the following components: episodic and semantic memory. In general, semantic memory deals with what one knows about the world, whereas episodic memory is related to conscious recall of one's specific past experiences. According to Tulving, episodic memory "receives and stores information about temporally dated episodes or events, and temporal-spatial relationships among these events" (Tulving, 1972, p.385). Therefore, episodic memory supplies information about 'what' and 'when' of events and about 'where' they happened.

Also, more recently, episodic future thinking has been posited as the future analog of episodic memory (Tulving, 2005). Taken together, they form the broader concept of "episodic cognition" or "chronesthesia". A crucial aspect of episodic cognition is mental time travel, i.e., the ability to mentally experience events in the future or in the past (Suddendorf & Corballis, 2007).

In the following, various research strands related to episodic cognition will be reviewed: the evolutionary origins of episodic memory in animals (1.2), memory, and the neurological basis of episodic cognition (1.3), mental time travel (1.4), the development of episodic memory and mental time travel in children (1.5), and the relation to other areas of cognition (1.6). This last chapter presents the literature related to the tasks administered to the children in this study.

2.2 Episodic-like Memory in Non-Human Animals

There is an ongoing debate whether only humans have episodic memory (Tulving, 2005) or also other non-human species. In the following section I will present some articles arguing for "episode-like" memory in species other than humans.

Clayton, Griffiths, Emery, & Dickinson (2001) argue that there are some species that have episodic-like memory. One of them is the meadow vole. Male meadow voles mate with several females, these females are scattered on a broad area, and they visit oestrus at different times. According to Clayton et al. (2001), episodic-like memory is one of the possible mechanisms by which the reproductive states of females can be monitored by the males. The components of this episodic-like memory can be stated as following (p. 1484): ""what" – the female identity, "where" – the location of the female and "when" – the altering reproductive state and relative time states between females". However, it might be asked "what about females?". Claiming episodic-like memory in a species requires that females of that species should also have this ability. It can be argued that there should be evidence for this ability in the females of this species as well and it should not be unique for males only. Another counter argument could be that it might be the case that these meadow vole males could smell the hormones of their females and behave accordingly to mate with them.

A more likely and much studied example for episodic-like memory is scatter hoarding birds (Clayton et al., 2001). These birds hide several seeds in their areas and they are confident in their memory to recover these foods even months later. Therefore, it is clear that these kinds of birds remember cache locations. Since it has been found that some of these species, including scrub jays cache seeds as well as insects and some perishable items (Vander Wall, 1990, as cited in Clayton et al., 2001), this caching event might be adaptable for them keep and remember the related information about what, where, and when. For this reason, Clayton et al. (2001) studied scrub jays that may have the ability to recall a particular finished experience and react accordingly.

In order to examine the ability of jays to encode and recall related information about "what, where, when" of a particular caching event, Clayton et al. tested the jays' capacity to remember the location and contents of the caches and relative time of caching. Thus, scrub jays were led to cache perishable things (e.g., mealworms, crickets) and non-perishable things (e.g., peanuts) in caching trays. They were also separated into two groups: degrade and replenish. These groups were different in the following respect: some jays got the opportunity to understand that some foods are perishable and therefore degrade over time. Both replenish group and degrade group were led to regain their caches 4 hours later, 28 hours later or 100 hours later. The reason behind these given intervals is as follows: When the food is fresh, scrub jays choose to hide, regain and eat it. In addition, they select both crickets and mealworms over peanuts; however they choose mealworms over crickets. But crickets and mealworms lose their edible quality over time. If degrade group can remember what, where, and when they hide, then they must find the perishable foods when they are still edible. However, they must find peanuts, if the perishable foods were hidden lots of days ago. Also, the authors made mealworms become not edible more quickly than crickets. That is, crickets are edible for 28 hours, but mealworms were only edible for 4 hours.

In order to see whether jays recall the www's of a particular hiding episode, the birds were tested in the following experiments. In these experiments, birds could hide mealworms and peanuts in two trays. Though the jays had no hint for guessing whether or not mealworms are edible, they quickly learned that mealworms were edible when they were found 4 hours after hiding, while after the long interval the worms were not. Therefore, the birds did not prefer mealworm caches and instead they recovered only peanuts. Overall, the result indicated that food-caching scrub jays can remember the content, location and time of caching. Therefore, at least episodic-like memory may be granted to these birds.

However, Easton & Eacott (2008) criticize that the task of hoarding birds just taps into the innate caching and food recovery mechanisms of birds, and thus it may reflect some special memory type for birds' innate food caching. Furthermore, Easton & Eacott (2008) propose that it would be more useful to have a mammalian model of episodic memory, since birds are evolutionarily very different from human beings.

Hampton, Hampstead and Murray (2005, as cited in Roberts, 2008) allowed rhesus monkey to select some preferred food and some non-preferred food at two of the three foraging sites in a testing room. A monkey was returned to this room after 1 or 25 hours for testing. If it returned 1 hour later, then both preferred food and non-preferred food were edible. However, after 25 hours, the preferred food was inedible, but the non-preferred food was still edible. Hampton et al. suggested that evidence of episodic-like memory would be shown if the monkeys first visited the site of the preferred food after 1 hour and first visited the site of the non-preferred food after 25 hours. The results indicated that the monkeys visited first preferred food in both cases. Therefore, the authors concluded that rhesus monkeys showed memory for "what" and "where" but not for "when".

Griffiths, Dickinson, & Clayton (1999) also state that episodic-like memory of scrub jays indicated that these birds remember wh- components of the caching event, but they do not meet the criterion of having autonoetic time consciousness – the crucial criterion for episodic memory. Griffiths et al. continue that it is a methodological problem since autonoetic time consciousness cannot be examined in non-humans which do not have linguistic behavioral markers. Thus, they conclude that "it is this feature (having autonoetic consciousness) that presently makes 'episodic' memory a uniquely human phenomenon, and probably always will" (p. 79).

2.3 The Neurological Basis of Past and Future Episodic Cognition

There is an intriguing question that has been studied recently, namely the extent to which the neural processes involved in remembering our past and predicting our future overlap. Okuda, Fujii, Otake, Tsukiura, Tanji, Suzuki, Kawashima, Fukuda, Itoh, and Yamadori (2003, as cited in Atance, 2008b) studied healthy subjects using positron emission tomography (PET) to measure regional cerebral blood flow (rCBF) while subjects spoke about recent or distant past events of theirs or near or distant future events that they anticipated occurring. The results showed that thinking about past and future share common areas in the brain that involve the superior frontal, medial temporal, and medial occipitoparietal areas. However, when subjects were thinking about the future, areas in the medial frontal pole were more active than when they thought about the past.

Addis, Wong, Schacter (2007) also examined the neural regions that mediate the construction and elaboration of past and future events by the help of fMRI. In their experiment, subjects were given a cue (a noun) for 20 seconds and they were required to create a past or a future event for a given time period (week, year, 5-20 years). As soon as the subjects kept the event in their mind, they pushed a button and elaborated on this event for 20 seconds. The results showed that the active area was the left hippocampus and posterior visuospatial areas during past and future event creation. However, there were also some specializations during this creation process, as well. Addis et al. (2007) explained that "future events recruited regions involved in prospective thinking and generation processes, specifically right frontopolar cortex and left ventrolateral prefrontal cortex, respectively" (p. 1363). Moreover, future event construction also engaged the right hippocampus, which is possible based on the fact that these events are novel for the subjects. The elaboration phase was characterized by "remarkable overlap in regions comprising the autobiographical memory retrieval network, attributable to the common processes engaged during elaboration, including self-referential processing, contextual and episodic imagery" (p. 1363).

Moreover, Botzung, Denkova, and Manning (2008) used functional MRI in healthy subjects to examine the existence of common neural structures that support pre-experiencing the future and re-experiencing the past. The medial prefrontal cortex, posterior regions and the medial temporal lobes were found as common areas in this respect. In addition, Szpunar, Watson, McDermott (2007) also studied fMRI while using event cues (e.g., Birthday). Their experiments had three parts: re-experiencing a past event, pre-experiencing a future event and imagining an event involving a familiar individual. As a result, they found that left lateral premotor cortex, left precuneus, and right posterior cerebellum was more active while pre-experiencing the future than re-experiencing the past (and more active in both of these conditions than in the task involving imagining a familiar individual). Also, another set of regions (e.g., bilateral posterior cingulate; bilateral parahippocampal gyrus; left occipital cortex) was very active during both the future and past tasks (again the imagery control task was less active).

Lastly, Brand & Markowitsch (2008) indicate that the dorsolateral portion of prefrontal cortex is responsible for episodic memory encoding and retrieval-related functions. The ventrolateral prefrontal region is related to strategic retrieval, information selection, and verification of content to be retrieved. This region is also engaged in activating autobiographical memory retrieval by synchronizing emotional and factual components of one's personal past. In addition, the dorsomedial prefrontal cortex is necessarily involved in episodic memory since it is the main region contributing to self-referential processing in the brain.

The section titled as “1.4 The Flexibility of the Subjective Time Concept in Healthy and Clinical Populations” was removed from the thesis since it was considered as not being necessary for thesis anymore.

2.4 Mental Time Travel

Suddendorf & Corballis (2007) define mental time travel as “the faculty that allows humans to mentally project themselves backward in time to relive, or forward to prelive, events.” (p. 2) They state that episodic memory entails a mental reconstruction of some particular earlier event which includes at least some of the properties of that event, e.g., main characters involved, the actions that took place, the setting, and the emotional reactions. Also, we can imagine particular events in the future which are based on previous experiences. Suddendorf & Corballis (2007) indicate that mental time travel into the future may involve some plans for a particular event or it may include the mental anticipation of an event which is set for a certain date, e.g., a job interview

Furthermore, Suddendorf & Corballis (2007) state that the mental recreation of past episodes and creation of future episodes might have been engaged for the concept of time and perception of a cohesion between past and future. They continue that possessing a time concept enables us to realize that past and future are the on the same dimension. Mental time travel let us to envision events at different points throughout this period. In the words of Suddendorf & Corballis “mental time travel is a generative process, incorporating known elements but arranged in particular ways to create the experience of events that are actually occurring” (p. 5).

Furthermore, Suddendorf and Corballis (2008, as cited in Atance, 2008b) indicated that working memory, self-awareness, theory of mind, and executive function are necessary cognitive components for mental time travel. They argued that in the absence of any of these components, mental time travel will be compromised. Atance (2008b) concluded that “determining the extent to which each of these components is integral to mental time travel (into the future specifically) will be an important issue for future research” (p. 110).

Dere, Zlomuzica, Huston, and De Souza Silva (2008) state that episodic memory (EM) requires autonoetic consciousness or autonoetic awareness. They continue that “in terms of EM these synonyms refer to the fact that humans are somehow aware that they remember a personally experienced event, a phenomenological experience which is both subjectively different from the awareness of the immediate present and from a mere feeling of familiarity” (p. 156). Therefore, episodic memory requires conscious recollection.

Moreover, episodic memory has been supposed to involve the capability to perceive the time in a personal manner. This subjective time sensation, called “chronaesthesia”, supplies information about one’s individual past, the capability to follow the flow of episodes experienced (which is also called retrospective memory) and to imagine about and make plans for the future (prospective cognition). Therefore, episodic memory could be used to remember the order of experienced events and to become ready to meet an oncoming need or figure out a present problem. Dere et al. (2008) summarize this ability as follows: “this requires a mind in which one’s own self exists as an entity different from the rest of the world, allowing one to distinguish between mental representations of oneself in the past, present, and future” (p. 156).

According to Dere et al. (2008) the concepts of chronaesthesia and autonoesis are supposed to be connected and inseparable preconditions for episodic memory. They state that this triple is supposed to make possible for human beings to mentally travel in time.

2.5 The Development of Episodic Memory and Mental Time Travel in Children

Studying episodic memory and mental time travel with children allows us taking a developmental perspective on this unique phenomenon, but at the same time it is a challenging enterprise, methodologically. Various experimental tasks regarding episodic memory and mental time travel have been used in the literature: (1) what-where-when (www) tasks, (2) mental time-line experiments, (2) episodic future thinking/mental time travel (MTT) tasks, and (3) non-episodic memory tasks.

2.5.1 What-Where-When (www) Tasks

Holland & Smulders (2011) investigated episodic memories of adults with a what-where-when (www) memory task. Participants were required to hide two different types of coins (eight coins in total) in different locations and then were tested for their memory of www information on two consecutive days. On the third day, they were tested on their recall of www information regarding the first and the second day of the experiment. On the third day, they were also tested on a classical episodic memory experiment (including incidental questions about the context of the hiding episodes like “Was the kitchen door open?” and “Was the light on in the living room when you first came?”). For this task, two different groups were created so as to observe the difference between informed and uninformed participants’ performance. In the Active group, participants were informed about memorizing the www information and in the Passive group participants were not informed about the memory test. According to the results of these experiments, the performance on the classical episodic memory task predicted the performance in the three components of the www task (i.e., what, where, and when) in the Passive group. In spite of this, in the Active group, only the “what” component could be predicted. This finding suggests that another memory system may be in charge during active encoding. Finally, the results showed that performance on the classical episodic memory task significantly predicted the performance on the www memory task. This may suggest that the www task is a reliable test for episodic memory, possibly also in children.

Hayne & Imuta (2011) studied episodic memories of 3- and 4-year-olds. A hide-and-seek task was developed to investigate what-where-when (www) recall of children. In this experiment, children were examined in their own home. The child and the experimenter hid three toys in the house. In the experiment, children were shown seven plush toys: Donald Duck, Ronald McDonald, Mickey Mouse, Eeyore, Bert, Bob the Builder, and The Count. Children were required to name the toys so as to introduce them to the children. After the toys were named, the experimenter told the child that they were going to play hide and seek. In order to play the game, the child is told to choose three toys. Then, the experimenter made the child hide the toys at three different locations in the home. When the child entered each room, the experimenter asked her/him to name the room. After the toys were hidden, the experimenter read the child a book for 5 minutes in order to make the child not to rehearse the hiding places. Then, the verbal and behavioral recall tests were carried out.

First, for the verbal recall test, the following three www questions were asked to the child for each hide and seek problem. The questions were ‘‘what room did we go into first (or next)?’’, ‘‘who was hiding there?’’ and ‘‘where did we hide him?’’ (Hayne & Imuta, 2011: 319). The order of the questions for each toy was the same. Verbal recall measure was calculated as the number of correct items out of three for each category. They were the name of the toy (what), the room where the toy was hidden (where), the specific location of the toy in the room (where), and the order of the hiding event (when).

For the behavioral part of the experiment, the child was asked ‘‘Can you show me the room that we went into first (or next) and then find who is hiding there?’’ (Hayne & Imuta, 2011: 319). Then, the experimenter followed the child and took notes about the www's of the hiding events. This was repeated for three times. Behavioral recall measure was calculated as the number of correct behaviors for each toy, (www), i.e., the room (where), the order of hiding event (when) and the specific location in the room (where).

The results showed that on the verbal recall test, 4-year-olds were more successful than 3-year-olds. On the behavioral recall test, 3-year-olds were equally successful as 4-year-olds on the "where" component of the task, whereas they were less successful on the "when" component. To summarize, we can conclude that by the age of 3, children begin to show their episodic memory skills.

We will use the www task because of its relations to episodic cognition in the narrow sense and to the frame problem in the wider sense. The www task might be related to the frame problem due to the need of representational content in the context of episodic cognition. That is, when there occur some changes in the environment, i.e., hiding/disappearing of objects in the context, then the child needs to update this representational content in his/her episodic memory. Therefore, this updating might be useful for us in understanding how children represent the changes in their mind *via* the help of the www task.

2.5.2 Time-line Tasks

To begin with, the ability of 4- through 10 year-old children to discriminate future events at different distances in time was examined in Friedman (2000). In this study, children were presented with a picture of a road and asked to guess how far events in the future were located on this road. Pictures of some important events were depicted on cards shown to the children. The events were dinner time, summer, Saturday, Christmas, Valentine's Day, Halloween, and Thanksgiving.

The experiment consisted of a series of questions and a picture-pointing task. The questions were the following ones: "Tell me some things that are coming soon. What else will happen soon? Now tell me some things that will not happen for long time. What else? Is your birthday coming soon?" (Friedman, 2000: 916). The picture-pointing task included an explanation, a practice phase and then a judgment task. In the practice phase children were told the following: "We're going to play a game. We'll use this picture (see Figure 1) to indicate how far things are in the future. So you should pretend we're standing here (pointing to the closest part of the road). Things that are next to us will happen very soon. Things that are here (pointing to the furthest section of the road) will happen a very, very long time from now." (Friedman, 2000: 916). Then, in the judgment task, children were required to label the seven stimulus cards and if they were wrong they were corrected. The following instructions were given to the children: "Now I want you to show me where you think they go. If something is going to happen very soon, then point (with an unsharpened pencil) to here (indicating 0-1). If something will happen in a very, very long time from now, point to here (indicating 20-25). Point here (6-15) if it will happen in an in-between amount of time from now." (Friedman, 2000: 916). This process was repeated for the other six cards.

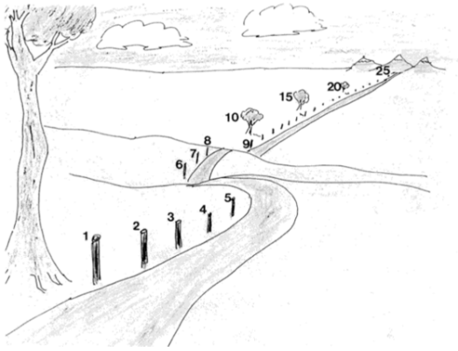

Figure 1 The representation of future distances used in the picture-pointing task (Friedman, 2000: 915)

The results indicated that there were distinctive differences between children of 4 and 10 years of age. In particular, the ability of pre-school children to differentiate future distances was very restricted. They could estimate only the events that would occur within the next days and weeks in the picture-pointing task. On the contrary, the oldest ones showed a good differentiation of the times of future events. The fifth graders' judgments about conventional events were very accurate. They easily determined the position of the present and the target events in the calendar. Most of the second graders were able to give exact answers until the time point "weekend" and these probably relied on their knowledge about the order of days of the week.

Overall, these studies showed that 4-year-old children were not able to discriminate between events that would occur in the near future and events that would occur many months ahead in the future. While 4-year-olds were not successful on this task, 5-year-olds could differentiate events that would occur in the coming weeks and months from events that would occur in the next several months. Children between the age of 5 and 7 could differentiate two or three categories of future distances. Children at the ages from 6 to 8 made more differentiated judgments about the future but they failed to discriminate events that were at a distance of a few months in the future. Between the age of 8 and 10, the ability of children to represent the order of months and annual events also developed. Moreover, between the age of 7 and 10, children improved their competence on differentiating distances of future events. Finally, by the age of 10, the ability of children to distinguish the times of future distances of events resembles that of adults.

In another study, Busby Grant & Suddendorf (2009) presented 3, 4, and 5-years old children with simple past and future timelines and asked them to place different pictures in appropriate places on this timeline. Three temporal groupings (24 hours, 12 months and several years) for both past and future events were represented in these pictures. The ability to place items in these categories correctly on the timeline improved with age. Three-year-olds placed the items which occurred many years ago further than the items which occurred most recently but they failed to place items for future events correctly. The performance of four-year-olds in the past timeline was not different from that of three-year olds but they were able to differentiate daily events from events that would occur many years later. Finally, 5-year-olds differentiated all categories for both past and future events.

There are two different measures used in these studies that allow children to determine the time of events: relative recency judgments and spatial metaphors. In relative recency judgment studies, children are required to nominate two events according to their relative position in time. The spatial metaphor paradigm also aims to reveal the ability to map the event to a point in time. However, this approach does not use conventional temporal labels. There are two spatial metaphors used in these tasks. In one of them, time is represented as a ruler, in the other as a road divided into distances. In both paradigms, children are asked to show how long ago in the past or how far in the future events occurred or will occur by using the ruler/road. For example, in the ruler studies children were told: “When we put cards here (indicating the near side) we mean something that was a short time ago, like when you just came into the room with me. When we put cards here (indicating the far side) we mean a very long time ago, like when you were a baby” (Friedman & Kemp, 1998, p. 347, as cited in Busby Grant & Suddendorf, 2009, p. 747). After the items had been presented, children were asked to place the pictures of particular events on the ruler. The list of events, time spans, and the point on the timeline they belong to are given in Table 1.

Table 1 List of items used in the timeline study of Busby Grant & Suddendorf (2009: 748), including the event (with picture representation), the time span and the point on the timeline it belongs to

Event	Time span	
Brushing teeth (toothbrush)	Past	Daily
Going to sleep (bed)	Past	Daily
Easter (Easter bunny)	Past	Annual
Birthday (birthday cake)	Past	Annual
Slept in a cot (cot)	Past	Several years
Drank out of a bottle (bottle)	Past	Several years
Going home (house)	Future	Daily
Having dinner (plate with food)	Future	Daily
Christmas (Christmas tree)	Future	Annual
Winter (jumper)	Future	Annual
Drive a car by yourself (car)	Future	Several years
Get married (wedding cake)	Future	Several years

In this experiment, two wooden boards (red and blue) were used as timelines. The "ruler" version of the timeline was used since children could not understand the "road" version of the task in the training sessions. Cue cards involved figures of the same black, filled silhouette of a person on plastic white cards (10 cm x 5 cm) (see Figure 2). The three figures gradually became smaller in the past condition as it shows the child's past and the other three figures gradually became larger in the future condition as it shows the child's future. The aim in using these cue cards was to make children successful in the task by allowing them to use simple correlations. For example, children could place a "cot" item on the road when they were given "baby's bottle" as an example.

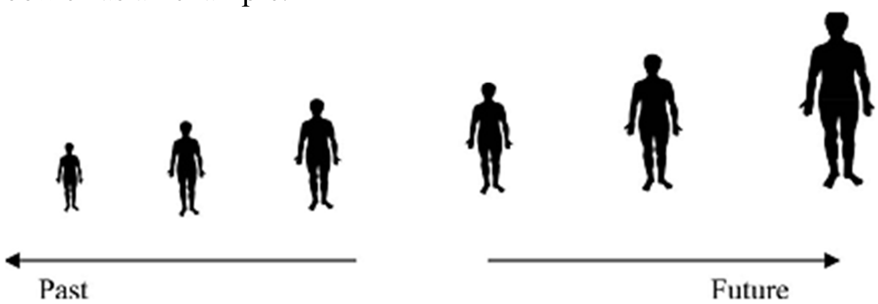

Figure 2 Figures (not to scale) used as ''cue cards'' for the past and future timelines respectively (Busby Grant & Suddendorf, 2009: 750)

The target items were 18 colored plastic cards representing 12 past and future events (and six for backup items). Each of six target items includes two pictures of events which occur daily (e.g., eat dinner), annually (e.g., birthday) or several years in the future (e.g., drive a car). In the experiment, children were shown two timelines and they were told that they would be playing two games. Then they were asked to answer these questions: for the past condition "How long ago things happened in the past?" (Busby Grant & Suddendorf, 2009: 750), and for the future condition "How long until things happen in the future?" (Busby Grant & Suddendorf, 2009: 750). Then the timeline was described to the child by placing the three figures at the appropriate places on the board. The scenario was also explained by the experimenter (e.g., "this person is really small, like when you were really really little" (Busby Grant & Suddendorf, 2009: 750)) and the child was told that s/he was required to put the items next to the picture of the person that has a proper size (e.g., "If something happened a really, really long time ago, like when you were really little, we put it here'' (Busby Grant & Suddendorf, 2009: 750)). In this experiment, the child was shown the pictures of the events and required to name it. If the child could not do it, then the experimenter labeled it. If the child was not still familiar to the task then one of the backup items was used. Then the experimenter asked the child "How long ago did you ……. [e.g., sleep in a cot]? Was it a little time ago, a long time ago, or a really, really long time ago? Put it on the board where you think it should go" (Busby Grant & Suddendorf, 2009: 751). The places of the cards were recorded by the experimenter.

All children were successful in distinguishing between more recent events and the events that occurred several years ago (see Table 2). However only the older children achieved to differentiate daily events from annual events.

Table 2 Differentiation of past events by 3-, 4- and 5-year-old children (Busby Grant & Suddendorf, 2009: 753)

Age group	Daily vs. annual	Daily vs. several years	Annual vs. several years
3-year-olds	x	✓	✓
4-year-olds	x	✓	✓
5-year-olds	✓	✓	✓

In the future condition, 3-year-olds could not differentiate any items in any categories. In other words, they did not discriminate items such as "getting married", "Easter" and "having dinner". Four-year-olds began to separate daily events from annual events and daily events from events that occur several years in the future. By 5 years of age, children became successful in all categories along the timeline.

Table 3 Differentiation of future events by 3-, 4- and 5-year-old children (Busby Grant & Suddendorf, 2009: 753)

Age group	Daily vs. annual	Daily vs. several years	Annual vs. several years
3-year-olds	x	x	x
4-year-olds	x	✓	x
5-year-olds	✓	✓	✓

Three-year-olds were successful at differentiating past events but they were unable to discriminate the times of future events "suggesting that they may view the future (if at all) as an undifferentiated time span" (p. 754). Unlike 3-year-olds, 4-year-old children began to discriminate future events but they only differentiated between items of daily events and more distant events.

By 5 years of age children were able to make all temporal discrimination for both past and future conditions. However, this does not mean that by 5 years of age, children can make all temporal discriminations.

Moreover, in Busby Grant & Suddendorf's (2005) study, children (aged 3-5) were required to describe something which they did yesterday and something they will do tomorrow. Later, they were required to report things they did not do yesterday and things that they will not do tomorrow. According to the results, most of the older children could properly answer the questions, but this was not the case for 3-year-olds. These findings indicated that the ability to recall past and to predict future events emerges between the ages of 3 and 5.

In this task, children were asked to answer the following four questions: (1) "Can you tell me something that you did yesterday? (p. 365)" (yesterday positive), (2) "Can you tell me something that you didn't do yesterday?" (p. 365) (yesterday negative), (3) "Can you tell me something you are going to do tomorrow?" (p. 365) (tomorrow positive), and (4) "Can you tell me something you are not going to do tomorrow?" (p. 365) (tomorrow negative).

The results revealed that 45% of the 3-year-olds and 65% of the 4-year-olds gave correct answers to the yesterday questions. The tomorrow question was answered by 60% and 80% of the age groups, respectively. There was no significant difference between the age groups.

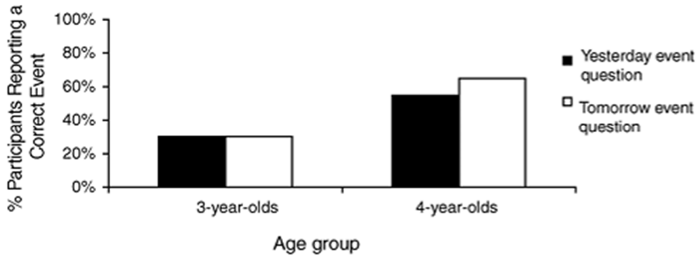

Figure 3 Percentage of 3- and 4-year-olds producing a correct answer in response to the yesterday and tomorrow event questions in Experiment 1 (Busby Grant & Suddendorf, 2005: 366)

Figure 3 shows the percentages of 3- and 4-year-olds producing a correct answer to the yesterday and tomorrow questions. Over half of the 4-year-olds produced answers that their parents judged as correct (for the past 55% and for the future 65%), while this was not the case for the 3-year-olds (for the past and the future, only 30% were correct). There was a significant age difference for the future condition. In Table 4 examples from children's responses are provided. Moreover, there was a significant correlation between achievement on the yesterday and tomorrow questions. This suggests that the ability to report the past and future events develops (to some extent) in parallel.

Table 4 Examples of children's correct and incorrect responses to each question type in Experiment 1, including child's age and gender
(Busby Grant & Suddendorf, 2005: 366)

Question type	Child's age	Gender	Response	Correct/incorrect
Yesterday +ve	3;0	Male	"Went on a swing"	Correct
Yesterday +ve	3;0	Male	"The beach"	Incorrect
Yesterday -ve	4;0	Female	"Didn't go shopping"	Correct
Yesterday -ve	4;2	Female	"Didn't go drawing"	Incorrect
Tomorrow +ve	4;0	Female	"Play Uno with mummy"	Correct
Tomorrow +ve	4;0	Male	"Go swimming"	Incorrect
Tomorrow -ve	4;0	Male	"Not going to the big slippery slide"	Correct
Tomorrow -ve	4;5	Male	(Won't)"play in the toy room	Incorrect

2.5.3 Episodic Future Thinking/Mental Time Travel Tasks

The experiments reported in this section all study episodic cognition, especially future thinking in children, either through invoking children to predict future states or future needs. The crucial question is whether children perform these predictions *via* semantic memory or episodic memory, i.e., if they can deduce a future state or need by drawing on knowledge of facts that would hold true in the future or by going on a mental time travel and imagine themselves in the future episode and thus pre-experience a future situation and future needs.

Russell, Alexis, & Clayton (2010) asked children (aged 3, 4, and 5) to select items they would need to play in a blow football game. In this game, two players contend a goal on one side of the table and bat the opponent's goal on the other side. As shown in Figure 4, the child first played the game on the side with the high box which was necessary to reach the table.

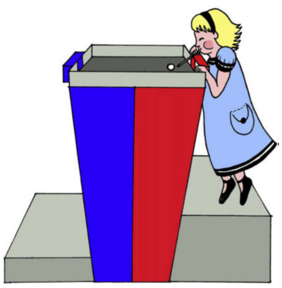

Figure 4 A schematic representation of a child playing on the "red" side
(Russell et al., 2010: 58)

After playing the game, the child was asked to select two items out of six that s/he would need when s/he again played the game on the next day from the other (unreachable) side of the table. The items were both functional (the box and the straw) and non-functional (e.g. a doll). In the crucial question the child was asked which items she (self-condition) or another child (other-condition) would need yesterday/now/on the next day when she/the other child was to play the game on the other side. In order to answer that question correctly, the child would have to imagine herself/the other child from the new spatial perspective and thus find out that she/the other child could only reach to the table if she had the high box. For Russell et al. (2010) MTT crucially involves spatial perspective (the "where" component). Still, it is difficult to show unambiguously if children actually engaged in MTT in this task.

Four experiments were carried out in order to shed light on young children's episodic future thinking abilities. In the first experiment, the child was required to state which of two items they would need when they played the game from the other side of the table "right now" (present-self condition). In the past-other condition, the child was asked to answer the question from another child's perspective, who had played the same game yesterday. The second experiment was the same as experiment one except for the change in the time condition. This time, future-self and future-other questions were asked. In the third experiment, future-self and future-other questions were again used but just for an extended 4-year old group. Finally, in the last experiment, the first experiment was carried out again, but for the past-other condition, however, present-self and present-other questions were used with the 4-year-olds again.

As a result, in the first experiment, all age groups were successful enough to answer the questions regarding the present-self and past-other condition. However, in the second experiment, while 3-year-old children performed very poorly on future questions, 4-year-olds found it easier to answer questions about another child than about themselves and 5-year-olds performed well on both conditions. As for the third experiment, it turned out again that 4-year-old children found it harder to understand a future-self question than a future-other question. Lastly, the result of the fourth experiment indicated that there was no difference at all between present-other and present-self conditions for 4-year-olds. Overall, these data suggest that the age of 4 was the critical age for the development of episodic future thinking.

Atance & Meltzoff (2005) assessed the ability of preschool-aged children to guess future physiological states of the self. Experiencing these future situations would induce children to choose items that would alleviate the future need states, e.g., choosing sun-glasses when going on a trip to a desert. Three, 4- and 5-year-olds were shown pictorial scenes which were intended for evoking thought about future states. The children were asked to imagine themselves in these scenarios and select one item from a given set of three items. In Experiment I, 3-, 4-, and 5-year-olds were presented with a series of future events. These events were the followings (p. 345): (1) walking across a sunny desert, (2) walking across a rocky stream, (3) walking along a long dirty road, (4) walking across a snowy forest, (5) walking up a steep, high mountain, and (6) walking close to a waterfall. These events were selected to evoke thought about the following states: sun in eyes, hurt, thirst, cold, hunger, and wet. After each event was presented, children were given three items and asked to choose one of them that they would need. Only one item was the answer to the question and the others were distracters. The correct items for each event were the following ones: sunglasses, Band-Aids, water, winter coat, lunch, and raincoat, respectively. In this experiment, the aim was to determine whether children would select the appropriate items for their needs or would select items randomly.

In the experiment, two sets of six trials were administered. The first set consisted of six warm-up scenarios (which will be neglected here, but see Table 5) and the second set of six test scenarios.

In the test scenarios, children were presented with six photographs showing the following scenes (p. 347): (1) a sandy desert with a sun and blue sky overhead (desert), (2) a rocky stream surrounded by a forest (stream), (3) a long dirty road bordered by trees and shrubs with blue sky overhead (road), (4) snow-covered mountains and a valley surrounded by trees (snow), (5) two grassy mountains with a valley in between (mountain), and (6) a waterfall bordered by grass (waterfall). Children were required to envision themselves in these scenarios after they are told the scenes. Then, they were asked: “What do you see in this picture? Okay, let’s pretend that you are going to go walk across the rocks. It’s time to get ready to go!” Then, the three items were presented to the child and they were asked “Which one of these do you need to bring with you: a pillow, Band-Aids, or tooth-paste?” (p. 347). In this case, the correct choice was Band-Aids because there was a risk of getting hurt on the slippery rocks. The complete list of scenarios, correct items, and distracters are given in Table 5. In the test scenarios, children were also asked to clarify their selection (i.e., How come you need to bring X?)

Table 5 Scenarios and item choices in Experiment I (Atance & Meltzoff, 2005: 349)

Scenario	Correct item	Distracter 1	Distracter 2
Warm-up			
Birthday	Card	Lunch	Toothpaste
Bedtime	Pillow	Sunglasses	Comb
Swimming	Water wings	Winter coat	Mirror
Bathtime	Soap	Band-Aids	Blanket
Cookies	Bowl	Raincot	Shampoo
Grocery store	Money	Water	Towel
Test			
Desert	Sunglasses	Soap	Mirror
Stream	Band-Aids	Pillow	Toothpaste
Road	Water	Card	Shampoo
Snow	Winter coat	Water wings	Towel
Mountain	Lunch	Bowl	Comb
Waterfall	Raincot	Money	Blanket

After completing the six warm-up and six test scenarios, children were tested with six control trials in order to make sure that their performance did not depend on chance. The results of these trials showed that it was not.

In the test scenarios, two dependent measures were used: (1) children’s explanations for their item choices (verbal explanation measure) and (2) children’s behavioral choices (nonverbal measure). The verbal measure was used to examine the choices of children in order to see whether they were using sentences that refer to future states (e.g., "I'm gonna get hungry"). There were two sub-measures showing that an explanation refers to a future state: (1) a future item (e.g., going to/gonna; will; could; would; can; when; might; maybe; in case; and if), and (2) the corresponding state term (e.g., hungry, thirsty, hurt, cold). The nonverbal measure was intended to determine the relation between children's choices and the future states in the questions. Other explanations that did not resemble either a future item or a corresponding item were grouped into two categories: (1) future talk (e.g., "it's gonna be hot"), and (2) non-future talk (e.g., "because it's cold"). If the child could not give an explanation at all, then this was counted as a non-future talk.

According to the results of the experiments, 4- and 5-year-olds' performance was very good and significantly higher than that of 3-year-olds. Their performance were also better for the verbal explanation measure (i.e., choices referring to a future state) than that of 3-year-old children.

In Atance & Meltzoff's (2005) experiment, it was vital to consider the role of language. Especially, the older children may have used their language skills in order to verbally refer to a future state. It is obvious that a 5-year-old child has better language skills than a 3-year-old child does.

In Experiment II, the effects of semantic associations for the picture-book task were examined. That is, these associations could negatively influence the child's performance. For this purpose, new items that were semantically related to the scenes were added to the distracter category, i.e., fish for stream; sticks for mountain; ice cubes for snow; seashell for desert; plant for road and rocks for waterfall. The complete list of correct items, distracters, and corresponding semantic associates are given in Table 6.

Table 6 Scenarios and item choices for the test trials in Experiment II (Atance & Meltzoff, 2005: 353)

Scenario	Correct item	Distracter 1	Semantic associate
Desert	Sunglasses	Soap	Seashell
Stream	Band-Aids	Pillow	Fish
Road	Water	Present	Plant
Snow	Winter coat	Bathing suit	Ice cubes
Mountain	Lunch	Bowl	Sticks
Waterfall	Raincot	Money	Rocks

The results of Experiment II indicated that 3- and 4-year-olds' performances were severely affected when the semantic associates were added, while 5-year-olds' were not. This means that preschool children's decisions about future events take advantage of topically oriented structure of the event. Only older children could guard themselves against the deceptive influence of the semantic associates and select those items related to their future need state.

In another, very similar study, Atance & O'Neill (2005) further examined the concept of episodic future thinking. Episodic future thinking is defined as the ability to live mentally in the future – hence it is related to MTT. Both verbal and nonverbal tests were developed for children in order to investigate this concept. The results suggested that episodic future thinking emerges between the age of 3 and 4.

Again, a trip task was designed to measure episodic future thinking. In this task, children were asked to pretend that they would go on a trip and were presented with eight items to choose from. These eight items are related to the following categories (p. 132): (1) juice and raisins, in case of possible physiological need state of getting hungry or thirsty; (2) sunglasses and band-aids, in case of possible physical situations of getting sun in one's eyes or getting hurt; (3) book and teddy bear, in case of possible emotional situations of needing something to do, or getting scared; and (4) telephone and money, in case of possible emergency situations of needing to telephone someone or to buy something. Later they were required to choose three items for their trip. After each selection, they were asked to verbally indicate why they had selected these items.

Two factors were coded for the children's explanations. First, the usage of "future terms" like will, would, should, can, going to, could, etc. Second, the usage of "uncertainty terms" such as if, maybe, might, in case, probably, etc. Results indicated that 37% of children explained the situations using future terms (e.g., "Because when I'm thirsty I will drink it", p. 11). Uncertainty terms was used over half of these explanations (e.g., "In case somebody has an owie", p. 11). Children's explanations comprised of the following future terms numerically: (1) getting thirsty and hungry (juice and raisins) (50% and 44%, respectively), (2) getting hurt (band-aids) (70%), and (3) needing to contact someone (telephone) (56%). The percentage of uncertainty terms in these explanations were as follows: juice 44%, raisins 75%, band-aids 86%, and telephone 45%. The high percentage of raisins and band-aids may indicate that children have more experience with states of hunger and getting hurt.

In a second experiment, the performances of children on a nonverbal task and the trip task were examined. In the nonverbal task, the children were presented with the juice, band-aids, teddy bear, and telephone and they were asked to pack them for their trip and the rest of the experiment was the same as the previously described trip task. According to the results, children talked about the future on 50% of the trials and uncertainty terms were used in two-thirds of these situations. Children's talk consisted of future terms 45% of the time for juice, 62% for the band-aids, 36% for the teddy bear, and 53% for the telephone. For the uncertainty terms, it was 53, 77, 64, and 57% for the juice, band-aids, teddy bear, and telephone.

A nonverbal block task was also given to the children in order to assess their episodic future thinking. In this task, the child was presented with a tower with four blocks (each having a different color). The child was told that "In this game, I will build a tower and I want you to build the same tower with the same colors in the same places" (Atance & O'Neill, 2005, p. 135). Then, the experimenter built a tower in front of the child and then asked for the child to do the same. Each block was contained in one of three plastic cups to prevent the child from quickly reaching for a block (see Figure 5).

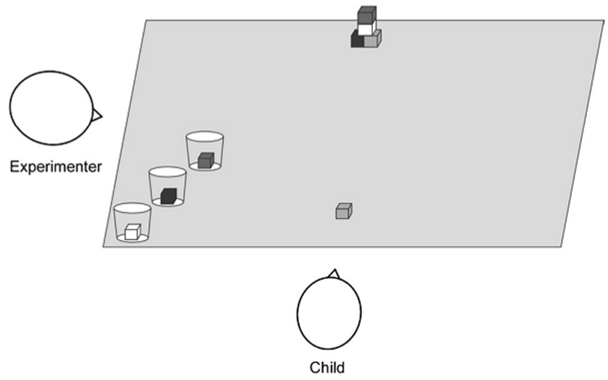

Figure 5 Experimental set-up for the block task (Atance & O'Neill, 2005: 136)

Results indicated that there was a significant relationship between the children's performance on the verbal trip task and the nonverbal block task.

Another type of study that is related with future thinking is delay of gratification (Atance, 2008a). In this experiment, children are required to select between a smaller or a larger reward that can only be obtained after a delay. For these kinds of experiments, Mischel, Shoda, & Rodriguez (1989) reported that the ability to delay for the larger reward improves with age. Furthermore, they indicated that 4-year-old children who delayed gratification longer will become more cognitively and socially competent adolescents, they can achieve higher academic performance, and they can cope better with stress and frustration. Additionally, in their study Mischel, Shoda, and Peake (1988) found that 4-year-olds who were successful to delay for the larger reward become adolescents that were also successful at planning and thinking ahead according to their parents' rating. The authors suggest that there may be a mutual interdependence between delaying gratification and future thinking since delaying would be irrelevant when the child could not conceptualize a time other than the present.

In addition, Atance (2008b) mentions some features that reflect future thinking (see section 1.5.2). They are as follows: (1) planning, (2) delay of gratification, (3) prospective memory, (4) judgments about the time of future events. With respect to (1), one of the most well-known planning tasks, the Tower of Hanoi, can be used as an example. In one version of this task (Carlson, Moses, and Claxton, 2004, as cited in Atance, 2008b), children were presented with wooden disks that vary in size and three wooden pegs. Then, children were shown that the experimenter had also pegs and disks. The aim of this task is to move the disks from peg to peg by obeying a number of rules such as a large disk cannot be put on a smaller disk and to match the disk configuration of experimenter at the end of the game. The results indicated that there was important age-related improvement for this task during the preschool years.

As for (2), Atance (2008b) describes delay of gratification as one of the future-oriented behaviors. Atance suggest that the ability to delay for the larger reward should be based on some representation of the future self. She continues that to inhibit one's wish for an immediate reward interferes with the ability of thinking about one's future self.

With respect to (3), prospective memory is described as "remembering to perform an intended action at some point in the future" (Kerns, 2000, as cited in Atance, 2008b, p. 103). Therefore, it is future-oriented unlike retrospective memory. Guajardo and Best (2000, as cited in Atance, 2008b) developed a task in which they asked 3- and 5-year-old children to remember to make several requests (e.g., ask for a sticker) after they completed a specified task. Children were also required to bring back a picture and to request for a pencil in the subsequent laboratory visit which came about between 24 and 72 hours later. The results showed that younger children started to show prospective memory skills, however these skills developed significantly by age. In addition, Guajardo and Best found that retrospective memory is also needed for prospective memory since, for instance, the subject has to remember what needs to be done and when in the experiment.

Lastly, as for (4), Atance (2008b) puts forward that the ability to predict when a future event will occur is an important aspect of future thinking. According to Atance, Friedman's (2000; see section 1.5.2) experiment is a good example in this respect. In this experiment, Friedman presented children with a pictorial representation of a road and asked them to point to the location of given events (e.g., Valentine's Day, Saturday cartoons, etc.) on the road. The results indicated that young preschool children were very unsuccessful in judging the distance of various future events.

Moore, Barresi, & Thompson (1998) carried out a further study in this area. Namely, they examined the relations between executive functioning, theory of mind, and delayed (future-oriented) prosocial behavior. They argued that, for a child, in order to show a future-oriented behavior, other than developing empathy, two abilities are required. First, representing a mental state that is suitable for the future is necessary, which is theory of mind. Second, inhibiting the response for the immediate situation in support of the future situation is necessary, which is executive functioning. These two abilities also show a developmental link (Russell, Mauthner, Sharpe, & Tidswell, 1991, as cited in Moore et al., 1998). In order to examine the relations between theory of mind and delayed prosocial behavior, children (3- and 4-year-olds) were presented with a standard false belief task in which the understanding of false beliefs in self and in others was examined and a sticker choice task in which selection of different choices were made according to a given preference list (i.e., 1 sticker for self now or 2 for self later (delay of self-gratification) or 1 for other now or 1 each later). According to the results, delaying for self and for sharing with others is more probable for older children. Also, there was a correlation between the performances in these two tasks which suggests that they might both hinge on the same necessary progressive mechanism. In the other study, the possible relations between the development of future-based prosocial action and executive functions were investigated. For the executive functioning task, Russell et al.'s (1991) windows task was used. In this task, children were shown two boxes and there was a hidden reward in one of the boxes. In the trials, children had to indicate one box so as to select a hand puppet to examine the selected box. If the selected box contained the gift, then the puppet kept it. If the selected box did not contain the gift, then it was taken from the other box and given to the child. Then, throughout the experiment the child will win if the box is empty. After the child had figured out this situation, the experimenter replaced the boxes by two other boxes but in this case only the child but not the puppet could see the box which has the gift. Then the game continued with some other trials in which the child pointed to one box in order to direct the puppet to the box. Overall, they found notable relationships between future-based prosocial action and executive functions in 3-year-olds and future-based action and theory of mind in 4-year-olds. The authors suggested that "it is possible that while executive functioning plays a role in future-oriented prosocial behavior early on in development, developing theory of mind is more important later." (p. 215).

We will use an episodic future thinking task (similar to Russell, Alexis, & Clayton, 2010) in order to examine the predicting and reasoning ability of children across increasing temporal distances. We tap children's ability to represent these temporal distances in their minds implicitly in the episodic future thinking task by asking them about the items that will be needed in order to play the game now or on the next day, at the other side of the table. This kind of study will help us to understand the details of looking ahead into the future in children. Also, we would like to see how they update their beliefs when there is a change in the environment, since, as required in this kind of experimental task they have to respond according to new spatial and temporal frames.

2.5.4 Non-episodic Memory Tasks

Atance (2008b) indicates that starting at around 4 years of age, children's ability to narrate past events develops significantly. Also, the fact that children younger than 4 or 5 years of age show various cognitive limitations which have been argued to show the lack of a fully formed episodic memory system is consistent with this claim. The failures are about: "(1) understanding that the self is continuous over time, (2) source memory, and (3) free recall" (p. 101). Regarding (1), Povinelli, Landau, & Perilloux (1996, as cited in Atance, 2008b) and Povinelli, Landry, Theall, Clark, & Castille (1999, as cited in Atance, 2008b) videotaped children (aged 2, 3, and 4) while the experimenter played a game with them in order to understand the concept of continuity of the self in children. In this game, experimenter secretly put a sticker on children's heads. Sometime after this marking event, children were shown a video of this event. The experimenters hypothesize that these children should remove the sticker from their heads if they understood that the event in the video they are watching right now is what they had just experienced. The results showed that only by 4 years of age children do so. Regarding (2), Atance (2008b) states that children younger than age 4 have some difficulty determining the source from which they get the information. For instance, O'Neill and Chong (2001, as cited in Atance, 2008b) claim that a 3-year-old child who has found out through smell that a clear liquid is strawberry perfume might err by indicating that she predicts this because she has touched it or looked at it, though she should indicate that she has smelled it. Finally, as for (3), free recall is argued to rely mostly on episodic memory by Perner and

Ruffman (1995, as cited in Atance, 2008b). Therefore, it is not surprising that older preschoolers shown a series of objects and later asked to recall them without any cue are much better than younger ones.

Moreover, Atance & O'Neill (2001, as cited in Atance, 2008b) argued that episodic future thinking is more involved in our thinking about novel versus everyday events. Therefore, there is a difference between the responses to the questions related with "things to do at bedtime" and "things to do when going to the ocean for the first time".

In addition, Tulving (2005, as cited in Atance, 2008b, p. 105) also stated that in order to conclude that "an observed behavior is indeed reflective of the ability to think about one's personal future, the behavior must not be motivated by the organism's current state, and it must have consequences that fulfill a future, rather than a present, need."

Tulving (2005, as cited in Atance, 2008b) also proposes a test that does not rely on language ability and thus is feasible for both young children and nonhuman animals. This test, "the spoon test" is as follows: a young girl goes to a party. In this party, all people are given a pudding. In order to eat this pudding, everybody must own his spoon. But this girl does not own her spoon. That night, the girl goes to sleep as holding a spoon in her hand because she does not want to err again. Tulving concludes that children under the age of 4 should not be successful on any task that shares the same underlying structure as the spoon test. However, it is not very clear that "bringing the spoon" to the party is semantically learned or not. Therefore, it might not be classified as an episodic task to remember to bring the spoon to the party.

Suddendorf and Busby Grant (2005) examined preschooler's ability to avoid boredom in the future. In the experimental condition, children were required to stay in an empty room (Room A) which contained just a puzzle board. In the control group, children were again required to stay in Room A but without a puzzle board. Children stayed in Room A shortly, after that they were required to stay in another room (Room B). After another short stay in Room B, they were instructed that they would return to Room A and were asked to select an item (one of these items were the puzzle pieces) to bring with them from Room B. While the choices of 3-year-olds did not change, the 4- and 5-year-old selected the puzzle pieces notably more frequently than the ones in the control group. The authors conclude that the youngest children may be unable to act in the present in anticipation of a future state.

Another study by Atance and Meltzoff (2006) aimed to examine children's (3-, 4- and 5-year-olds) ability to anticipate future desire states. There were two groups in this study: children given pretzel to eat (pretzel group) and children not given pretzel (control group). For the next 12 minutes, the children were read stories by the experimenter during which the pretzel group was given the chance to eat pretzels. Then, all children were asked whether they wanted water or pretzels. The pretzel and control group were also classified with respect to a temporal dimension: in one of the pretzel groups and one of the control groups, children were asked to choose what they wanted right now, while in the other pretzel group and the other control group, they were asked to choose what they would want tomorrow. The results indicated that both of the control groups chose pretzels significantly more often than water. Children in the "pretzels+choice for now" group chose water instead of pretzels. And, children in the "pretzels+choice for tomorrow" group also chose water more significantly indicating that children had some difficulty overriding a current desire state to consider a future one in which they would not have that desire. However, this current desire could be hard to override for young children because it is a salient need for them. Therefore, using an unimportant need for these children at the time of decision could change the results of this study. For this reason, in our experiment, we do not ask children to select the answer of the given task from their physiological needs in our future-prediction task.

2.6 The Relation of Episodic Cognition to Other Areas of Cognition

In this section, some background information is summarized on different kinds of tasks that are related to episodic cognition, future thinking, future tense usage, counter-factual thinking, complex working memory, and incidental episodic memory questionnaires. This section is related to our own tasks and immediately precedes chapter 2 on "Methods" where detailed information on these tasks (stimuli and procedure) will be provided.

2.6.1 Future Tense Usage

Episodic future thinking and mental time travel are related to the linguistic expression of tense markers, especially future tense. However, this relation is not straightforward, due to young children's restriction in the use of linguistic markers for future tense.

Harner (1975, as cited in Atance, 2008a) investigated 2-, 3-, and 4-year-olds' understanding of the temporal terms "yesterday" and "tomorrow", by using a toy selection task. The results showed that two-year-olds did not understand these terms since they could not discriminate between the toys they had played with "yesterday" and the toys they will play with "tomorrow". At 3 years of age, children understand "yesterday" better than "tomorrow". Lastly, 4-year-olds could understand both past and future terms very well. These results are reminiscent of the findings by Busby Grant and Suddendorf (2005) on the developmentally earlier understanding of past as compared to future events in 3-5 year old children.

Future tense is expressed differently cross-linguistically. Turning from English to Turkish, in the following, language acquisition studies on Turkish will be reviewed. Turkish is known as a highly agglutinative language that uses separate and clearly distinguishable morphemes for expressing morpho-syntactic functions. Tense marking in Turkish is also expressed by dedicated morphological inflections, which, however, are not readily used by young children. Children are supposed to be in the “pre-inflectional period” after the “pre-linguistic period”. This period is characterized by the lack of overt grammatical marking. In this period, children’s first verbal constructions are either imperatives or infinitives (Aksu-Koç, 1988, as cited in Koyuncuoğlu, 2002). The next period is the period of inflections which begins within the second year. In this period, the “emergence of verb inflections and overt marking of the semantic distinction between modalized and nonmodalized utterances are seen” (Koyuncuoğlu, 2002:21). Olguin & Tomasello (1993, as cited in Koyuncuoğlu, 2002) found out that around 2½ and 3 years of age children noticeably use their language in a productive manner in diverse ways that show a grammatical category of verb. However, future tense is not used during this developmental period.

Temporal reference only emerges at around the second half of the third year (Aksu-Koç, 1988 as cited in Koyuncuoğlu, 2002) when children start to make distinction between the past, present and future tenses. In the following period, i.e., in the period of complex temporal reference, Aksu-Koç indicates that more complicated meaning relations are marked and more complicated syntactic structures are used.

Moreover, Aksu-Koç observed three 21-30 month-old children longitudinally so as to reveal the early inflectional development of Turkish. Then, she examined the differentiation of the tense-aspect-modality functions of the two past inflections cross-sectionally in communication tasks with sixty preschoolers between 3;0-6;4 years of age. One comprehension, three production and one combined production-comprehension tasks were carried out. The result showed that definite past, present progressive, and the optative marker indicating desire were the very first forms to be acquired by children.

In another study by Çapan (1988, as cited in Koyuncuoğlu, 2002), the acquisition of verb inflections was examined. The language of a Turkish girl was investigated between 15 and 26 months of age. The results indicated that during this period of her life, she had past, future, and progressive tense markers. Specifically, first, the definite past marker (-dI) was observed. Then, she produced the indefinite past marker (-mIş) in her speech at around age 2, but she did not use it productively. And then, the present progressive marker (-Iyor) was used at around 18 months of age. She did not use the aorist in any of her utterances, but the future tense marker (-AcAk) started to be seen at about 20 months of age.

Koyuncuoğlu (2002) studied the verb-tense acquisition process of Turkish preschoolers (age range: 2-6 years). She carried out three different tasks with children, i.e., story generation, story-telling, and structured play. The results showed that the production of future tense in the various age groups did not differ significantly from each other. She also found out that future tense was more often produced in story-telling and structured play sessions than in story generation.

In sum, the acquisition of tense markers, and, especially, of future markers in Turkish is a developmental challenge for young children due to the intricate morphological structure of Turkish. Furthermore, the Turkish tense system is intricately related to its mood and aspect system (see Aksu- Koç, 1988). It develops over a protracted period of time, from 2 to 6 years of age.

2.6.2 Counter-Factual Thinking Task

Counterfactual thinking is the ability to conceive of cases that may have happened, but did not happen in fact (German & Nichols, 2003). The initial signs of counterfactual thinking might become apparent during pretend play while children are in their second year of life (Amsel & Smalley, 2000, as cited in Guajardo & Turley-Ames, 2004; Rakoczy, 2008).

For Beck, Robinson, Carroll and Apperly (2006) the "reason to expect future hypotheticals and counterfactuals to be related in development" (p. 413) is that counterfactual cases are not only cases which did not happen in reality, but they could still have changed the current reality. Thus, the perception that several probable events might occur in the future forms the basis for both future hypothetical and counterfactual thoughts. Beck et al. (2006) also mention Byrne (1997) who highlights that counterfactual and actual possibilities are strongly related and that "counterfactuals are grounded in the factual reality from which they depart" (p. 108, as cited in Beck et al., 2006, p. 413). Beck et al. (2006) state that both counterfactual and future hypothetical tasks request children to refuse defining the current reality as it is. They continue that future hypotheticals are considered to be not a difficult task for young children than counterfactuals since counterfactual events are assumed to stand in for what might have happened in the past while future hypotheticals do not. For instance, Robinson and Beck (2000, as cited in Beck et al., 2006) used a toy road that has garages of its each end (for age group 3 and 4). In their experiment, a toy car starts in the middle of the toy road and then goes through one of these garages. There were two kinds of questions for the children: a future hypothetical one ("What if next time he drives the other way, where will he be?", p. 415) and a counterfactual one ("What if he had driven the other way, where would he be?", p. 415). As a result, most of the 3-4-year-olds answered correctly to the future hypothetical question; however, the counterfactual one was significantly more difficult for these children.

Moreover, Goldinger, Kleider, Azuma, & Beike (2003) found that counterfactual judgments of adults were directly operated if memory load was not varied. They continue that the processing of counterfactual is more restricted when there was a comparably high load of memory. In the same way, Turley-Ames and Whitfield (2000, as cited in Drayton, Turley-Ames, and Guajardo, 2011) observed that adults who have less WM resources spent more time when they processed counterfactual statements. Turley-Ames and Whitfield extend this observation and claim that some children who have less WM resources might show the same outcomes in a counterfactual thinking task.

Guajardo & Turley-Ames (2004) classify counterfactual thinking tasks as follows: (1) consequent tasks (which require subjects to change a consequence), and (2) antecedent tasks (which require subjects to change an antecedent). Although both task demands to suppress of children's current knowledge about the reality, some differences also exist. One of them is that the antecedent ones require them to both remember the result of the action and to develop some feasible antecedents to alter the result. However, the consequent ones are supposed to demand less executive functioning since children are just requested to remember the antecedent while they consider the information of the consequent.

Next, Roese (1994, as cited in Guajardo & Turley-Ames, 2004) categorizes counterfactual statements both according to direction (upward or downward) and structure (additive or subtractive). While upward counterfactuals compare the current situation to a better alternative antecedent, downward counterfactuals compare the current situation to a worse alternative antecedent. Additive counterfactual statements add an element to an antecedent, whereas subtractive counterfactuals delete an element. For instance, “if only the truck had not run the stop sign (p. 56)” would be subtractive but “if only I had kept my eyes on the road (p. 56)” would be additive.

Furthermore, Kavanaugh, Goodrich, & Harris (1995) conducted a study about children’s counterfactual thinking. They showed children a puppet that was placed in a bowl of water which made it wet. Then children were asked what would be the outcome when the antecedent condition had been different. Namely, they were asked to think of the puppet being put into a bowl of milk or a bowl of popcorn. And then, they were asked “what would have happened?”. Children (age range: 2-3) were able to discriminate between antecedent conditions which would not have caused the event of getting wet versus those which would have caused it.

Robinson & Beck (2000) mention a study in which children were given a counterfactual and future hypothetical test questions in a sorting task. In this sorting task, children were required to sort items with pictures on them and items without picture on them. In the picture/no picture sorting task, the children were introduced to a set of sorting items with pictures (e.g., rubbers, badges, cards) and two boxes which were used separating the items with and without pictures. At the beginning of the experiment, children were told to sort these items into these two boxes: the first box for the items with pictures and the second box for the items without pictures. Then the experimenter took a blank piece of paper from the second box, drew something on it and asked the children “where the paper should now go” (p. 103). Next, the experimenter asked a counterfactual reasoning question: “If I had not drawn on the piece of paper, which box would it be in?” (p. 103). In the corresponding future hypothetical question, the experimenter drew on a blank piece of a paper, put it in the first box, and then asked the child “If I rub out the drawing I just did, which box will the paper go in?” (p. 103). Riggs, Peterson, Robinson, & Mitchell (1998, as cited in Robinson & Beck, 2000) also conducted a similar study in which the experimenter did not really draw on the paper in the future hypothetical task, but asked children “If I draw on this piece of paper, which box will it go in?” (p. 103). In both studies, children were more successful in answering the future hypothetical questions than they were in the counterfactual one.

In another study, Robinson & Beck (2000) further investigated children’s counterfactual reasoning ability. In this study, children were given two counterfactual tasks which were narrated. In a narrative story, “Jenny paints a picture in the garden and leaves it on the garden table while she goes to school, when a wind blows it up into the tree” (p. 104). After each narrative story, the children were asked about a counterfactual physical state (e.g., “If the wind had not blown, where would Jenny’s picture be?” (p. 104) or “Pretend that the wind did not blow, where would the picture be?” (p. 104)). The results showed that children had no difference in answering both the questions with the “pretend” and with the “if-then” wordings. Robinson & Beck concluded that the difficulty in answering counterfactual reasoning question is not due to the wording of the questions.

German & Nichols (2003) also conducted a study on counterfactual thinking. They presented children with stories describing causal chains of several events. Then, children were asked counterfactual thinking questions related with the changes at different points in the chain of stories.

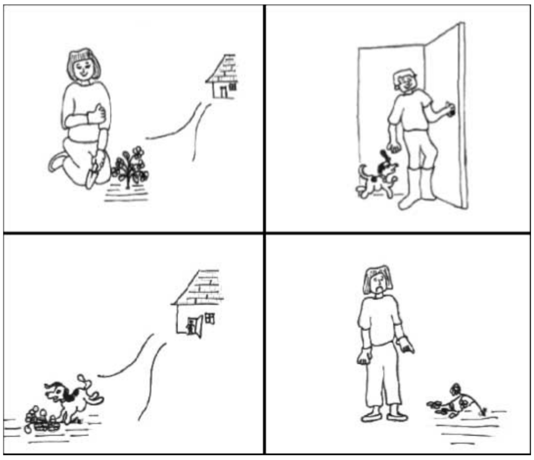

Figure 6 Pictures accompanying the ‘flower’ story in the experiment (German and Nichols, 2003:517)

In their task, German & Nichols (2003) have four different chains of pictures for a complete event. This event is described as follows (p. 517):

> 1. ‘Here is Mrs. Rosy. She’s just planted her new flower and she’s very happy with it. She calls her husband from the house to come and have a look.’
>
> 2. ‘When Mr. Rosy opens the door to come into the garden, the dog escapes from the kitchen.’
>
> 3. ‘The dog runs around the garden. Look he jumps on the flower and squashes it!’
>
> 4. ‘Now the flower is all flat, and Mrs. Rosy is sad.’

Then, all children were asked about short-medium-long inference condition questions (p. 517):

> *Short inference condition*: ‘What if the dog hadn’t squashed the flower, would Mrs. Rosy be happy or sad?’

Medium inference condition: 'What if the dog hadn't escaped from the house, would Mrs. Rosy be happy or sad?'

Long inference condition: 'What if Mrs. Rosy hadn't called her husband, would Mrs. Rosy be happy or sad?'

The results indicated that counterfactual reasoning ability is not only related with the inferential length of the problem, but also with the age of children: older children were more successful in answering these inference questions than younger ones.

In addition, in Beck, Riggs, & Gorniak (2009) study, three different measures were used in order to investigate counterfactual reasoning: short causal chains, location change counterfactual conditionals (like Robinson & Beck's (2000) wind blow story), and false syllogisms. The results indicated that children's performance on the counterfactual reasoning task was predicted by receptive vocabulary ability (The British Picture Vocabulary Scale) and inhibitory control (a child-friendly go/no go task). Beck, Riggs, & Gorniak (2009) also found no evidence that counterfactual thinking ability relates to the developments in working memory.

It was also mentioned in the literature (Ursu & Carter, 2005 & Baird & Fugelsang, 2004, as cited in Beck, Riggs, & Gorniak, 2009) that executive functions and counterfactual thinking recruit some similar areas in the prefrontal cortex.

Recently, a new term, "episodic counterfactual thinking" has been discussed by De Brigard, Addis, Ford, Schacter, and Giovanello (in press). Episodic counterfactual thinking is our ability to think about what could have happened in our past. In their experiments, De Brigard et al. asked the participants both to remember personal past events and to envision alternative outcomes to these events while undergoing fMRI. The results indicated that counterfactual thinking engages regions that form the core brain network (the network that is supposed to be useful for mental processes which is activated when participants are not busy with a target-oriented task (Raichle, MacLeod, Snyder, Powers, Gusnard, & Shulman, 2001)). According to Bar (2009), this is an associative network that derives predictions about possible future outcomes on the basis of analogies.

Counterfactual thinking is closely related to this study since it is connected to episodic past and future thinking (Van Hoeck, Ma, Ampe, Baetens, Vandekerckhove, and Van Overwalle, 2012). Van Hoeck et al. (2012) suggested: "To construct a counterfactual, key elements from past experiences need to be remembered (like episodic past thinking) and, crucially, some elements need to be recombined so that a novel imagined scenario can be constructed (like episodic future thinking)" (p.1). The counterfactual thinking task also includes some processes which are related to updating mental representations since one should update one's mental representations when one is asked a counterfactual question. Therefore, we will also study counterfactual thinking and discern the relation of this kind of thinking with episodic future thinking.

2.6.3 Working Memory

Episodic cognition, MTT and working memory (WM) are obviously related. In this section, this relation will be pointed out and possible WM tasks will be identified that might be capable of predicting episodic cognition. First, the history of the most widely used WM model, Baddeley's multi-componential model of WM, will be briefly summarized as it shows that an episodic component was only added quite recently.

The first working memory model was a model in which there were various components: the visuospatial sketchpad, the phonological loop, and the central executive (Baddeley and Hitch, 1974, as cited in Repovs & Baddeley, 2006). In brief, the phonological loop is dedicated to store and to manipulate phonological information, whereas visuospatial sketchpad is responsible for visual and spatial information in short-term memory. The central executive is devoted to control these two slave components.

A new component, the episodic buffer, was also added after various studies in the area of working memory (Baddeley, 2000, as cited in Repovs & Baddeley, 2006; see also Baddeley, 2003, 2012). It is assumed to be "a limited capacity store that is capable of multi-dimensional coding, and that allows the binding of information to create integrated episodes" (Repovs & Baddeley, 2006, p. 7). The episodic buffer is related to both the central executive and episodic long term memory.

In the current literature, the two broad research areas – the episodic memory system (i.e., studies inspired by Tulving's notion of episodic memory as one memory system) and working memory, especially episodic working memory (i.e., studies inspired by Baddeley's notion of the episodic buffer as a component of working memory) – have not really been related to each other. It is one aim of this study to establish such a broad link and to show that performance in both areas is intimately related to each other. More specifically, since episodic memory is directly related to the central executive, we also want to study the development of complex working memory (i.e., central executive) functions in relation with episodic memory. We would like to see any correlations between episodic memory and the central executive, since the capability to store and control information in memory increases significantly in the course of childhood (Gathercole, 1999; Courage & Cowan, 2009). Furthermore, episodic future memory has been linked to spatial memory abilities, such as the ability to imagine oneself in a different place in the future as compared to the present (Russell et al., 2010). In order to study the relation between episodic cognition and working memory, we therefore selected the Day/Night Stroop Task and the Corsi Block Tapping Test as representative working memory tests for executive and visuo-spatial abilities.

2.6.3.1 Day/Night Stroop Task

Gerstadt, Hong, and Diamond (1994) developed the Day/Night Stroop task specifically for overcoming the limitation of the standard Stroop task in which children has to read some material. In Day/Night Stroop task children are requested to respond to two pictures: one picture with a sun and the other picture with moon and start (see Figure 7). Children are required to say "night" when they are shown the card with sun and to say "day" when they are shown the card with moon and stars.

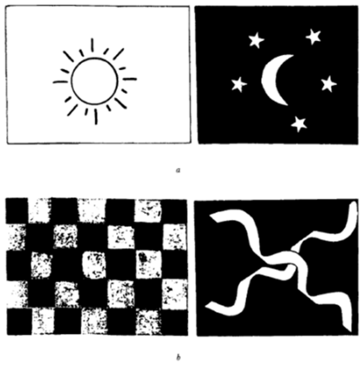

Figure 7 The stimuli used for the Day/Night Stroop Task. a. Cards used in the standard condition. b. Cards used for the control condition (Diamond, Prevor, Callender, & Druin, 1997: 54)

In their initial study, Gerstadt, Hong, and Diamond (1994) tested 240 normal, healthy children (age range: 3½-7). They did not include the age group 3, because the Day-Night Stroop task seemed to be hard for them. According to the results of the experiment, children <5 years had great difficulty in the Day/Night Stroop task. These children started out performing well, but then could not continue this over the whole session of 16-trials. Gerstadt et al. (1994) also indicated that the delay in response declines from 3½ to 4 years. If children under 4½ years are allowed to respond with very long latencies, they performed well.

It was also found that children under the age 5 had great difficulty to complete the Day/Night Stroop Task (Gerstadt, Hong, & Diamond, 1994). At first, these children started performing very well; however, they could not maintain this during the 16-trial session. Also, children under the age of 4.5 performed well when they were granted very long time to respond.

Moreover, Diamond & Taylor (1996) describe the Day/Night Stroop task as necessitating remembering two rules and exerting control over the response one is required to make. They state that the capacity to remember two rules and the capacity to prevent oneself from responding spontaneously improves between 3-6 years of age. They conclude that this improvement might represent significant development in the frontal cortex during this early childhood period (see also Bunge & Wright, 2007). Lastly, it has been found that the prefrontal cortex which is related with areas of executive functions like working memory, goal-planning, strategy selection, attentional control, and behavioral inhibition is active while executing the Day/Night Stroop task (Diamond, 2002, as cited in Montgomery & Koeltzow, 2010). Diamond (2002) stated that when the abstract stimuli (in Figure 7) were used in the experiment, children did not have any difficulty at all. Therefore, it can be inferred that learning and recalling the two rules required for the Day-Night Stroop task seems insufficient to be successful in this task. Diamond (2002) concluded that it is easier for young children to remember two rules and to inhibit saying what the pictures suggest as compared to pictures that are semantically related to the children's answer.

This task may be related to episodic memory and episodic future thinking tasks as these require the inhibition of the representation of a current situation/episode and the activation of a representation of a counter-factual past or future episode in which other states of affairs and other needs may prevail. At the same time, the representation of the present needs to be upheld as a temporal reference point for the mental time travel.

In summary, as Pasalich, Livesey, and Livesey (2010) claim, the Day/Night Stroop task taps into children's executive skills of inhibition as a part of their working memory (Carlson, Moses, & Breton, 2002; Diamond, Kirkham, & Amso, 2002; Simpson & Riggs, 2005, as cited in Pasalich, Livesey, and Livesey, 2010). This makes the task particularly suitable in the scope of our study.

2.6.3.2 Corsi Block-Tapping Task

The Corsi Block-Tapping Task is a simple but powerful test that is used by developmental and cognitive psychologists as well as clinical neuropsychologists (Berch, Krikorian, & Huha, 1998). This task was developed by Corsi (1972, as cited in Berch, Krikorian, & Huha, 1998) and it is a spatial counterpart for investigating verbal memory. Fischer (2001) also indicates that spatial memory is frequently determined by the outcomes of Corsi-Block Tapping task. In the literature, it was been shown that children's performance on the Corsi-Block Task increases with age (Logie and Pearson, 1997 as cited Pickering, 2001; Gathercole, 1999).

The Corsi Block-Tapping Task is generally used in order to measure the abilities of complex working memory and visuospatial short-term memory (Kessels, van den Berg, Ruis, & Brands, 2008). As Piccardi, Iaria, Ricci, Bianchini, Zompanti, & Guariglia, (2008) indicate: "It is suitable for studying short- or long-term memory, depending on the length of the sequence and the interval between stimulus presentation and response" (p. 128).

The Corsi-Block Tapping task includes nine blocks that are unevenly distributed on the board (23 x 28 cm). The numbers 1 to 9 are illustrated on one side of the block which is visible to the experimenter only.

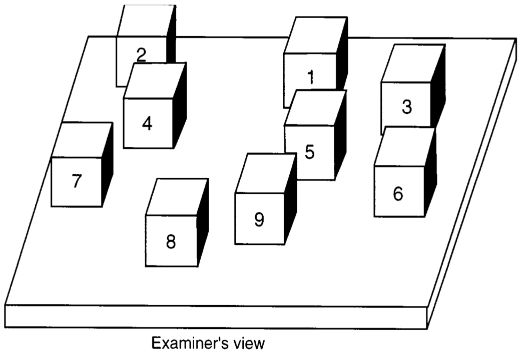

Figure 8 The original illustration of the Corsi apparatus

(Berch, Krikorian, & Huha, 1998: 319)

Some variations in display characteristics (color, size of the blocks, and display area) of the Corsi Block-Tapping task are allowed (Berch et al., 1998). For instance, the colors of blocks may be white (on a white board), or blue (on a yellow board). Block sizes may be 2.5 cm, 3 cm, 4.4 cm, or 4.5 cm. In addition, display area may vary from 20x25 cm, 22x28 cm, to 26x31 cm. The block-tapping rate may be one block per second, or 1.5 second, or one block every 3 seconds.

There are some methodological limitations of the Corsi Block-Tapping task. One of them is that the items are presented in incremental order. Although this procedure might be suitable for children or patients, the difficulty of the task may cause some biases while estimating the span. The other limitation is proactive interference. Since working on similar kinds of problems in memory could make the present item less explicit than previous items, it may lead to interference at the retrieval level and consequently spatial span might be underestimated.

For the evaluation of the Corsi-Block Tapping Task, Kessels et al. (2000) compute two scores for each participant. First, the Block Span is calculated in which the last correctly repeated block array's length is counted. Then, the Total Score, which is the product of the number of correctly repeated arrays and the Block Span until the task is finished, is calculated.

Lastly, Vandierendonck, Kemps, Fastame, and Szmalec (2004) state that the Corsi block-tapping task with a forward-recall order needs assistance not from the phonological loop but from the visuospatial sketchpad. They state that when the block sequences to be reproduced becomes longer than three or four items, then central executive resources are also requested.

In summary, this task is valuable in the scope of our study since visuo-spatial abilities may be correlated with the www task since the Corsi Block-Tapping Task has also what-where-when components. The "what" component would be a block that is tapped, the "where" component would be the exact place of that block on the board, and the "when" component refers to the serial order of the tapping event. Furthermore, spatial working memory abilities may be recruited in the Future-Prediction task.

2.6.4 Incidental Episodic Memory Questionnaires

Finally, there are studies that assessed episodic memory with a classical questionnaire. For instance in Holland & Smulders' study (see section 1.5.1), the participants were tested on a real-life test of episodic memory which includes unexpected questions about the context of each of two hiding occasions (e.g., "Was it raining when you came to the house?", "Was there a bike in the hallway?" (Holland & Smulders, 2011: 101)). These questions were unrelated to the actual www task. In total, 16 questions were asked about each hiding episode. In order to answer these questions, a link should be established between the questions and the occasion of the hiding event. Thus, some general memory would not be enough to answer the questions correctly. The results showed that the real episodic memory task significantly predicted the achievement in the www task. This means that the www task could have been solved by using episodic memories of the participants.

This task is valuable for our study since it assesses episodic memory in a more ecologically valid way, that is, in real-life contexts. Furthermore, it allows predicting and generalizing the results of the www-task.

CHAPTER 3

METHOD

3.1 Participants

In this study, there are three age groups (i.e., 3, 4, and 5 years). In total, 94 subjects (age group 3: 31 children, age group 4: 31 children, and age group 5: 32 children) have been studied. Descriptive statistics about the ages of the children and information regarding the number of subjects and the location of kindergartens is given below in Table 7 and Table 8.

Table 7 Descriptive statistics about children's ages (in months)

Age	Mean	Min.	Max.	S.E.
3	41,77	36	47	,569
4	53,35	48	59	,647
5	64,41	60	69	,462

Table 8 Information about the number of subjects and location of the kindergartens

Kindergarten	Name of the district	Number of subjects		
		Age: 3	Age: 4	Age: 5
Kindergarten #1	Gölbaşı	7	4	5
Kindergarten #2	Gölbaşı	6	5	7
Kindergarten #3	Eryaman	7	3	5
Kindergarten #4	Eryaman	6	11	7
Kindergarten #5	Etimesgut	5	8	8

Table 9 shows the education level of mothers and fathers as well as their occupation. Please note that only 32 of the 94 parents (34%) returned the questionnaire about the socio-economic background. However, even this limited set of data might give some clue about the general socio-economic and educational background of the families of our subjects. According to the information given in Table 8 and Table 9, it can be stated that the families of the children in this study are mainly coming from middle-level socio-economic background.

Table 9 Information about the education level and occupations of the parents

		Mothers	**Fathers**
Education Level	High school	17 (53.13%)	13 (40.63%)
	University	15 (46.87%)	19 (59.37%)
Occupation	Teacher	13 (40.62%)	10 (31.25%)
	Officer	9 (28.13%)	11 (34.37%)
	Self-employment	0 (%)	5 (15.63%)
	Doctor	2 (6.25%)	2 (6.25%)
	Other	8 (25%)	4 (12.50%)
	Overall	32(100%)	32(100%)

3.2 Experiments

In the following section, the tasks which have been developed for this study will be explained.

3.2.1 What-Where-When (www) Task

Material & Procedure

A middle-sized square carton box which is divided into nine subparts was used. Three items (out of six different items, i.e., a small ball, a small toy duck, a small toy car, a small toy saucepan, a small toy mobile-phone, a small toy doll) were hidden in these boxes by the children. In the experiment, the child is asked to select three items out of six items in order to hide them in the holes of the given box. After hiding all items, the child was required to recall the www's of the experiment: which items s/he hid, at which place in the box, and the serial order of the hiding event. The following instruction was used: "Can you find where we hid the toys? Which toy did we hide first? Where did we hide it? Which toy did we hide next? Where did we hide it? Which toy did we hide next? Where did we hide it?" ("Oyuncakları nereye sakladığımızı bulabilir misin? Önce hangi oyuncağı sakladık? Nereye sakladık? Sonra hangi oyuncağı sakladık? Nereye sakladık? Sonra hangi oyuncağı sakladık? Nereye sakladık?").

Figure 9 The carton box used in the www task

Figure 10 The items used in the www task

The dependent variables of this task were the total numbers of whats, wheres, and whens known by the child. The number of correct answers could range from 0 (minimum) to 3 (maximum) for each component (i.e., what, where, and when).

3.2.2 Future-Prediction Task

Material & Procedure

For this task, a mini–football game was used. In this game, for each game player, there are four sticks that are connected to the football players and there is one ball. In this game, the goal was to shoot the ball into the opponent's goal and to prevent the ball from going into one's own goal. Before the game began, each of the players, the experimenter and the child, wore a colored badge (either green or red) on his/her arm in order for the child to understand that s/he is a player of the team on one particular side. After the game was over, children were asked to select two out of six items (the pictures of a ball, a pair of football shoes, a whistle, a football t-shirt, a football hat, and a badge) that should be necessary to play the game on the other side on either after the game or the day after the child played the game. The following instruction was used for the "present" condition: "We are going to play football game one more time, but this time you are going to play on my side. Point to the two things you have to have to play football right now on my side." (Russell et al., 2010, p. 60) ("Futbol oyununu bir kez daha oynayacağız, fakat bu sefer sen benim tarafımda oynayacaksın. Benim tarafımda futbol oyununu oynayabilmen için gereken iki şeyi bana göster"). For the "future" condition, the following instruction was used: "Tomorrow, you are going to come back and we are going to play football. When you play football tomorrow, you are going to be on my side. So, point to two things you have to have to play football tomorrow on my side" (Russell et al., 2010, p. 62) ("Yarın, sen tekrar geleceksin ve futbol oyunu oynayacağız. Yarın futbol oyunu oynayacağın zaman, benim tarafımda olacaksın. Öyleyse, yarın benim tarafımda futbol oyununu oynayabilmen için gereken iki şeyi göster”).

Figure 11 Mini–football game

Figure 12 The pictures of items used in the future-prediction task

The correct answers to these questions are the ball (functional item), which is necessary for playing the game and “badges” (episodic item) which is necessary for indicating to which team on which side the child would then belong. According to Russell et al. (2010) episodic future thinking crucially involves some spatial cognition: the child must imagine herself playing the game on the other side next time (right now/tomorrow). If they do so, the likelihood would increase that they chose the badges which indicate to which team, now playing on the other side, the child and the experimenter would then belong, respectively. In that sense, the badges are the crucial episodic item.

The number of correct answers was determined, which could range from 0 (minimum) – 2 (maximum).

3.2.3 Story-Telling Task

Material & Procedure

In this task, 24 pieces of small pictures are used. The adventures of a girl named "Ayşe" are illustrated in these pictures (see Appendix A for all pictures used in this task). At the beginning of this game, the child was introduced to the girl "Ayşe". Then, three stories for each time-slot (i.e., yesterday, now, and tomorrow) were told to the child. The experiment is composed of 3 parts: two trainings and one test.

1) Training #1: Children are shown 3 different drawings and then asked about the situation in these pictures with the question prompts below the picture.

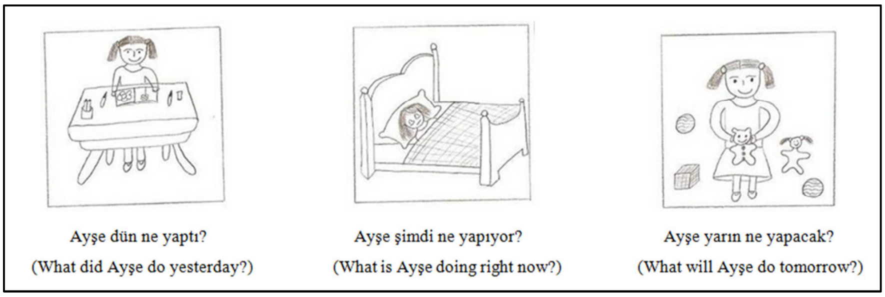

Figure 13 Examples of the story-pictures used in the story-telling task

2) Training #2: In this part, the children are again shown 3 different drawings and then asked about the situations in these pictures. However, this time, the temporal words "yesterday, today, and tomorrow" are not used. For example, the child is asked "Peki ya dün?" (What about yesterday?). If the child cannot understand and give an answer, then this question are followed by "…Ayşe ne yaptı?" (What did Ayşe do?).

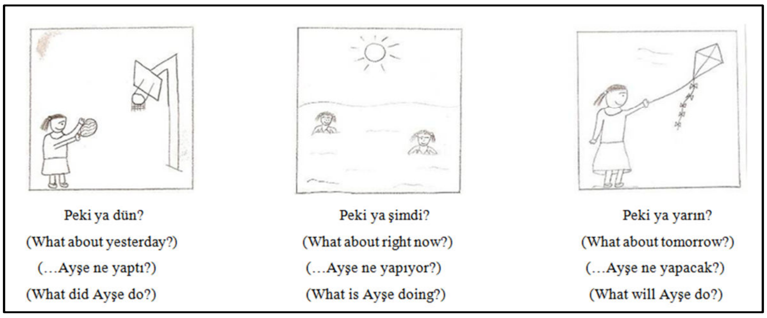

Figure 14 Examples of the story-pictures used in the story-telling task

3) Testing: In the testing session, the questions about the past, present, and future, e.g., "Peki ya şimdi?" (What about right now?) are asked to the children directly.

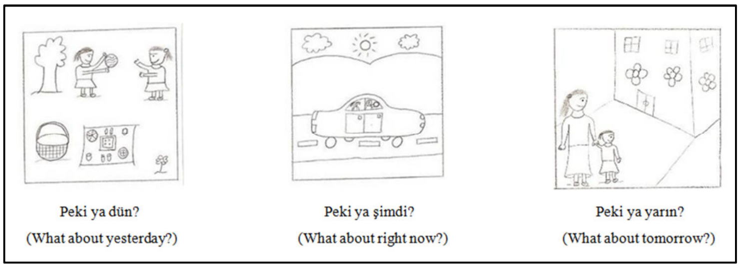

Figure 15 Examples of the story-pictures used in the story-telling task

The dependent variables of this task were the total number of past tense used, the total number of present tense used, and the total number of future tense used. However, mainly "the total number of future tense used" was used as the dependent variable. The minimum value for these variables was 0 and the maximum value was 8.

3.2.4 Counter-Factual Thinking Task

Material & Procedure

In this task, the children are given a total of 40 cards with pictures (like animals, fruits, etc.) on them and cards without pictures. Children are required to put the cards which have pictures on them in one box (first box) and the cards without pictures into another box (second box). And then, they are given the following questions in the following situations (only the second question is directly related to counter-factual thinking):

Figure 16 Pictures used in the counter-factual thinking task

1. The experimenter takes a blank piece of paper from the second box, draws something on it and asks the child: "Where should the paper now go?" (Robinson & Beck, 2000, p. 103) ("Bu kâğıt şimdi hangi kutuya gitmeli?")
2. Next, the experimenter asks: "If I had not drawn on the piece of paper, which box would it be in?" (Robinson & Beck, 2000, p. 103) ("Eğer bu kâğıda bir şey çizmeseydim, bu kâğıt hangi kutuda olacaktı?")
3. Again, the experimenter draws on a blank piece of a paper, puts it in the first box, and then asks the child "If I erase the drawing I just did, which box will the paper go in?" (Robinson & Beck, 2000, p. 103) ("Bu kâğıdın üzerine az önce yaptığım resmi silersem, bu kâğıt hangi kutuya gidecek?")

4. The experimenter takes a blank piece of paper from the second box and asks the child: “If I draw on this piece of paper, which box will it go in?” (Robinson & Beck, 2000, p. 103) (“Bu kâğıdın üzerine resim çizsem, bu kâğıt hangi kutuya gidecek?”)

Among these questions, the second one is a counter-factual reasoning question and the third one is the corresponding future hypothetical question. Also, the fourth one is a future hypothetical question.

The dependent variable of this task was the total number of correctly answered questions (minimum: 0, maximum: 4). However, the answer given for the question 2 was also used as a dependent variable (minimum: 0, maximum: 1).

3.2.5 Day-Night Stroop Task

Material & Procedure

In this task, two different cards were used. In one of the cards a bright sun is presented and in the other card there is a white moon. The measure of the cards is 13.5 x 10 cm (Diamond et al., 1997). During the task, children were required to respond “day” when a card with a moon were shown and to respond “night” when they are shown a card with a sun was shown. The experimenter presented the child a moon card and told the child that “When you see this card, I want you to say day” (Gerstadt et al., 1994, p. 134) (“Bu kartı gördüğün zaman gündüz demeni istiyorum.”). Then, the sun card was presented to the child and the experimenter instructed the child: “When you see this card, I want you to say night” (Gerstadt et al., 1994, p. 134) (“Bu kartı gördüğün zaman gece demeni istiyorum.”). After explaining the rule of the task, on the pretest, the experimenter shows a white sun card and waits for the child to respond with the right word. If the subject responds correctly, the subject is praised and then the experimenter shows a black moon card. If the subject again responds correctly, then these trials were counted as the first and the second test trials. If the subject responds incorrectly, these two trials were considered as practice and the experimenter reminds the subject of both rules, then the test begins. During the test, no feedback is given to the participant.

Totally, 16-trial sessions were given. The following order was used in the experiment: AB, BABAABBABAABAB (Simpson and Riggs, 2005). The dependent variable of this task was the total number of correct responses (minimum: 0, maximum: 16).

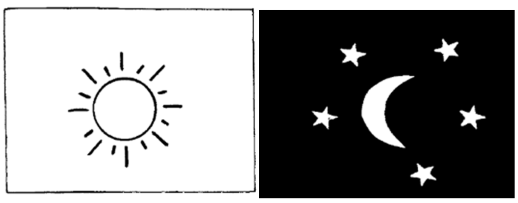

Figure 17 The stimuli used in the Day/Night Stroop Task

3.2.6 Corsi-Block Tapping Task

Material & Procedure

In the Corsi Block Tapping Task, a three-dimensional apparatus was used. In this apparatus, nine blocks were attached to the board nonsymmetrically. Also, these blocks were marked with numbers and they can only be seen by the experimenter. At the beginning of the experiment, the experimenter tapped a series of two blocks and the child was asked to repeat this sequence. The experimenter used the following instruction: "Now, I will tap some cubes gently and I want you to tap these cubes in the same order like me" (Kessels et al., 2000) ("Şimdi, bazı küplere yavaşça dokunacağım ve senin de bu küplere benim gibi aynı sırada dokunmanı istiyorum."). The length of the block sequences increased until the child fails to produce all trials of a given length. Also, the span score was calculated as the maximum number of block size (between 2-9) that can be recalled correctly and the total number of correct answers (between 1-88).

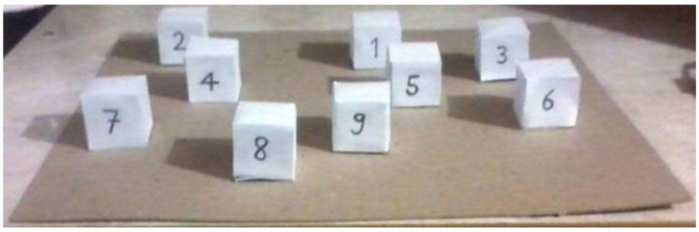

Figure 18 The stimuli used in the Corsi Block Tapping Task

The dependent variable of this task were the span size (minimum: 2, maximum: 9) and the total number of correctly recalled items (minimum: 0, maximum: 88).

3.2.7 The Classical Episodic Memory Questionnaire

Material & Procedure

In this task, a questionnaire including questions about things (or events) related to the testing sessions are used. The questions are asked after finishing all experiments. The full list of questions can be found in the Appendix A.

The dependent variables of this task were the total number of correctly answered "what" questions (minimum: 0, maximum: 3), the total number of correctly answered "where" questions (minimum: 0, maximum: 3), and the total number of correctly answered "when" questions (minimum: 0, maximum: 3). Also, the total of these three variables was used as a dependent variable (minimum: 0, maximum: 9).

3.3 Analysis of the tests

After the experiments had been conducted, a statistical data analysis was carried out on all tasks. Non-parametric tests were used because the results of Kolmogorov-Smirnov Test and Shapiro-Wilk Test indicated that the data was not normally distributed ($p < .05$). In addition, ANOVA was used when examining the interactions, because it is not possible to include more than one variable in non-parametric tests. For the predictions, hierarchical linear and logistic regressions were used.

3.4 Research Questions and Hypotheses

There are two main research questions of this study.

Research Question 1: "Could the working memory tasks (the Day/Night Stroop Task and the Corsi Block Tapping Task), counter-factual thinking task, story-telling task, and the classical episodic memory questionnaire predict the main tasks (www task and future-prediction task) of this study?".

Research Question 2: "How do the www task and the future-prediction task develop in preschoolers?". Apart from the development in the two main tasks, the development in the other tasks was also of interest.

The main hypothesis of the study is the following one:

- **H1**: The performance in the working memory tasks (Day/Night Stroop Task and Corsi Block Tapping Task), counter-factual thinking task, story-telling task, and episodic memory task (the classical episodic memory questionnaire) should predict the main tasks, i.e., the www task and the future prediction task.

With respect to the single tasks, we are interested in their development from 3-5 years of age:

The hypotheses for the www task are the following ones:

- **H1**: The performance in the www task should increase with age.
- **H2**: The "what" component of the www task should be recalled best, then the "where" and lastly the "when" component.
- **H3**: There might be an interaction between the age and the www components.

The hypotheses for the future prediction task are the following ones:

- **H1**: The performance in the future prediction task should also show developmental progression.
- **H2**: We should see a main effect of time for the present and the future condition such that the correct choice of the items: ball (functional item)

and badge (episodic item) is higher in the present than in the future condition.

- **H3**: There might be an interaction between the age and the tense factor in the future prediction task.

The hypothesis of the Day/Night Stroop task is the following one:

- **H1**: The performance of older children in the Day/Night Stroop task should be better than that of the younger ones, thus there should be main effect of age.

The hypothesis of the Corsi Block Tapping task is the following one:

- **H1**: The performance of older children in the Corsi Block Tapping task should be better than that of the younger ones, thus there should be main effect of age.

The hypothesis of the counter-factual thinking task is the following one:

- **H1**: The performance of younger children should be worse than the performance of older children in the counter-factual thinking task.

The hypothesis of the classical episodic memory questionnaire is the following one:

- **H1**: The performance of older children in the classical episodic memory questionnaire should be better than that of the younger ones, thus there should be main effect of age.

CHAPTER 4

RESULTS

Prior to the major analyses, the outcomes of all tasks were tested for any gender effects. However, as a result we found no statistically significant gender differences in the performance of the children, except in the counter-factual thinking task (only for question 2). In this task, boys performed slightly better than girls (p = 0.043). Since overall, gender effects were absent, we can safely assume that boys and girls behaved similarly in all tasks which will be presented now.

4.1 Main Tasks

4.1.1 www Task

In the www task, there are three items for each component (what-where-when). The three "what"-items determine whether the child was aware what toy s/he had hidden. The three "where"-items tell us whether the child remembered where s/he had hidden the toys. Finally, the three "when"-items indicate the serial order of hiding the toys. The total number of correct answers for "what" (minimum: 0, maximum: 3), the total number of correct answers for "where" (minimum: 0, maximum: 3), and the total number of correct answers for "when" (minimum: 0, maximum: 3) were summed up separately for each child (see Table 10 – 12 for means and standard deviations). Also, non-parametric tests (Kruskal-Wallis Test) were run separately for each *wh*-component. The results again indicated that they all developed significantly by the age factor.

Table 10 Descriptive statistics for the "what" component of the www task

	Age Group	N	Mean	Std. Error
The total number of whats	3	31	1,58	,129
	4	31	2,77	,076
	5	32	2,72	,103

Table 11 Descriptive statistics for the "where" component of the www task

	Age Group	N	Mean	Std. Error
The total number of wheres	3	31	1,13	,101
	4	31	2,06	,191
	5	32	2,66	,106

Table 12 Descriptive statistics for the "when" component of the www task

	Age Group	N	Mean	Std. Error
The total number of whens	3	31	,61	,120
	4	31	1,71	,198
	5	32	2,37	,125

A 3x3 mixed ANOVA (www (what, where, when); age: 3, 4, 5 years) was run. Age was used as a between subjects factor and within subject factor was www. The ANOVA results indicated that the www effect was significant (F (2, 90) = 41.978, $p < 0.01$, $\eta_p^2 = .483$). The "what" component was recalled (M = 2.358, SE = .061) better than "where" (M = 1.950, SE = .080) and "when" (M = 1.566, SE = .087) components. Planned contrasts revealed that, in particular, "what" was remembered better than "where" (F (1, 91) = 19.247, $p < 0.001$, $\eta_p^2 = .175$) and "when" (F (1, 91) = 81.209, $p < 0.001$, $\eta_p^2 = .472$). Also, it was found that age had a main effect (F (2, 91) = 56.517, $p < 0.001$, $\eta_p^2 = .554$). Specifically, 3-year-olds (M = 1.108, SE = .102) were less successful than 4-year-olds (M = 2.183, SE = .102) and 5-year-olds (M = 2.583, SE = .100). In addition, the www*age interaction was significant (F (2, 91) = 6.814, $p = 0.002$, $\eta_p^2 = .130$). More specifically, both the interaction www*age between "what" and "where" and between "what" and "when" were significant (F (2, 91) = 4.122, $p = 0.019$, $\eta_p^2 = .083$ and F (2, 91) = 6.673, $p = 0.002$, $\eta_p^2 = .128$). That is, 5-year-olds recalled "what" component (M = 2.719, SE = .104) better than 4-year-olds (M = 2.774, SE = .106) and 3-year-olds (M = 1.581, SE = .106). Again, 5-year-olds (M = 2.656, SE = .137) recalled "where" component better than 4-year-olds (M = 2.065, SE = .139) and 3-year-olds (M = 1.129, SE = .139). Also, "when" component was remembered by 5-year-olds (M = 2.375, SE = .150) better than 4-year-olds (M = 1.710, SE = .152) and 3-year-olds (M = .613, SE = .152).

Furthermore, we also compared the age groups according to their success in the www task (see Figure 19-21) with *post-hoc* tests (Bonferroni-corrected). The results showed that children significantly differ from each other at the age of 3 and 4 regarding "what" ($p < .001$), "where" ($p = .001$), and "when" ($p = .001$) components. Between age 3 and 5, again there were differences for all components ($p < .001$). However, the difference between age 4 and age 5 was not significant for the "what" component ($p > .005$) but significant for the "where" ($p = .009$), and "when" ($p = .007$) component. These results suggest that children significantly develop between 3 and 5 years of age regarding the three www components of episodic memory. More specifically, the "what" component develops between 3 and 4 years of age and reaches ceiling at 4; however, the "where" and "when" components start from lower levels at age 3 and develop throughout the entire observation period until 5 years of age, where the "where" component (almost) reaches ceiling, however, the "when" component not yet.

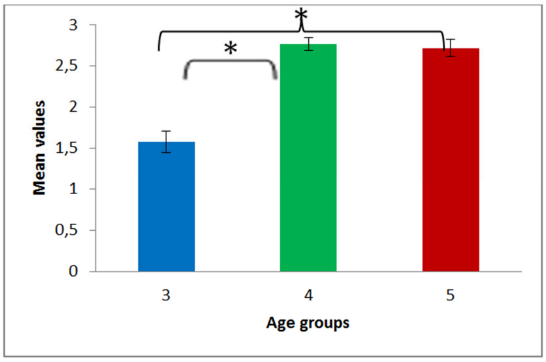

Figure 19 The development of the www task ("what" component)
(Error bars represent SEs)

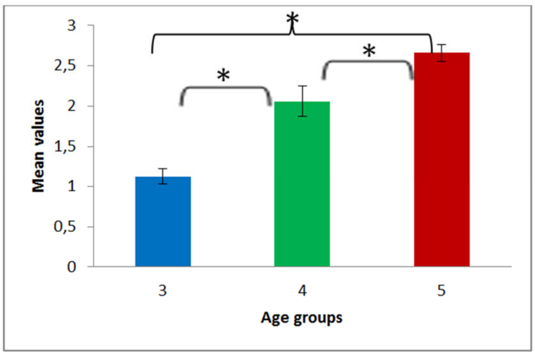

Figure 20 The development of the www task ("where" component)
(Error bars represent SEs)

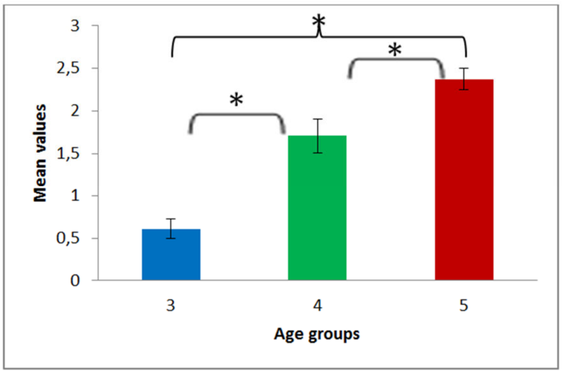

Figure 21 The development of the www task ("when" component)
(Error bars represent SEs)

From these results, it can be concluded that children developed in all three measures of the www experiment. Our results conform to the www experiment in Hayne & Imuta (2011) and Russell, Cheke, Clayton, and Meltzoff (2011).

All hypotheses regarding the www task were confirmed since the performance in the www task increased with age. In addition, the "what" component of the www task was recalled best, then the "where" and lastly the "when" component. There was also an interaction between the age and the www components such that the three components developed differently over time. By looking at Figures 19-21, it can be seen that there is a big step between 3 and 4&5 years, especially for the "episodic" where and when information. Thus, episodic cognition, as measured in the www task, clearly develops quantitatively over that period. However, against Tulving, we would not like to draw an "ontological", qualitative distinction between 3-year olds on the one hand and 4&5-year olds on the other hand in the sense that they belong to different kinds of "cognizers" – one kind without and one kind with episodic cognition. At least in the case of children (maybe not in the case of animals) there must be some continuity. Thus, we suggest that there is no sharp distinction between the ages of 3 and 4 in terms of episodic cognition but there exists some continuity. Moreover, there were also individual differences in the results of the www task. That is, while, as a group, the 3-year olds may still perform very poorly, there are some young children who can already do it. Therefore, we cannot claim that episodic cognition in 3 and 4 year olds is strictly different.

In addition, "where" information was easier in Hayne and Imuta's (2011) task than in our task since they used specific rooms in children's houses that the children may know easily. This contradicts the implicational hierarchy. The results, which component appears more difficult than which other, may therefore also depend on the specific settings of the task.

Furthermore, Hayne and Imuta (2011) had found a facilitation of the task in the non-verbal condition in which the children had to retrieve the objects in the order of their hiding as compared to the verbal condition in which the children had to state the three www's for each object. As compared to these two conditions, our task had verbal as well as non-verbal aspects. It may be considered more behavioral because any verbalization was embedded in the actual manipulation of the hiding apparatus which was in full sight during the response period. Furthermore, children could easily understand the questions regarding the www task since the wording used in this task was clear for them (see section 2.2.1 in the Method chapter) and the question words used in this task had already been acquired by children (for instance, children start to use the question word "nerede" (where) between 18 and 20 months of age (Yazıcı & Yaşar, 2006)).

To conclude, it can be said that the www task is a viable "operationalization" of the abstract concept of episodic memory in terms of the 3 www's. It is a fair task for young children from 3 years onwards allowing them to display their increasing episodic memory skills. The critical question about the "autonoetic" component is a separate question that is not addressed in this task. It is related to the construction of a notion of a "self" in the child which can be assumed to develop throughout this period as well.

4.1.2 Future-Prediction Task

In the future-prediction task, in order to be successful in the game, the correct answers are "ball" (top), the functional, semantic item, and "badge" (kurdele), the episodic item. Therefore, a child could have zero, one, or two correct answer(s) for this task (i.e., minimum: 0, maximum: 2). In two subsequent analyses, the answer "ball" and the answer "badge" were also used as a separate single dependent variable in this task (minimum: 0, maximum: 1).

There were two between-subjects variables in the future prediction task: age (3, 4, 5 years) and "time" (present, future). The question which items s/he would like to choose in order to play the game on the other side was asked to the child either for present tense ("şimdi" ("right now")) or future tense ("yarın" ("tomorrow")).

In the following, the results of the two-factorial ANOVAs for the total score of the two items (ball and badges) and then separately for each item (ball, badges) are presented. First, we conducted a two-factorial ANOVA with age and time (present or future tense) as independent variables and the total number of correctly chosen items (ball, badges) as dependent variable. The results indicated that age was a significant factor (F (2, 88) = 17.871, p < .001, η_p^2 = .289) which means that children's responses developed over time regarding the future-prediction task. The future-prediction task of Russell, Alexis, & Clayton (2010) also yielded similar test results. In more detail, 3-year olds' score (M = .68, SE = .126) was lower than 4-year olds' (M = 1.19, SE = .097) which again was lower than 5-year olds' (M = 1.50, SE = .090).

In addition, both the time variable (present or future tense) (F (1, 88) = 6.778, p = .011, η_p^2 = .072) and the age*time interaction (F (2, 88) = 3.348, p = .040, η_p^2 = .071) were significant. In the present tense condition, the two correct items were mentioned to a higher extent (M = 1.27, SE = .092) than in the future condition (M = 1.00, SE = .101). That means, the responses of the children changed according to the time condition and the way in which answers were affected by age was also different in two tense conditions (i.e., present and future). More specifically, the slope of the increase in the future condition across age (which developed from 3 years (M = .33, SE = .126) to 4 years (M = 1.06, SE = .135) to 5 years (M = 1.53, SE = .125)) was steeper than in the present condition (which developed from 3 years (M = 1.00, SE = .183) to 4 years (M = 1.36, SE = .133) to 5 years (M = 1.47, SE = .133)). The two main effects and their interaction are shown in Figures 22-24.

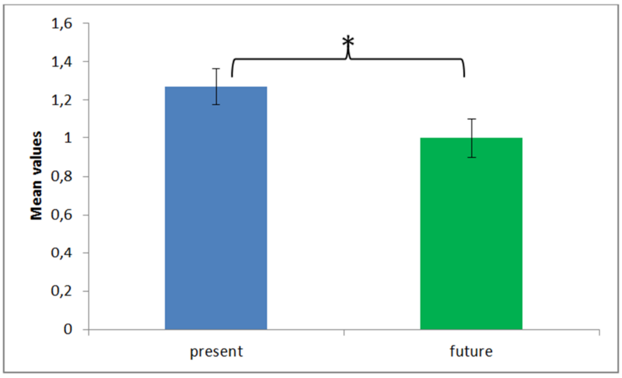

Figure 22 The development of the future-prediction task (total): time effect (Error bars represent SEs)

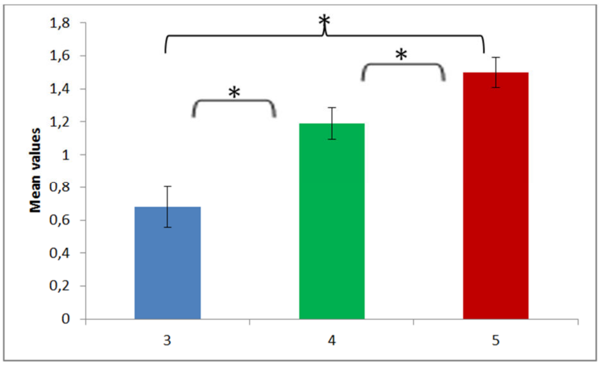

Figure 23 The development of the future-prediction task (total): age effect (Error bars represent SEs)

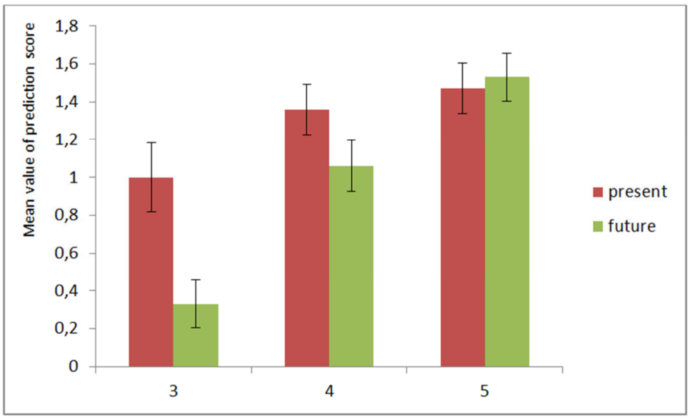

Figure 24 The development of the future-prediction task (total): interaction between age*time (Error bars represent SEs)

Moreover, we ran an ANOVA with age and time (present or future tense) as independent variables and the correctly chosen functional item (ball) as dependent variable. The results indicated that age was a non-significant factor (F (2, 88) = .562, p = .572, η_p^2 = .013) which means that children's response did not developed over time for this item in the future-prediction task. Overall, 3-year olds' scores (M = .52, SE = .091) were not different from 4-year olds' (M = .61, SE = .089) and 5-year olds' (M = .62, SE = .087). (Non-parametric tests were also run and the same non-significant outcome was found). In addition, the time variable (present or future tense) was not significant (F (1, 88) = 1.581, p = .212, η_p^2 = .018) either. However, the age*time interaction was significant (F (2, 88) = 5.433, p = .006, η_p^2 = .110). That means, the way in which answers were affected by age was different in the two tense conditions (i.e., present and future). Whereas in the present condition the mentioning of the ball is stable for 3-year olds (M = .75, SE = .112) and 4-year olds (M = .71, SE = .125), it slightly decreases for 5-year olds (M = .47, SE = .133). In the future condition, however, the mentioning of the badges linearly increases from 3 years of age (M = .27, SE = .118) over 4 years (M = .53, SE = .125) to 5 years (M = .76, SE = .106). These results are shown in Figure 25.

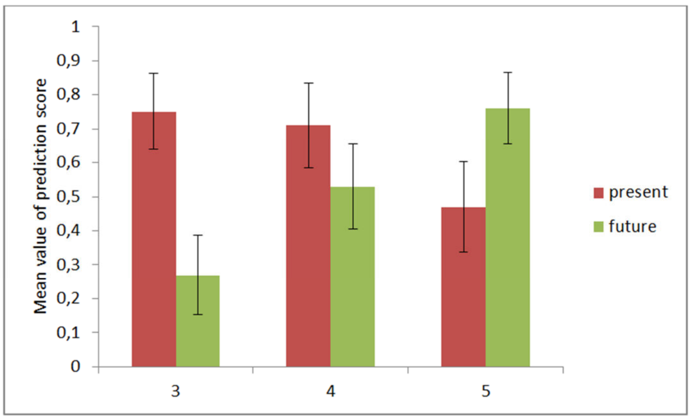

Figure 25 The development of the future-prediction task (ball): interaction between age*time (Error bars represent SEs)

Furthermore, we also ran an ANOVA with age and time (present or future tense) as independent variables and the correctly chosen episodic item (badges) as dependent variable. The results indicated that age was a significant factor (F (2, 88) = 25.317, $p < .001$, $\eta_p^2 = .365$) which means that children's responses for the episodic item "badges" developed over time in the future-prediction task in general. Three-year old children enumerated the badges less often (M = .16, SE = .067) than four-year olds (M = .58, SE = .090) and five-year olds even more often (M = .87, SE = .059). As contrasts revealed, all age differences were significant. In the present condition, the mentioning of the badge significantly changed between 3-year olds (M = .25, SE = .112), 4-year olds (M = .64, SE = .133), and 5-year olds (M = 1.00, SE = .00). In the future condition, the mentioning of the badges also linearly increases from 3 years of age (M = .07, SE = .067) over 4 years (M = .53, SE = .125) to 5 years (M = .76, SE = .106).

Table 13 Descriptive statistics for the future-prediction task (badge)

	Age Group		N	Mean	Std. Error
Future-prediction task (badge)	3	present	16	,250	,112
		future	15	,070	,067
	4	present	14	,640	,133
		future	17	,530	,125
	5	present	15	1,000	,000
		future	17	,760	,106

In addition, the time variable (present or future tense) was significant (F (1, 88) = 4.482, $p = .037$, $\eta_p^2 = .048$). Children in the present condition enumerated the badges more often (M = .62, SE = .073) than children than children in the future condition (M = .47, SE = .072). The age*time interaction was not significant (F (2, 88) = .178, $p = .837$, $\eta_p^2 = .004$). This might mean that the responses of children changed according to the type of the question, but the way in which answers were affected by age was not different in two tense conditions. In the present condition the mentioning of the badge changed significantly between 3-year olds (M = .250, SE = .101) and 4-year olds (M = .643, SE = .108), and 5-year olds (M = 1.000, SE = .105). In the future condition, the mentioning of the badges linearly increases from 3 years of age (M = .067, SE = .105) over 4 years (M = .529, SE = .098) to 5 years (M = .765, SE = .098). These results are shown in Figure 26.

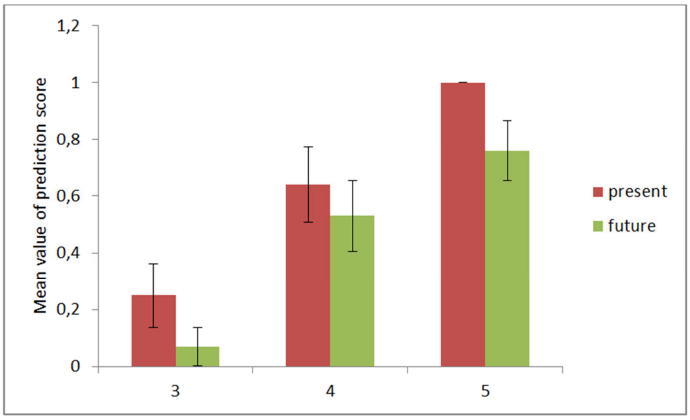

Figure 26 The development of the future-prediction task (badge): interaction between age*time (Error bars represent SEs)

In addition, a non-parametric Mann-Whitney test was run in order to test the difference between present and future tense. The results showed that in the age group 3 there was a significant difference between the answers for present and for future (Z = -2.599, p = .009). However, for the age group 4 (Z = -1.476, p = .140) and the age group 5 (Z = -.349, p = .727) there was no significant difference. Therefore, it can be stated that after the age of 3, no significant development occurs between present and future tense for the other age groups. Note, however, that at the ages of 4 and 5 the scores in the present condition are still numerically higher than the scores in the future condition.

The hypotheses regarding the future-prediction task were also confirmed since the performance in the future prediction task showed developmental progression. There was a main effect of time and there was an interaction between the age and the time factor.

The results of the future-prediction task provide good evidence for the development of episodic future thinking in children since it shows the same development as Russell et al.'s (2010) episodic item ("step"): it is related to the perspective (standing on the other side) (see section 1.5.3 in Literature Review chapter). However, it could also be the case that as children grow older they are more aware of not only salient functional items (such as the "ball") but also less salient items such as the episodic item "badges".

As observed in the experiment, children chose the ball first quickly, which indicates that it is a salient item related to the "football" domain. The younger ones chose the second item also quickly if it was not the badge. However, children choosing the badge, which are mostly older children, thought for a while and only then chose the badge. This observation may indicate that they may engage in mental time traveling or reasoning processes related to the episodic item. The time they need for thinking may indicate inhibition of the "obvious" semantic items which are suppressed so that the less obvious episodic item can be chosen. Older children even asked if the badges needed to be changed, which may indicate that they were aware that with the changed context also this item needed to be changed, accordingly.

Interestingly, the ball was mentioned less often in the 5-year olds. The reason might be that they know more about football so that they may therefore enumerate other items (e.g., football shoes, and football t-shirt) as well. These items become stronger competitors for the "ball" item in the selection process. A good piece of evidence, however, that the older ones make a clear distinction between the semantic item(s) and the episodic item is that older ones who did not choose "ball" but another football-related item, did not choose the second football-item on the expense of the episodic item but substituted the semantic item "ball" with another semantic item, while keeping the episodic item.

Lastly, the fact that "time" showed a main effect and did not interact with age means that future thinking is effortful for all children within that age range. They always enumerate badges more often in the present condition than in the future condition. This effort is still considerable for even the 5-year olds. Clearly, the development has not finished at that age yet.

4.1.3 Relation between the two main tasks

In this section, the correlation between the two main tasks is discussed. There was a clearly significant correlation between the www task (total score) and future prediction task (total score) (Pearson's r = .463, R^2 = .27, p < .001). The correlation between the www task (total) and the future prediction task (badge) was also significant (Pearson's r = .531, R^2 = .28, p < .001). The two main tasks clearly share variance with each other (27 %), that is, they are clearly related with each other. This is expected because they are both about "episodic cognition", however, they are also separate tasks, representing different aspects of episodic cognition: the www representing the representational content ("what") and context ("where", "when") of an item, and the future prediction task the mental time travel aspect.

The future-prediction task and the www task capture different but related aspects of episodic cognition: www captures the main dimensions of episodic cognition (not specifically future oriented but in general "episodic") whereas future prediction captures the future dimension of episodic cognition and the mechanism by which it operates: mental time travel. As has been reported in the literature (see section 1.3 in the Literature Review chapter), there is a considerable overlap between past episodic memory, future episodic memory and MTT; thus, there should be a strong correlation between them. Russell et al. (2010) also review that there is a major overlap in the brain areas when subjects are required to remember episodes and imagine future events.

4.2 Additional Tasks

4.2.1 Day/Night Stroop Task

In the Day-Night Stroop Task, the number of correctly answered cards (minimum: 0, maximum: 16) was counted. As a result of a univariate ANOVA, it was found that there was a significant difference between the age groups (F (2, 91) = 75.282, $p < .001$, $\eta_p^2 = .623$). Overall, the performances of 5-year-olds size (M = 15.06, SE = .220) were better than 4-year-olds size (M = 12.03, SE = .421) and 3-year-olds size (M = 9.45, SE = .307). Also, the results were significant when non-parametric tests were run.

Table 14 Descriptive statistics for the Day-Night stroop task

	Age Group	N	Mean	Std. Error
Day/Night Stroop Task	3	31	9,45	,307
	4	31	12,03	,421
	5	32	15,06	,220

Moreover, we also compared the age groups according to their success in the Day/Night Stroop task (see Figure 27). The results of *post-hoc* tests (Bonferroni-corrected) showed that there was a significant difference between age 3 and age 4 ($p < .001$), age 3 and age 5 ($p < .001$), and age 4 and age 5 ($p < .001$). This indicates a linear development of the Day/Night Stroop task in pre-school children. At 5 years of age, children have mastered it fully.

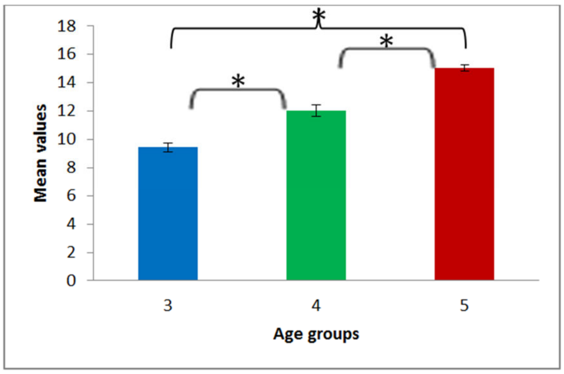

Figure 27 The development of the Day/Night Stroop task (Error bars represent SEs)

The Day-Night Stroop task shows steady development over 3-5 years where it reaches ceiling which also confirmed our hypothesis about this task. This finding is also consistent with the literature (Gerstadt et al., 1994 and Simpson & Riggs, 2005). Although Gerstadt et al. (1994) state that the Day-Night Stroop task might be hard for children since they both need to remember the two rules (sun-night; moon & stars-day) and suppress the familiar rule (sun-day; moon & stars-night), our finding of a smooth and successful development indicate that children, across the observed age range master this task well.

4.2.2 Corsi-Block Tapping Task

In the Corsi Block Task, both the span length (minimum: 2, maximum: 9) and the total number of correct answers (minimum: 1, maximum: 88) were calculated (see Table 15-16 for descriptive statistics). The results of a univariate ANOVA indicated that span size increased significantly ($F (2, 91) = 18.006$, $p < .001$, $\eta_p^2 = .284$). While 3-year olds' span size (M = 2.00, SE = .000) was equal to that of 4-year olds (M = 2.00, SE = .000), 5-year olds' was higher (M = 2.38, SE = .087). These findings are also consistent with the literature (Logie and Pearson, 1997 as cited in Pickering, 2001). Also, the total number of correct answers increased significantly by age according to a univariate ANOVA ($F (2, 91) = 46.266$, $p < .001$, $\eta_p^2 = .504$). 3-year olds' tapped less items (M = 4.03, SE = .032) than 4-year olds (M = 4.87, SE = .145), who tapped less items than 5-year olds (M = 7.28, SE = .397). Non-parametric tests were also run and the same significant outcome was found.

Table 15 Descriptive statistics for the Corsi-Block tapping task (span length)

	Age Group	N	Mean	Std. Error
Corsi-block tapping task - span length	3	31	2,00	,000
	4	31	2,00	,000
	5	32	2,38	,087

Table 16 Descriptive statistics for the Corsi-Block tapping task (total number of correct answers)

	Age Group	N	Mean	Std. Error
Corsi-block tapping task –	3	31	4,03	,032
total #of correct answers	4	31	4,87	,145
	5	32	7,28	,397

Figures 28-29 show that the Corsi-Block Tapping task develops just from 4 years onwards but not yet between the ages 3-4. This might indicate that the performance of children in this task is stable at a low level – at which they can point to no more than two subsequent spatial locations correctly – until age 4 and then shows a sudden development, in particular, when the total number of correct answers is considered.

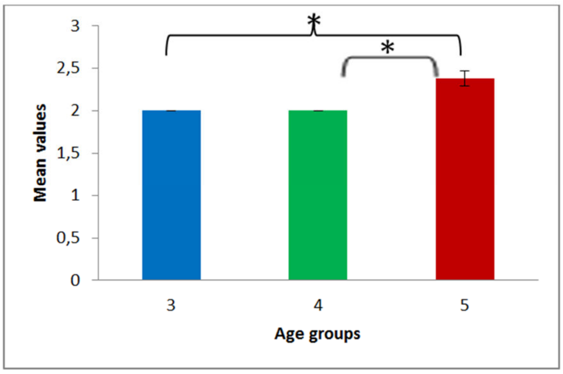

Figure 28 The development of the Corsi-Block Tapping task (span length) (Error bars represent SEs)

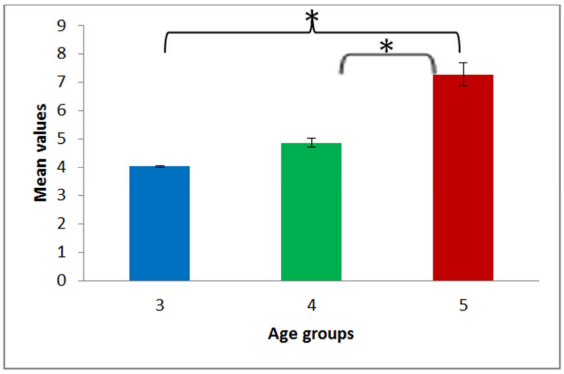

Figure 29 The development of the Corsi-Block Tapping task (total # of correctly recalled items) (Error bars represent SEs)

Our hypothesis about the Corsi-Block Tapping task was also confirmed since children showed significant development between 3-5 years of age. In particular, the Corsi-Block Tapping task shows no development between 3 and 4 but then a sudden but not too strong development occurs between 4 and 5. The development in the Corsi-Block Tapping task might be either due to an increase in the capacity of the visuospatial sketchpad or a change in strategic activity (Pickering, 2001).

The Corsi-Block Tapping task might be hard for children since they may not really understand what they should do in the task, especially young children. Without having fully understood what they had to do they just tapped some sequence in the experiment. It may actually be an "odd" task for younger ones because the task is not "about" something (all these blocks are the same), it is only "about" the places and the sequence – information which, as was shown in the www task – is not in the focus of their attention. It is like taking out the most prominent feature, the "what" feature, from the hierarchy, and urge them to concentrate on the less prominent ones, "where" and "when". Another way to explain the hardness of the task could be in terms of the 2 different number systems (Feigenson, Dehaene, & Spelke, 2004): (1) exact number (in adults up to 4, however, in children only 1 or 2), (2) approximate number (for higher numbers than in the first system). As long as the number of boxes does not exceed the capacity of children's system (1), they can easily do the experiment; however, if it exceeds it, then they have to resort to system (2) which will not help them because it is approximate but they need specific information. Alternatively, they have to invoke a language strategy such as rehearsal. They may engage in verbal strategies such as counting or silently rehearsing: there – there – there ... or "right", "up", etc. This may help them to handle longer sequences. The younger ones may not yet have rehearsal in their repertoire, however.

In the literature, children's performance on the Corsi Block Tapping task has also been reported to increase with age (e.g., Logie and Pearson, 1997). In addition, Gathercole (1999) indicated that generally, in this task memory performance increases in a steep manner up to eight years of age.

4.2.3 Story-Telling Task

In the story-telling task, the total number of future tense used (minimum: 0, maximum: 8) significantly developed according to the results of a univariate ANOVA ($F(2, 91) = 21.627$, $p < .001$, $\eta_p^2 = .322$, see also Table 17 for means and standard errors). 3-year olds' use of future tense was quite low (M = .87, SE = .159) as compared to that of 4-year olds (M = 3.00, SE = .417) and 5-year olds (M = 3.56, SE = .284). Also, the results were significant when non-parametric tests were run.

Table 17 Descriptive statistics for the story-telling task (future)

	Age Group	N	Mean	Std. Error
Story-telling task - future	3	31	,870	,159
	4	31	3,000	,417
	5	32	3,560	,284

We also compared these age groups with respect to their success in the story-telling task (see Figure 30). The results indicated that children developed significantly between the ages 3-4 and 3-5 but not between 4-5 years of age. However, they still showed a numerical increase in usage of future tense. This may indicate that the ability of children to use future tense in their sentences increases dramatically from 3 to 4 and then increases only slightly until the age of 5.

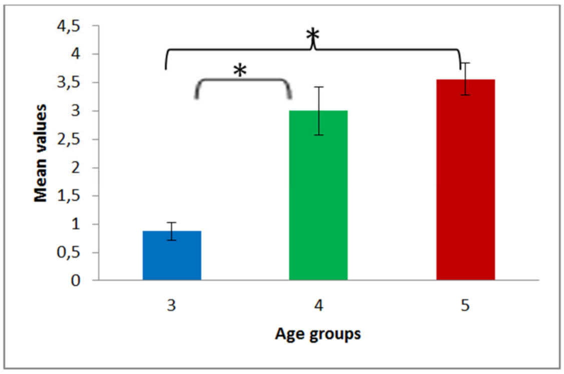

Figure 30 The development of the story-telling task (total # of future tense used) (Error bars represent SEs)

The hypothesis concerning the story-telling task was also confirmed since it significantly developed from almost zero at the age of 3. However, it does not reach ceiling even in the oldest age group (max. = 8, however, at 5 years, an average score of 3.5 is reached). The reason behind this finding may be that "present tense" is always an option (default) for answering the future question. But still it could be claimed that those who have a higher score in this task can also represent and distinguish the three tenses: past – present – future (in particular future) better than those with a lower score.

In addition, as Çapan (1988) states the future tense marker (-AcAk) is started to be observed at about 20 months of age; however, this study and also Aksu-Koç's study (see section 1.6.1 in the Literature Review chapter) were only case studies and our task was – to the best of our knowledge – the first one that tested usage of future tense suffixes in Turkish children of 3-5 years with a bigger group of children at various ages. Despite the fact that the present tense marker is used frequently in this task, the effect of the usage of the future tense marker could be seen readily in the developmental progression from 3 to 5 years.

4.2.4 Counter-factual Thinking Task

In the counter-factual thinking task, a total of 4 questions were asked: (1) positive present-related; (2) counter-factual past; (3) negative future; and (4) positive future. Hence, a maximum of 4 points could be reached (minimum score: 0, maximum score: 4). The result of a univariate ANOVA indicated that overall, for all four questions, children's ability to reason counterfactually developed significantly (F (2, 91) = 63.578, $p < .001$, $\eta_p^2 = .583$). 3-year olds' total scores were quite low (M = 1.42, SE = .121) as compared to that of 4-year olds (M = 3.03, SE = .157) and 5-year olds (M = 3.34, SE = .106). More specifically, children's scores also increased in the same way in the second question which was directly related with counter-factual thinking (see also Figure 32; F (2, 91) = 24.060, $p < .001$, $\eta_p^2 = .346$). Also, the results were significant when non-parametric tests were run. These findings are also consistent with the literature (German & Nichols, 2003).

Table 18 Descriptive statistics for all 4 questions of the counter-factual thinking task

	Age Group	N	Mean	Std. Error
Counter-factual thinking task	3	31	1,420	,121
	4	31	3,030	,157
	5	32	3,340	,106

Table 19 Descriptive statistics for the counter-factual thinking task (for question #2)

	Age Group	N	Mean	Std. Error
Counter-factual thinking task	3	31	,030	,032
	4	31	,610	,089
	5	32	,690	,083

Figures 31-32 show the total results and the result for only the question #2 (related directly to counter-factual thinking), respectively. The results indicate that counter-factual thinking develops between age 3 and 4, but only slightly further between 4 and 5. At age 3 they can hardly reason counter-factually, in particular not in question 2, which hardly any of the youngest children could answer correctly. This may show that between the ages of 3 and 4 children rapidly and almost fully comprehend the basics of counter-factual thinking and thus there might only be some slight further development for this task between the ages of 4 and 5, like in the story-telling task.

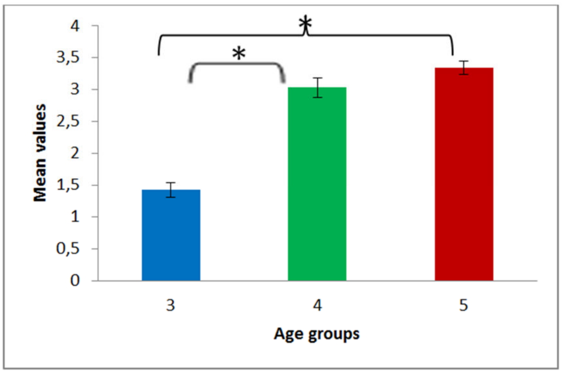

Figure 31 The development of the counter-factual thinking task (total)
(Error bars represent SEs)

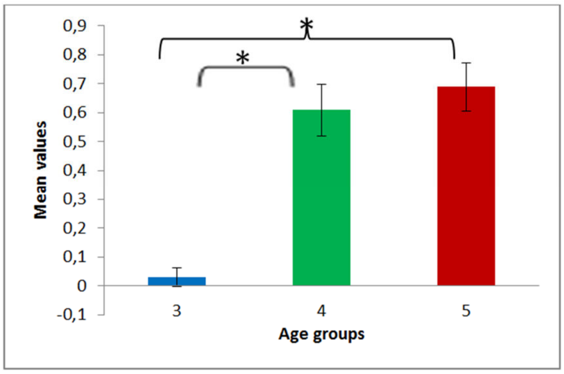

Figure 32 The development of the counter-factual thinking task (2nd question)
(Error bars represent SEs)

We also ran a mixed ANOVA in order to study the effect of all four questions and their interactions with age. As a between subjects factor age was used and question type was a within-subject factors. According to the ANOVA results, the effect of question type was significant (F (3, 89) = 25.398, p < 0.001, η_p^2 = .218). Question #1, which is about the present and which therefore serves as a kind of "baseline", was always answered more correctly than the other questions. That is, question #1 (M = .915, SE = .029) was answered correctly more than question #3 (M = .646, SE = .035), question #4 (M = .593, SE = .046), and question #2 (M = .444, SE = .042). In addition, the interaction between the question type and age was also significant (F (6, 273) = 8.265, p < 0.001, η_p^2 = .154). More specifically, when the first question, which is about the present is compared to the other questions, all interactions were significant (between question #1 and question #2: F (2, 91) = 27.213, p < 0.001, η_p^2 = .374; between question #1 and question #3: F (2, 91) = 8.276, p < 0.001, η_p^2 = .154; between question #1 and question #4: F (2, 91) = 24.313, p < 0.001, η_p^2 = .348). That is, 5-year-olds (M = .937, SE = .050) answered question #1 better than 3-year-olds (M = .935, SE = .051) and 4-year-olds (M = .871, SE = .051). 5-year-olds (M = .687, SE = .072) also answered question #1 better than 4-year-olds (M = .613, SE = .073) and 3-year-olds (M = .032, SE = .073). For question #3, the performances of 5-year-olds (M = .906, SE = .060) were better than 4-year-olds (M = .871, SE = .061) and 3-year-olds (M = .161, SE = .061). Lastly, for question #4, the performances of 5-year-olds (M = .812, SE = .079) were better than 4-year-olds (M = .677, SE = .080) and 3-year-olds (M = .290, SE = .080). This means that the difference between answering question #1 versus all other questions changed across age, as can also be seen in Figure 33:

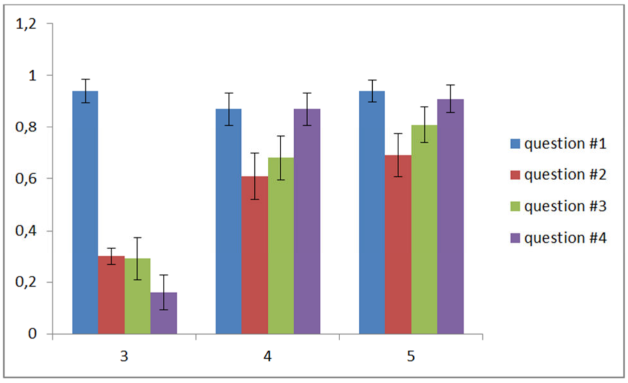

Figure 33 The development of the counter-factual thinking task (all questions #1-4) (Error bars represent SEs)

The hypothesis regarding the counter-factual thinking task was also confirmed since it developed significantly. Counter-factual thinking seems to develop from very low values to high values but does not yet reach ceiling at 5 years yet. This is also consistent with the literature (Guajardo & Turley-Ames, 2004). Especially the results for the question #2 (counterfactual question) develops from almost zero and suddenly jumps to a higher score between 3 and 4 years. It was observed that the future hypothetical question was answered more correctly than the counterfactual one (see Figure 33). This finding is also consistent with the literature (Robinson & Beck, 2000 and Riggs, Peterson, Robinson, & Mitchell, 1998).

The following monthly graph also indicates that there is a somehow step-wise development although the graph is scaled according to the age of children in months. More specifically, 3-year old children until the age of 46-47 months cannot succeed in the task at all. Any noteworthy development starts after a jump from practically no success to moderate success from 48-49 months onwards, increases continuously until 56-57 months of age, but after then it decreases a little and then stabilizes.

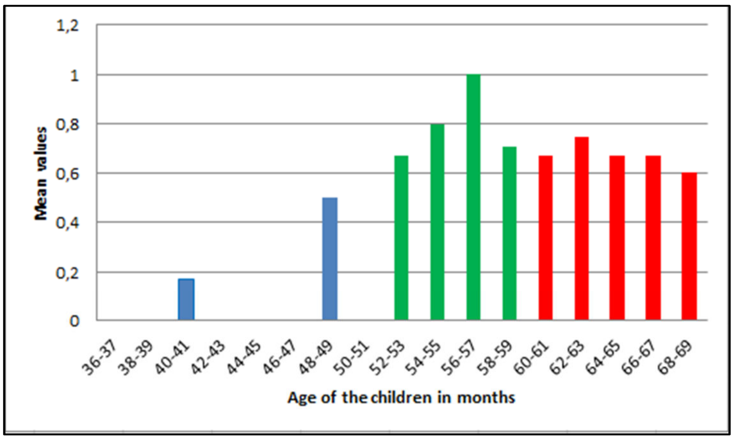

Figure 34 Monthly graphs for the development of the counter-factual thinking task (blue bars represent 3-year-olds, green bars represent 4-year-olds, red bars represent 6-year-olds)

4.2.5 Classical Episodic Memory Questionnaire

In the classical episodic memory questionnaire, there were 3 items for each component – "what", "where", and "when". The total number of correctly answered questions) (minimum score: 0, maximum score: 9) was entered as dependent variable. The results of a univariate ANOVA on the means of all answered questions indicated that children developed significantly in that task (F (2, 91) = 82.690, $p < .001$, $\eta_p^2 = .645$). When we run non-parametric tests, similar significant results were obtained.

Table 20 Descriptive statistics for the classical episodic memory questionnaire (mean of the total number of questions)

	Age Group	N	Mean	Std. Error
Classical episodic memory questionnaire - total	3	31	3,839	,248
	4	31	6,613	,240
	5	32	7,969	,207

We also ran a mixed ANOVA in order to study the www effect and its interaction with age. Age was used as a between subjects factor and as within subject factors www was used. The results of the mixed ANOVA revealed that the www effect was significant (F (2, 90) = 20.501, $p < 0.001$, $\eta_p^2 = .184$). In particular, "where" component was remembered better than "what" (F (1, 91) = 9.609, $p = 0.003$, $\eta_p^2 = .096$) and "what component" was remembered better than "when" (F (1, 91) = 12.374, $p = 0.001$, $\eta_p^2 = .120$) ("where" component (M = 2.270, SE = .043) was recalled better than "what" (M = 2.067, SE = .056) and "when" component (M = 1.834, SE = .073)). Furthermore, there was a main effect of age (F (2, 90) = 89.236, $p < .001$, $\eta_p^2 = .662$). Overall, 3-year-olds produced less correct answers (M = 3.839, SE = .248), while 4-year-olds (M = 6.613, SE = .240) and 5-year-olds (M = 7.969, SE = .207) produced more. In addition, the interaction between www and age was also significant (F (4, 182) = 14.651, $p < .001$, $\eta_p^2 = .244$). More specifically, while the interaction www*age between "what" and "where" was significant (F (2, 91) = 18.202, $p < 0.001$, $\eta_p^2 = .286$), it was not significant for "what" and "when" (F (2, 91) = 1.668, $p = 0.194$, $\eta_p^2 = .035$). More specifically, "what" component was recalled best by 5-year-olds (M = 2.750, SE = .097) than 4-year-olds (M = 2.065, SE = .098) and 3-year-olds (M = 1.387, SE = .098). Also, 5-year-olds (M = 2.096, SE = .073) remembered "where" component better than 4-(M = 2.774, SE = .074) and 3-year-olds (M = 1.129, SE = .074). For "when" component, again, 5-year-olds (M = 2.406, SE = .126) were better than 4- (M = 1.774, SE = .128) and 3-year-olds (M = 1.323, SE = .128).

Figure 35, which is based on *post-hoc* tests (Bonferroni-corrected) shows that children developed significantly and linearly in this task since the comparisons between the ages of 3-4 ($p < .001$), 3-5 ($p < .001$), and 4-5 ($p < .001$) were all significant.

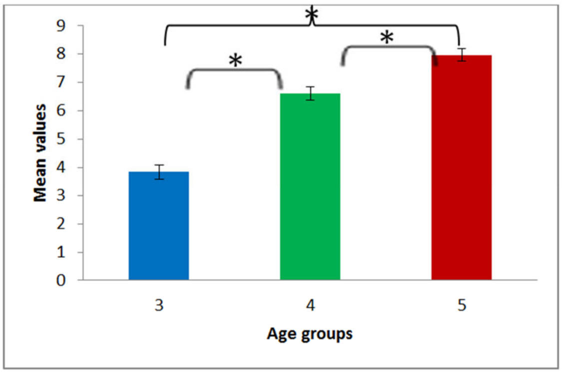

Figure 35 The development of the episodic memory questionnaire: age effect (means of the total number of questions) (Error bars represent SEs)

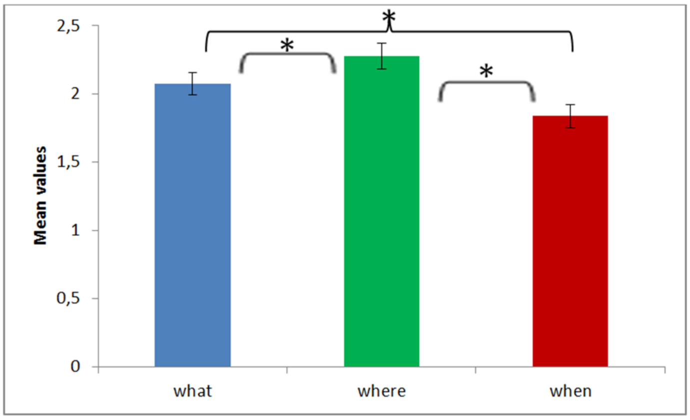

Figure 36 The development of the episodic memory questionnaire: www effect (Error bars represent SEs)

The hypothesis for the episodic memory questionnaire was also confirmed because the performance in this task developed significantly. The results of the episodic memory questionnaire are not so clear because the development of the 3 www's did not proceed as orderly as in the www task. In particular, the "where" component was as good as the "what" component both of which were better than the "when" component. This may have to do with the www information being distributed over different items as compared to the www task where each item had a what, where, and when aspect. In the classical episodic memory questionnaire, however, each question was about a different object. This led to the situation that "what" items could be harder than "where" items, which were answered correctly by even the youngest children. This was also the case for Hayne & Imuta (2011) who found that "where" was simpler than "what" in their www task. However, generally, "what" seems easiest, as revealed in the www task. The success of correct retrieval seems to depend on the kind of questions that you ask and whether you ask the three www questions for the same item, as in our www task, or not, as in our episodic questionnaire.

In the original episodic memory questionnaire (Holland & Smulders, 2011), adults were asked questions twice, i.e. once referring to the first hiding episode and once to the second one on two consecutive days (see 1.5.1 in Literature Review chapter for further details). Therefore, their aim was to make the participants go back mentally to the relevant episode. However, our episodic memory questionnaire was different in the following respect. In our case, questions were asked in only one session and we used some incidental questions regarding the experimental room. Consequently, in our case, we required children to mentally go back to the relevant moments that had just occurred 10-15 minutes before the questions were asked. To the best of our knowledge, ours is the first episodic memory questionnaire for Turkish children, so there is no other to which we can compare our results.

4.2.6 Comparison and correlations between the additional tasks

In this first part of the results, the development of the sample in the 7 separate tasks was presented. Overall, there are significant developments across the observed age range between 3 and 5 years of age. In particular, the www task, future prediction task, the Day-Night Strop task, and the episodic memory questionnaire developed linearly. The Corsi-Block Tapping task showed a big stepwise increase between 4 and 5 years of age, and the story-telling task and counter-factual thinking task showed a big stepwise increase between 3 and 4 years of age.

In addition, there were significant correlations between all additional tasks (see Table 21). Namely, the most significant correlation were between the counter-factual thinking task and episodic memory questionnaire (Pearson's r = .732, $p < .001$) and Day-Night Stroop task and episodic memory questionnaire (Pearson's r = .743, $p < .001$).

Table 21 Pearson's correlations and significance value table for all additional tasks

		Day-night stroop task	Corsi-block tapping task – total # of correct answers	Story-telling task – total # of future tense used	Counter-factual thinking task - total	Total of questionnaire
Day-night stroop task	Pearson correlation Sig. (2-tailed)	1	,517 ,000	,541 ,000	,714 ,000	,732 ,000
Corsi-block tapping task – total # of correct answers	Pearson correlation Sig. (2-tailed)	,517 ,000	1	,350 ,001	,412 ,000	,530 ,000
Story-telling task – total # of future tense used	Pearson correlation Sig. (2-tailed)	,541 ,000	,350 ,001	1	,662 ,000	,676 ,000
Counter-factual thinking task - total	Pearson correlation Sig. (2-tailed)	,714 ,000	,412 ,000	,662 ,000	1	,828 ,000
Total of questionnaire	Pearson correlation Sig. (2-tailed)	,732 ,000	,530 ,000	,676 ,000	,828 ,000	1

In the following, we will use those tasks in order to predict the results of the two main tasks – the www task and the future prediction task, by means of hierarchical linear and logistic regression.

4.3 Multiple Regressions

By means of the additional tasks, we tried to predict the main tasks, i.e. the www task and the future prediction task. We proceeded as follows: first, we used all additional tasks as predictors, however, after entering age. In a second step, we removed insignificant predictors and retained only those which had a significant relationship with the criterion, respectively. In general, we ran hierarchical regressions, with "age" as the first model and then we entered the other tasks in the second model. The rationale why age is entered first is, to subtract the common age variance from the other predictors and thus retain the unique variance of those tasks as they are related to the outcome variable. Otherwise, one might object that the high predictive power of each predictor variable is due to possibly unspecific age-related variance because cognition in general increases in children of that age. This is methodologically sound; however, it has the disadvantage of possibly camouflaging the actual predictive power of a predictor task because of the high amount of shared age variance. This may leave little room for further increasing the amount of explained variance.

Before starting with the regressions, we will consider the correlations of the two main tasks and the additional tasks, along with their part and partial correlations. In Table 22, it can be seen that there is significant correlation between the www task and the future prediction task (Pearson's r = .518, $p < .001$). Also, for the main tasks, the most significant correlations are between www task and episodic memory questionnaire (Pearson's r = .743, $p < .001$) and between the future prediction task and the story telling task (Pearson's r = .459, $p < .001$).

The correlations were also controlled for the two main tasks (the predicted variables: www task and the future prediction task) for the additional tasks (the predicting variables) since the predictive value of each task could be observed while keeping the main tasks aside from. The results were presented in Table 23. When the correlations between the additional tasks (the predicting variables) were controlled for by the two main tasks (the predicted variables) some correlations among them became insignificant: the correlation between the Day-Night Stroop task and the story telling task (Pearson's r = .172, $p = .101$), the correlation between the Corsi-Block Tapping task and the story telling task (Pearson's r = -.007, $p = .947$), and the correlation between the Corsi-Block Tapping task and counter-factual thinking task (Pearson's r = .106, $p = .313$) disappeared. This may indicate that the original correlation between them had been mediated by the correlation each of them shared with the main tasks.

Table 22 Pearson's correlations and significance value table for all tasks

		The total sum of what-where-when	Day-night stroop task	Corsi-block tapping task – total # of correct answers	Future-prediction task	Story-telling task – total # of future tense used	Counter-factual thinking task - total	Total of questionnaire
The total sum of what-where-when	Pearson correlation Sig. (2-tailed)	1	,707 ,000	,533 ,000	,518 ,000	,627 ,000	,657 ,000	,743 ,000
Day-night stroop task	Pearson correlation Sig. (2-tailed)	,707 ,000	1	,517 ,000	,394 ,000	,541 ,000	,714 ,000	,732 ,000
Corsi-block tapping task – total # of correct answers	Pearson correlation Sig. (2-tailed)	,533 ,000	,517 ,000	1	,390 ,000	,350 ,001	,412 ,000	,530 ,000
Future-prediction task	Pearson correlation Sig. (2-tailed)	,518 ,000	,394 ,000	,390 ,000	1	,459 ,000	,312 ,002	,318 ,002
Story-telling task – total # of future tense used	Pearson correlation Sig. (2-tailed)	,627 ,000	,541 ,000	,350 ,001	,459 ,000	1	,662 ,000	,676 ,000
Counter-factual thinking task - total	Pearson correlation Sig. (2-tailed)	,657 ,000	,714 ,000	,412 ,000	,312 ,002	,662 ,000	1	,828 ,000
Total of questionnaire	Pearson correlation Sig. (2-tailed)	,743 ,000	,732 ,000	,530 ,000	,318 ,002	,676 ,000	,828 ,000	1

Table 23 Pearson's correlations and significance value table for all tasks (controlled for the main tasks)

Control Variables			Day-night stroop task	Corsi-block tapping task – total # of correct answers	Story-telling task – total # of future tense used	Counter-factual thinking task - total	Total of questionnaire
The total sum of what-where-when & Future-prediction task	Day-night stroop task	Correlation	1,000	,230	,172	,472	,446
		Sig. (2-tailed)		,027	,101	,000	,000
	Corsi-block tapping task – total # of correct answers	Correlation	,230	1,000	-,007	,106	,260
		Sig. (2-tailed)	,027		,947	,313	,012
	Story-telling task – total # of future tense used	Correlation	,172	-,007	1,000	,445	,438
		Sig. (2-tailed)	,101	,947		,000	,000
	Counter-factual thinking task - total	Correlation	,472	,106	,445	1,000	,674
		Sig. (2-tailed)	,000	,313	,000		,000
	Total of questionnaire	Correlation	,446	,260	,438	,674	1,000
		Sig. (2-tailed)	,000	,012	,000	,000	

4.3.1 Multiple Linear Regression for the www task

First, we ran a stepwise (hierarchical) multiple regression for the total scores in the www task, with the following two blocks of predictors (number of subjects: n = 94): (1) age, and (2) Day/Night Stroop Task (total # of correct items), (3) Corsi-Block Tapping Task (total # of correct items), (4) story-telling Task (total # of future tense used), (5) the episodic questionnaire (total # of correct items), and (6) Counterfactual Thinking Task (total # of correct items).

For the first block, it was found that age was a significant factor that explained the www task ($F (1, 92) = 98.914$, $p < .001$, R^2 change = .518, p of R^2 change < .001). This means that the first model, which relied entirely on the age effect, could explain 51.8% of the variance of the criterion variable, the www task. Again, when the other tasks in the second block were added to the model, this second model could also explain the www task significantly ($F (5, 88) = 32.704$, $p < .001$, $R^2 = .651$, R^2 change = .133, p of R^2 change < .001). This means that by adding the additional predictors, the model improved by explaining 13.3% more of the variance. These additional predictors were the Day-Night Stroop task (B = .202, t = 2.168, $p = .033$), the story telling task (B = .257, t = 2.433, $p = .017$), and episodic memory questionnaire (B = .303, t = 2.157, $p = .034$). This means that executive functions, language ability, and episodic memory were important factors for predicting the total score of the www task besides mere age. In addition, the age factor becomes insignificant in the second model since a high amount of age variance is shared among all additional tasks (due to the fact that all additional tasks developed significantly by age) (In the table below, B value stands for the regression coefficient that makes prediction on the changes of the dependent variable. Standard Error represents the standard deviation for the B value. The Beta value indicates the power of each predictor on the predicted variable and t-value represents whether the coefficient value is meaningfully different from 0.).

Table 24 The multiple regression results for the www task (for all additional tasks)

		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
Model						
1	(Constant)	-2,964	,909		-3,260	,002
	Age of the child	2,208	,222	,720	9,946	,000
2	(Constant)	-1,685	,893		-1,887	,063
	Age of the child	,483	,418	,158	1,156	,251
	Day-night stroop task	,209	,096	,242	2,184	,032
	Corsi-block tapping task – total # of correct answers	,119	,114	,093	1,051	,296
	Story-telling task – total #of future tense used	,267	,109	,217	2,436	,017
	Counter-factual thinking task – total	-,099	,280	-,043	-,353	,725
	Total of questionnaire	,331	,161	,282	2,054	,043

In Table 25, zero-order correlations indicate the simple correlations between variables. The partial correlation indicates the relationship between two variables while the effects of one or more variables are controlled. Part correlations, however, reflect the relationship between two variables while the effects of a third variable are controlled on only one of the variables (Field, 2009).

Table 25 The multiple regression results for the www task: correlations and collinearity statistics

Model		Correlations			Collinearity Statistics	
		Zero-order	Partial	Part	Tolerance	VIF
1	Age of the child	,720	,720	,720	1,000	1,000
2	Age of the child	,720	,123	,073	,216	4,628
	Day-night stroop task	,707	,228	,138	,326	3,063
	Corsi-block tapping task – total # of correct answers	,533	,112	,067	,516	1,937
	Story-telling task – total #of future tense used	,627	,253	,154	,508	1,968
	Counter-factual thinking task – total	,657	-,038	-,022	,266	3,761
	Total of questionnaire	,743	,215	,130	,213	4,692

In Table 25, while zero-order correlations were high for all additional tasks, their part and partial correlations were diminished. The reason behind this is that zero-order correlation only represents the linear relationship between the predicted variable and the predicting variable. However, when partial and part correlations are considered, some of the relationship between the two variables is explicable in terms of their correlation with other variables. Since our many additional tasks are all significantly inter-related with each other, this issue recurs throughout all regressions reported here.

Some collinearity statistics, as exemplified in the tolerance and VIF statistics are represented in Table 25. In particular, the VIF (Variance Inflation Factor) explains the significant effect of collinearity among variables in the regression model and "tolerance" is equal to (1/VIF). It is stated that values of 10 for VIF and values below 0.1 for tolerance indicate serious problem for multicollinearity (Field, 2009). Therefore, in Table 25, there exists no serious problem regarding multi-collinearity; however, as indicated above, collinearity of the additional tasks is a guiding theme in our regression analyses (for more information about the collinearity on this regression see Appendix B).

Since the Corsi-Block Tapping Task and counter-factual thinking task did not turn out to be significant predictors, we reran the stepwise (hierarchical) multiple regression for the www task, with the following two blocks of predictors, however, omitting the Corsi-Block Tapping task and the counter-factual thinking task: (1) age, and (2) Day/Night Stroop Task, story-telling task (total # of future tense used), and the total of the episodic questionnaire. For the first block, it was found that age was a significant factor for the www task (F (1, 92) = 98.914, $p < .001$, R^2 change = .518, p of R^2 change < .001). Again, when the other tasks in the second block were added to the model, it could also explain the www task significantly (F (4, 89) = 40.437, $p < .001$, R^2=.803, R^2 change = .127, p of R^2 change < .001). From Table 26-28 below, it can be concluded that the Day-Night Stroop Task, the story-telling task, and the total of questionnaire could predict the www task. Also, it can be concluded that all tasks are significantly important for the main task (www) as it can be observed in Table 28 (for more information about the collinearity on this regression see Appendix B).

Table 26 The multiple regression results for the www task (for Day-Night Stroop task, story-telling task, and episodic memory questionnaire)

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-2,964	,909		-3,260	,002
	Age of the child	2,208	,222	,720	9,946	,000
2	(Constant)	-1,773	,868		-2,042	,044
	Age of the child	,687	,365	,224	1,883	,063
	Day-night stroop task	,197	,093	,228	2,116	,037
	Story-telling task – total #of future tense used	,255	,106	,208	2,410	,018
	Total of questionnaire	,304	,141	,259	2,156	,034

Table 27 The multiple regression results for the www task: correlations and collinearity statistics for the restricted set of predictors: Age, Day-Night Stroop Task, Story-Telling Task, and Episodic Questionnaire

Model		Correlations			Collinearity Statistics	
		Zero-order	Partial	Part	Tolerance	VIF
1	Age of the child	,720	,720	,720	1,000	1,000
2	Age of the child	,720	,196	,119	,282	3,546
	Day-night stroop task	,707	,219	,134	,342	2,921
	Story-telling task – total #of future tense used	,627	,248	,152	,538	1,859
	Total of questionnaire	,743	,223	,136	,276	3,617

Table 28 Excluded variables in the results of the regression for the www task and their Betas (standardized regression coefficients)

Model		Beta In	t	Sig.
1	Day-night stroop task	,368	3,290	,001
	Story-telling task – total # of future tense used	,337	4,274	,000
	Total of questionnaire	,463	4,302	,000

In summary, the www task can be clearly predicted by the Day-Night Stroop Task, the story telling task, and the episodic memory questionnaire.

The hypothesis regarding the regression for the www task was partially confirmed since not all additional tasks but just the Day-Night Stroop task, the story-telling task and the episodic memory questionnaire could predict the www task.

More specifically, the Day-Night Stroop task was a good predictor since this task requires executive functions, namely attention to choose the correct answer. Children were required to memorize the instruction and needed selective attention to report the www information in the www task. Therefore, the Day-Night Stroop task could predict the www task. For the story-telling task, it can be stated that there was reference to time and order which could be related to the www task since there was also a "time line" in the www task. For the www task, there is actually no counterfactual aspect in it – so it is not expected that counterfactual thinking task is significantly related to www in the first place. Lastly, the episodic memory questionnaire was a good predictor since both of the task includes www components.

Separate regressions for each age group (i.e., 3, 4, and 5 years) were conducted in order to see whether and if so, which of the additional tasks could predict the www tasks at these ages, respectively.

First, for the total scores in the www task, a multiple regression was run with all additional tasks as predictors for age 3. The results indicated that the additional tasks could explain the www task significantly (F (1, 30) = 29.345, $p < .001$, $\Delta R^2 = .854$, p of $\Delta R^2 < .001$). That is, the additional tasks could explain 85.4% of the variance of the www task. More specifically, the Day-Night Stroop task (B = .241, t = 2.780, p = .010), the Corsi block-tapping task (B = 10.653, t = 7.524, $p < .001$), and the episodic questionnaire (B = -.700, t = -3.440, p = .002) could significantly predict the www task for 3-year-olds. Note that the *B* weight of the episodic questionnaire is negative.

Table 29 The multiple regression results for the www task (only for 3-year-olds)

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-38,352	5,468		-7,014	,000
	Day-night Stroop task	,241	,087	,289	2,780	,010
	Corsi block-tapping task	10,653	1,416	1,344	7,524	,000
	Story-telling task	-,209	,318	-,130	-,658	,517
	Counter-factual thinking task	-,483	,433	-,228	-1,116	,275
	Total of questionnaire	-,700	,204	-,679	-3,440	,002

Next, the same regression was run again for age 4. The results indicated that the additional tasks could explain the www task significantly (*F* (1, 30) = 7.867, $p < .001$, $\Delta R^2 = .611$, *p* of $\Delta R^2 < .001$). 61.1% of the variance of the www task could be explained at that age. Specifically, the Day-Night Stroop task (B = .396, $t = 2.128$, $p = .043$) and the episodic memory questionnaire (B = .851, $t = 2.869$, $p = .008$) could significantly predict the www task for the age group 4. Note that this time the *B* weight of the episodic questionnaire is positive.

Table 30 The multiple regression results for the www task (only for 4-year-olds)

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-6,078	3,275		-1,856	,075
	Day-night Stroop task	,396	,186	,424	2,128	,043
	Corsi-block tapping task	,522	,485	,192	1,078	,291
	Story-telling task	,130	,193	,138	,675	,506
	Counter-factual thinking task	-,230	,493	-,092	-,467	,645
	Total of questionnaire	,851	,297	,519	2,869	,008

Lastly, the same regression was conducted for age 5. The results indicated that the additional tasks could not explain the www task significantly (*F* (1, 31) = 1.033, $p = .419$, $\Delta R^2 = .166$, *p* of $\Delta R^2 = .419$). Only 16.6% of the variance of the www task could be explained. Overall, none of the additional tasks could predict the www task for the age group 5.

Table 31 The multiple regression results for the www task (only for 5-year-olds)

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	6,740	3,974		1,696	,102
	Day-night Stroop task	,063	,221	,056	,284	,779
	Corsi-block tapping task	,157	,114	,254	1,382	,179
	Story-telling task	-,047	,176	-,054	-,267	,792
	Counter-factual thinking task	-,748	,504	-,323	-1,483	,150
	Total of questionnaire	,199	,267	,168	,746	,462

4.3.2 Multiple Linear Regression for the Future Prediction Task

Next, we ran a multiple linear regressions for the future-prediction task (for the total score, i.e., the semantic, functional item "ball" and the episodic item "badges"). In this multiple regression, only the condition for future tense was used as data (number of subjects: n = 49) because this was the crucial condition with which children struggled as compared to the present condition in which they did significantly better.

There were two blocks in the regression in the following order: (1) age, and (2) Day/Night Stroop Task (total # of correct items), (3) Corsi-Block Tapping Task (total # of correct items), (4) Story-telling Task (total # of future tense used), (5) the episodic questionnaire (total # of correct items), and (6) Counterfactual Thinking Task (total # of correct items). The result showed that both the first model (F (1, 47) = 41.890, $p < .001$, R^2 change = .471, p of R^2 change < .001) and the second model (F (6, 42) = 12.634, $p < .001$, $R^2 = .643$, R^2 change = .172, p of R^2 change = .004) could significantly predict the future-prediction task. In particular, the second model explained 17.2% more variance and therefore is a better model. Also, in the second model, age remained a significant factor (B = .457, t = 2.844, $p = .007$). However, other than the story-telling task (B = .161, t = 3.831, $p < .001$), none of the additional tasks in the second step could explain the future prediction task directly, once age was controlled for (see also Table 32-33). This might indicate that the future-prediction task, in general, is related with linguistic ability. Also, the reason behind the fact that age does not lose its predictive power might be because of the distinctive variance explained by the story telling task which is different from the age variance.

Table 32 The multiple regression results for the future-prediction task (ball+badge)

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-1,405	,379		-3,708	,001
	Age of the child	,595	,092	,686	6,472	,000
2	(Constant)	-1,172	,389		-3,011	,004
	Age of the child	,457	,161	,527	2,844	,007
	Day-night stroop task	,028	,048	,106	,579	,566
	Corsi-block tapping task – total # of correct answers	,071	,050	,215	1,408	,167
	Story-telling task – total #of future tense used	,161	,042	,480	3,831	,000
	Counter-factual thinking task – total	,033	,142	,053	,235	,815
	Total of questionnaire	-,146	,074	-,466	-1,970	,055

Table 33 The multiple regression results for the future-prediction task (ball+badge): correlations and collinearity statistics

Model		Correlations Zero-order	Partial	Part	Collinearity Statistics Tolerance	VIF
1	Age of the child	,686	,686	,686	1,000	1,000
2	Age of the child	,686	,402	,262	,247	4,051
	Day-night stroop task	,613	,089	,053	,253	3,946
	Corsi-block tapping task-total # of correct answers	,593	,212	,130	,365	2,736
	Story-telling task – total #of future tense used	,630	,509	,353	,540	1,851
	Counter-factual thinking task - total	,448	,036	,022	,168	5,962
	Total of questionnaire	,509	-,291	-,181	,152	6,580

The collinearity diagnostics, as shown in Table 34, reveals that again age and the Day-Night Stroop task, and age and the counter-factual thinking task share a big proportion of variance. Also, the Corsi-Block Tapping task and the counter-factual thinking task share some common variance. Note that age is now spread out on two dimensions (6 and 7), each of which overlap with different tasks: One big lump is shared with the Day-Night Stroop task, counter-factual thinking and the episodic questionnaire and the other with the Corsi-block Tapping task and the counter-factual thinking task.

We ran a second hierarchical regression by excluding the episodic memory questionnaire since it had the highest value of VIF which means that its multicollinearity value is somewhat critical, as compared to that of the other tasks. Therefore, there were two blocks: (1) age, and (2) Day/Night Stroop Task (total # of correct items), (3) Corsi-Block Tapping Task (total # of correct items), (4) Story-telling Task (total # of future tense used), and (5) Counterfactual Thinking Task (total # of correct items). The result showed that both the first model (F (1, 47) = 41.890, $p < .001$, R^2 change = .471, p of R^2 change < .001) and the second model (F (5, 43) = 13.482, $p < .001$, $R^2 = .611$, R^2 change = .139, p of R^2 change = .009) could significantly predict the future-prediction task. In particular, the second model explained 13.9% more variance. Also, in the second model, age remained a significant factor (B = .376, t = 2.342, $p = .024$). However, again other than the story-telling task (B = .136, t = 3.280, $p = .002$), none of the additional tasks in the second step could explain the future prediction task directly (see also Table 35-36).

Table 34 The collinearity diagnostics results for the future prediction task (criterion) and the predicting tasks

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions						
				(Constant)	Age of the child	Day-night stroop task	Corsi-block tapping task – total # of correct answers	Story-telling task – total # of future tense used	Counter-factual thinking task - total	Total of questionnaire
1	1	1,981	1,000	,01	,01					
	2	,019	10,112	,99	,99					
2	1	6,572	1,000	,00	,00	,00	,00	,00	,00	,00
	2	,257	5,055	,01	,00	,00	,00	,61	,00	,00
	3	,084	8,839	,00	,00	,00	,29	,04	,11	,01
	4	,055	10,93920,	,21	,00	,01	,16	,29	,05	,04
	5	,016	183	,19	,00	,24	,05	,00	,08	,45
	6	,009	27,248	,58	,49	,06	,48	,00	,40	,10
	7	,006	32,280	,00	,51	,69	,02	,04	,37	,40

Table 35 The multiple regression results for the future-prediction task (ball+badge)

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-1,405	,379		-3,708	,001
	Age of the child	,595	,092	,686	6,472	,000
2	(Constant)	-1,233	,401		-3,077	,004
	Age of the child	,376	,161	,434	2,342	,024
	Day-night stroop task	,052	,048	,200	1,093	,280
	Corsi-block tapping task – total # of correct answers	,029	,047	,088	,614	,542
	Story-telling task – total #of future tense used	,136	,041	,404	3,280	,002
	Counter-factual thinking task – total	-,164	,105	-,259	-1,564	,125

Table 36 The multiple regression results for the future-prediction task (ball+badge): correlations and collinearity statistics

Model		**Correlations** Zero-order	Partial	Part	**Collinearity Statistics** Tolerance	VIF
1	Age of the child	,686	,686	,686	1,000	1,000
2	Age of the child	,686	,336	,223	,264	3,783
	Day-night stroop task	,613	,164	,104	,272	3,680
	Corsi-block tapping task-total # of correct answers	,593	,093	,058	,445	2,247
	Story-telling task – total #of future tense used	,630	,447	,312	,597	1,675
	Counter-factual thinking task - total	,448	-,232	-,149	,331	3,017

In Table 37, it can be observed that again age and the Day-Night Stroop task share a big proportion. Also, again the Corsi-Block Tapping task and the counter-factual thinking task have some common proportions. In addition, the story telling task explains a big proportion on the 2^{nd} level by its predictive power and shares the remaining variances with the Corsi-Block Tapping task and the counter-factual thinking task. Note that by taking out the episodic questionnaire, the age variable now loads only on a single dimension. Thus, by this operation, we could unify the age variance again.

In sum, besides age, other than the story-telling task, none of the other predictors could predict the total score of the future prediction task significantly.

Table 37 The collinearity diagnostics results for the future prediction task (criterion) and the predicting tasks

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions					
				(Constant)	Age of the child	Day-night stroop task	Corsi-block tapping task – total # of correct answers	Story-telling task – total # of future tense used	Counter-factual thinking task - total
1	1	1,981	1,000	,01	,01				
	2	,019	10,112	,99	,99				
2	1	5,595	1,000	,00	,00	,00	,00	,01	,00
	2	,257	4,666	,01	,00	,00	,00	,69	,00
	3	,082	8,251	,00	,00	,00	,38	,01	,21
	4	,047	10,872	,26	,00	,00	,21	,29	,29
	5	,010	23,435	,62	,08	,63	,22	,00	,50
	6	,008	26,873	,10	,92	,37	,19	,00	,01

Logistic regression: predicting the episodic item (badge) in the future condition of the Future Prediction Task

In order to predict the episodic item (badges), we ran a logistic regression since this time the predicted value was a categorical variable (i.e., 0 or 1: a child may choose or may not choose the episodic item). Also, in this logistic regression, only the condition for future tense was used as data (number of subjects: n = 49). There were two blocks in the following order: (1) age, and (2) Day/Night Stroop Task (total # of correct items), (3) Corsi-Block Tapping Task (total # of correct items), (4) Story-telling Task (total # of future tense used), (5) the episodic questionnaire (total # of correct items), and (6) Counterfactual Thinking Task (total # of correct items). The results indicated that both models in the first (χ^2 (1) = 17.011, p <.001, see Table 38) and the second block (χ^2 (6) = 27.335, p < .001, see Table 39) were significant in predicting the mentioning of the badges in the future-prediction task. However, the second step did not add significantly to the success of the second model (p=.069).

Table 38 The results of the omnibus test of model coefficients for the future-prediction task (badges) (Block 1)

		Chi-square	df	Sig.
Step 1	Step	17,011	1	,000
	Block	17,011	1	,000
	Model	17,011	1	,000

Table 39 The results of the omnibus test of model coefficients for the future-prediction task (badges) (Block 2)

		Chi-square	df	Sig.
Step 1	Step	10,324	5	,067
	Block	10,324	5	,067
	Model	27,335	6	,000

The progressive increase in predictive power of the 3 models can be seen by considering the percentage of correctly classified subjects. By “Model 0” (the model with just the constant)[1], only 53.1% of the outcome could be predicted. By “Model 1” (first step: age) 71.4% and by “Model 2” (second step: all additional tasks) 77.6% of the outcome could be predicted (see Table 40-42).

Table 40 Classification table for the step 0 of future prediction task (badge)

Observed			Predicted		
			Future-prediction task - badges		Percentage Correct
			0	1	
Step 0	Future-prediction task- badges	0	26	0	100,0
		1	23	0	,0
	Overall Percentage				53,1

Table 41 Classification table for the step 1 (age) of future prediction task (badge)

Observed			Predicted		
			Future-prediction task - badges		Percentage Correct
			0	1	
Step 1	Future-prediction task- badges	0	22	4	84,6
		1	10	13	56,5
	Overall Percentage				71,4

[1] Model 0 bases the prediction just on the category with the higher number of subjects in it, here 26 subjects who did not mention the badges, as compared to only 23 subjects who did mention the badges. It then assumes that none of the children mentioned the badges, which yields an overall correct prediction of 53%.

Table 42 Classification table for the step 1 (all tasks) of future prediction task (badge)

Observed			Predicted: Future-prediction task - badges 0	1	Percentage Correct
Step 0	Future-prediction task- badges	0	20	6	76,9
		1	5	18	78,3
	Overall Percentage				77,6

In Table 43, as indicated above, it can be seen that none of the additional task can predict the episodic item of the future prediction task. The reason is due to the fact that all additional tasks share some common variances with age and when age and all additional tasks are entered together in the same model, they lose their predictive power. However, when all predictors were entered separately, some tasks turned out to be significant factors, besides age. In addition, informal regressions that were run with more (but not all) predictors yielded inconsistent Beta values, i.e., some predictors would have a reverse (negative) predicting effect, due to the high collinearity (since all tasks correlate with each other). For that reason, only the story telling task and the counter-factual thinking task were chosen as good predictors (they did not take variance away from age (which remained a significant predictor) and still retained a reasonably high amount of own variance (though marginally significant in terms of their Beta-values) to improve the model).

Table 43 B values, S.E.'s and significance values of step 1 for the future prediction task (badge)

		B	S.E.	Sig.
Step 1	age	-,295	,903	,744
	day_night_stroop_task	,247	,306	,420
	corsi_block_task_total_correct	,511	,367	,164
	story_telling_task_total_future	-,017	,251	,947
	counterfactual_task_total	,470	,841	,576
	questionnaire_total	,332	,443	,453
	Constant	-8,521	3,225	,008

First, only the story telling task was used as a predictor in the logistic regression (when controlled for age). The results indicated that both the models in the first (χ^2 (1) = 17.011, p <.001, see Table 44) and the second block (χ^2 (6) = 19.865, p < .001, see Table 45) were significant in predicting the mentioning of the badges in the future-prediction task. However, the story telling task only improved the model marginally (p =.091).

Table 44 The results of the omnibus test of model coefficients for the future-prediction task (badge) (Block 1)

		Chi-square	df	Sig.
Step 1	Step	17,011	1	,000
	Block	17,011	1	,000
	Model	17,011	1	,000

Table 45 The results of the omnibus test of model coefficients for the future-prediction task (badge) (Block 2)

		Chi-square	df	Sig.
Step 1	Step	2,854	1	,091
	Block	2,854	1	,091
	Model	19,865	2	,000

53.1% of the outcome could be predicted by "Model 0" (the model with the constant). By "Model 1" (first step: age) 71.4% and by "Model 2" (second step: adding the story-telling task) 79.6% of the children who did or did not mention the badges, could be properly categorized (see Table 46-48).

Table 46 Classification table for the step 0 of future prediction task (badge)

Observed			Predicted		
			Future-prediction task - badges		Percentage Correct
			0	1	
Step 0	Future-prediction task- badges	0	26	0	100,0
		1	23	0	,0
	Overall Percentage				53,1

Table 47 Classification table for the step 1 (age) of future prediction task (badge)

Observed			Predicted		
			Future-prediction task - badges		Percentage Correct
			0	1	
Step 1	Future-prediction task- badges	0	22	4	84,6
		1	10	13	56,5
	Overall Percentage				71,4

Table 48 Classification table for the step 1 (the story telling task) of future prediction task (badge)

Observed			Predicted		
			Future-prediction task - badges		Percentage Correct
			0	1	
Step 1	Future-prediction task- badges	0	20	6	76,9
		1	4	19	82,6
	Overall Percentage				79,6

In terms of the regression coefficient B, it was found that the story telling task was a marginally significant predictor for the episodic item of the future prediction task (B = .303, p = .096).

Table 49 B values, S.E.'s and significance values of step 1 for the future prediction task (badge)

		B	S.E.	Sig.
Step 1	age	1,412	,532	,008
	story_telling_task_total_future	,303	,182	,096
	Constant	-6,732	2,154	,002

Then, only the counter-factual thinking task was used as a predictor in the logistic regression (when controlled for age). The results indicated that both the models in the first (χ^2 (1) = 17.011, p <.001, see Table 50) and the second block (χ^2 (6) = 20.459, p < .001, see Table 51) were significant in predicting the mentioning of the badge in the future-prediction task. However, again, the counterfactual thinking task only improved the model marginally (p = .063).

Table 50 The results of the omnibus test of model coefficients for the future-prediction task (badge) (Block 1)

		Chi-square	df	Sig.
Step 1	Step	17,011	1	,000
	Block	17,011	1	,000
	Model	17,011	1	,000

Table 51 The results of the omnibus test of model coefficients for the future-prediction task (badge) (Block 2)

		Chi-square	df	Sig.
Step 1	Step	3,448	1	,063
	Block	3,448	1	,063
	Model	20,459	2	,000

53.1% of the outcome could be predicted by "Model 0" (the model with the constant). By "Model 1" (first step: age) 71.4% and by "Model 2" (second step: all additional tasks) 79.6% of the outcome could be predicted (see Table 52-54).

Table 52 Classification table for the step 0 of future prediction task (badge)

Observed			Predicted		
			Future-prediction task - badges		Percentage Correct
			0	1	
Step 1	Future-prediction task- badges	0	26	0	100,0
		1	23	0	,0
	Overall Percentage				53,1

Table 53 Classification table for the step 1 (age) of future prediction task (badge)

Observed			Predicted		
			Future-prediction task - badges		Percentage Correct
			0	1	
Step 1	Future-prediction task- badges	0	22	4	84,6
		1	10	13	56,5
	Overall Percentage				71,4

Table 54 Classification table for the step 1 (the counter-factual thinking task) of future prediction task (badge)

Observed			Predicted		
			Future-prediction task - badges		Percentage Correct
			0	1	
Step 1	Future-prediction task- badges	0	20	6	76,9
		1	4	19	82,6
	Overall Percentage				79,6

In Table 55, it can be seen that the counter-factual thinking task (B = .787, *p* = .071) is a marginally significant predictor for the future prediction task (badges) while age still remains significant (B = 1.236, p = .030).

Table 55 B and significance values of step 1 for the future prediction task (badge)

		B	S.E.	Sig.
Step 1	age	1,236	,569	,030
	counterfactual_task_total	,787	,436	,071
	Constant	-7,577	2,384	,001

To summarize, apart from age, the episodic item of the future prediction task could be marginally predicted by the story telling task or by the counter-factual thinking task, respectively. The reason behind this is that only these two tasks have explanatory effects other than the age variance which is not the case for all other additional tasks.

The hypothesis regarding the regression for the future-prediction task was also partially confirmed since not all additional tasks but just the story-telling task and counter-factual thinking task could (marginally) predict the future-prediction task.

The Day-Night Stroop task did not predict the future prediction task significantly. The possible reason could be that the behaviors of the children were more focused directly on the two pictures in the Day-Night Stroop task (see Figure 17 on Method chapter). Children were instructed in a very concrete way to just say the opposite of what the picture showed. However, in the future-prediction task the suppression might be more indirect. Even, it might be the case that the children do not really have undergone any suppression in the future-prediction task. The need to change perspective is always the same in the Day-Night Stroop task and is mandatory by the task. The children are explicitly told to say the opposite, whereas in the future prediction task they are not instructed like that, so they have to do it deliberately. Therefore, this might be much harder for them. Their engagement in inhibition is an outcome of their thought processes: if they engage in mental time travel, they would have to suppress their current thoughts but if they don't, they wouldn't.

The Corsi Block Tapping task turned out to be an unsuccessful predictor, for both the www task and the future prediction task. Also, it showed a different developmental trajectory than most of the other tasks. Although spatial imagery should have a relation with episodic foresight/future mental time travel, in particular because a change in spatial perspective was involved in the future prediction question, it did not show up in the regressions. The reason might be that the Corsi Block Tapping task only measures immediate and simple visuo-spatial ability whereas in the future prediction task imagery (at least in the future condition) is much further into the future and more complex because children have to imagine a whole situation and also switch perspectives. Furthermore, the fact that the Corsi Block Tapping task never predicted any main task may lie in the fact that its range (only from 4-7 points) was too narrow to correlate well with the criterion.

However, the story-telling task was a marginally good predictor for the future-prediction task due to its episodic and mental time travel aspect. When they are required to give an answer to the question “what will Ayse do?” in the story-telling task, children might engage in future mental time travel and imagine Ayse going on a picnic. Furthermore, in order to understand the future question in the future prediction task, children may benefit from knowing the time adverbials (“today”, “now”, “tomorrow”) and the tense suffixes (-AcAk) which are measured in the story-telling task.

For the counterfactual thinking task, it was again a marginally good predictor for the future-prediction task because both of the tasks have similar structure. In addition, in both “present” and “future” conditions of the future-prediction task, children are required to imagine themselves in a situation which is different from the current settings of the game. Also, since both tasks are dependent on some linguistic knowledge and they have the same developmental trajectory, the counter-factual thinking task could predict the future-prediction task.

The episodic memory questionnaire was no successful predictor for the future prediction task. It may be the case that the episodic questionnaire asks about incidental information which is unnecessary to be encoded in a strictly episodic form for being successful in the tasks – whereas in the future prediction task the episodic information is clearly relevant for selecting the correct episodic item. So it wouldn’t make a difference if children remembered the items in the episodic questionnaire with respect to their correct choice of the episodic item in the future prediction task.

Separate regressions for each age group (i.e., 3, 4, and 5 years) were conducted for the future-prediction task, as well. Firstly, for the total scores in the future-prediction task, a multiple regression was conducted for age 3. The results indicated that the additional tasks could explain the future-prediction task significantly (F (1, 30) = 3.922, p = .009, ΔR^2 = .440, p of ΔR^2 = .009). The additional tasks could explain 44% of the variance of the future-prediction task. In detail, the Day-Night Stroop task (B = .188, t = 2.251, p = .033) and the Corsi block-tapping task (B = 4.496, t = 3.282, p = .003) were significant positive predictors, whereas the episodic memory questionnaire (B = -.548, t = -2.782, p = .010) was a negative predictor. The story-telling task (B = -.624, t = -2.026, p = .054) was a marginal negative predictor.

Table 56 The multiple regression results for the future-prediction task (only for 3-year-olds)

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-16,871	5,289		-3,190	,004
	Day-night Stroop task	,188	,084	,459	2,251	,033
	Corsi-block tapping task	4,496	1,370	1,151	3,282	,003
	Story-telling task	-,624	,308	-,787	-2,026	,054
	Counter-factual thinking task	,201	,419	,192	,479	,636
	Total of questionnaire	-,548	,197	-1,078	-2,782	,010

Then, the same regression was carried out for age 4. The results indicated that none of the additional tasks could explain the future-prediction task significantly (F (1, 30) = .822, p > .005, ΔR^2 = .141, p of ΔR^2 > .005). Only 14.1% of the variance of the future-prediction task could be explained by the additional tasks.

Table 57 The multiple regression results for the future-prediction task (only for 4-year-olds)

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	,906	1,208		,750	,460
	Day-night stroop task	-,015	,069	-,064	-,217	,830
	Corsi-block tapping task	,056	,179	,083	,312	,758
	Story-telling task	,082	,071	,353	1,160	,257
	Counter-factual thinking task	,069	,182	,111	,378	,709
	Total of questionnaire	-,039	,109	-,097	-,359	,722

Lastly, the same regression was run for age 5. The results of the multiple regression indicated that the additional tasks could explain the future-prediction task significantly (F (1, 31) = 5.310, p = .002, ΔR^2 = .505, p of ΔR^2 = .002). 50.5% of the variance of the future-prediction task could be explained. Specifically, the story-telling task (B = .169, t = 3.419, p = .002) and the episodic memory questionnaire (B = -.210, t = -2.794, p = .010) could significantly predict the future-prediction task for age group 5. Note again that the B-weight of the episodic memory questionnaire is negative.

Table 58 The multiple regression results for the future-prediction task (only for 5-year-olds)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4,044	1,117		3,619	,001
	Day-night stroop task	-,087	,062	-,214	-1,409	,171
	Corsi-block tapping task	,032	,032	,143	1,008	,323
	Story-telling task	,169	,049	,533	3,419	,002
	Counter-factual thinking task	-,116	,142	-,138	-,820	,420
	Total of questionnaire	-,210	,075	-,484	-2,794	,010

Age-specific regressions for the story-telling task

We also run age-specific regressions in order to see the age-based effects of the story telling task on the main tasks more clearly. First, the regressions were run separately for each age group for the www task and significant results were found for 3-year-olds (t = 3.935, $p < .001$) and 4-year-olds (t = 2.831, $p = .008$) but not for the 5-year-olds (t = .437, $p > .050$) anymore. For the future-prediction task, the regression for the 3-year-olds could not be run because only one child knew the correct answer for this task. However, for 4-year-olds ($p = .050$) the story-telling task was significantly predictive while it was not the case for the 5-year-olds ($p > .050$). These more detailed results show that in general a positive relation between the story-telling task and the two main tasks occurred at 3- and 4-years of age but the relation was decoupled at 5 years of age, presumably because by that time, all 5-year olds had reached the same (quite high) level in the story telling task.

CHAPTER 5

GENERAL DISCUSSION AND CONCLUSION

5.1 Discussion of the Results

5.1.1 Main Results

Overall, children across the observed age range from 3-5 years greatly developed on the main tasks, i.e. the www task and the future-prediction task. Specifically, for the www task children showed a significant development regarding what, where, and when components of the task. The "what" component was recalled best, followed by the "where" component and lastly the "when" component. As Hayne & Imuta (2011) indicate, "the temporal aspect of the event may be most difficult to recall" (p. 320). Why might this be so? An explanation may be given in terms of an "implicational hierarchy": when > where > what (C. Temurcu, personal communication, May 15, 2013). If representational resources are scarce, most likely "what" information will be encoded – because it is highest in the encoding hierarchy, in terms of likelihood of becoming encoded. In the implicational hierarchy, however, it is most embedded. The other two kinds of memories are contextual, framing the "what" component in terms of space ("where") and time/order ("when"). Obviously, without any content, those frames would be void; however, once some content is to be memorized these contextual frames may be helpful in retrieving the "what" information. If there are no further resources left, then nothing else will be encoded. With increasing representational/memory resources, also the other, less salient, contextual, episodic information will be encoded: first "where" and if there are still resources left, also "when" will be encoded. Therefore, we suggest that the development in the www task is dependent on short-term memory resources but not on the changes in the representational domains (what, where, when) of to be-memorized objects.

In this task, the development is stepwise, i.e., there is a big step between 3 and 4&5 years. However, we propose that there is no sharp distinction between the ages of 3 and 4 in terms of representational abilities for the three www components. Rather, the development in the www task is dependent on short-term memory resources that allow the contextual information ("where" and "when") to be encoded after the main memory content ("what") has been encoded.

In addition, Hayne & Imuta (2011) discuss that in their www task all memory aspects occur within the same brief session and thus it is difficult for children "to use differential fading of information as a clue about the order in which each toy had been hidden" (p. 320). Therefore, their task, and also ours, is harder than the one used with scrub jays in which the hiding events take place on different days (see section 1.2 in Literature Review chapter).

In the second main task, i.e., in the future-prediction task, children also showed developmental improvement. This progression was in terms of both the age and the time factor. This means that children know better that "badge" is the correct answer as they get older and the "present" condition was easier than the "future" condition for all age groups. We proposed that children might need more mental resources for projecting themselves into the future, one day ahead of their present situation, than projecting themselves into the very next moment which can be considered still as the present situation. Whether they answer the critical question based on semantic or episodic cognition is controversial, yet. It cannot be directly stated that children travel mentally in time since they could use their semantic memories in order to answer the questions. There is no independent proof of what kind of memory process they are engaged in, qualitatively. However, we follow Russell et al.'s (2010) reasoning that a task involving a change in spatial perspective is highly likely to engage subjects in MTT and a non-functional item such as our badges rather engages episodic than semantic memory processes. In addition, the reason why "time" showed a main effect but did not interact with age might be due to the fact that future thinking is effortful for all children in our experiment.

We also observed that "ball" and "badge" showed different developmental trajectories in the future-prediction task. That is, while the performance of children for the episodic "badge" item developed linearly for both "present" and "future" condition, this was not the case for the functional "ball" item. Three- and 4-year old children selected "ball" nearly at the same rate in the present condition. However, 5-year-olds' performance was the lowest which might be because of the fact that more knowledge on the football game increased the candidate set of functional items for the older children's choice so that they were more likely to also select other football related items.

Regarding the age-specific regression, the results for the www task showed that while 3-year-olds may make use of executive functions (Day-Night Stroop task), visuo-spatial abilities (Corsi block-tapping task), and episodic memory abilities (episodic memory questionnaire) so as to solve the www task, for 4-year-olds, visuospatial abilities lose their effect but only executive functions and episodic memory abilities are still predictive. At the age of 5 years, all tasks become non-predictive for www performance. This may be due the fact that these abilities reach already maximum scores at that age. These results might indicate that episodic memory of past initially depend on working memory functions (executive + visuo-spatial), then only the executive functions of working memory remain predictive, and lastly none of the predictors are effective anymore since all of them already reach their maximum values. It should also be noted that linguistic knowledge of future terms – while being predictive in the overall regression – is not predictive at any of the age-specific regressions. This may show that language ability develops over the age range of 3-5 years, hence contributes to the variance explained by age in the model, without necessarily being a predictor at any specific age.

In the future-prediction task the "present" condition was easier than the "future" condition for all age groups. The reason behind this finding could be the fact that in the present condition, children could still use the "now", the "immediate" setting, which they still have in their working memory representation, without updating it, whereas they had to update it if asked to think further ahead. The task in general and the future condition in particular may give rise to some complexity problems. First of all, this task was difficult for children since the experimental setting (new game, interaction with the experimenter) was unfamiliar for them. Additionally, children have infrequently encountered this particular task (table football game, particular questions of the experimenter) which could make the task even harder. In addition, the "future" condition of the future-prediction task invokes a change in the setting. This may lead to some difficulties for children to understand the change in the current setting and what its outcome might be. In this respect, the challenging reasoning process might actually be facilitated by MTT. MTT might be a strategy to avoid representational complexity since imagining the future (or the past) implies a dual representation of the present and the future/past. That is computationally costly. If one mentally travels in time along the spatio-temporal frames, however, one can remain in just one representational state (present) and "pretend"/"simulate" being in or moving through the other state (future/past). By traveling along those frames, past, present and future states remain connected through the "trace" left behind during the simulation. The subject remains "grounded" in the present like in a "time capsule" while simulating being in the past or future. This handling of time is experiential and dynamic rather than representational and static. Engaging in episodic cognition might therefore significantly ease the task and help overcome complexity issues. The significance of the spatio-temporal frames (where, when), then, is, to guide the mental time travel in a similar coordinate-system as in real life. As the subject moves in a spatio-temporal coordinate system in real life and experiences herself in this system she can move in the same kind of coordinate system in our MTT and experience novel states and events in that system.

The longer the interval this simulation must span, however, the more difficult it might become for the young subject. Children may need more mental resources for projecting themselves into the future instead into the next moment and that might draw resources away from selecting the proper items. Also, items less strongly associated with the football game, i.e., episodic ones, may suffer from this effect more than strongly associated items, i.e., the functional items. This might be because of the fact that contextual information, which is episodic information, is less strongly represented and not in the focus of attention since it does not directly relate to the object itself, i.e., the representational content. Note that "badge" has nothing to do with the proper functioning of the "football game" itself but is associated with it more loosely, in terms of team membership and the side on which the game is played.

In addition, Russell et al. (2010, p. 68), invoking Flavell's model of perspective taking (Flavell, Everett, Croft, & Flavell, 1981) argued that children below the age of 4 can only conceive *what* another person can see (Level 1). However, after age 4, children can additionally conceive of *how* it looks to others given their spatial perspective (Level 2). Therefore, children at the age of 4 in the future-prediction task may "tend to apply their new capacity and represent to themselves how playing the game will look from that position, rather than simply what will be visible, and rather than what will be needed to play it" (Russell et al., 2010, p. 68).

In the following, we will consider the relation of the future prediction task with the linguistic story telling task. When membership to age groups (which was significant in the regression analysis) was disregarded and rather individual performance was looked at in more detail, the relations between the tasks could be observed more closely. For instance, in the sample, there was one child at the age of 3 who scored very high both at linguistic ability (scored 5 out 8) and the future-prediction task. Also, there were 4 children at the age of 5 who scored very low in their linguistic ability (scored 1 out of 8) and there were again 4 children at age 5 who scored very low at linguistic ability (scored 2 out of 8). All these 8 children performed better in the future-prediction task, i.e., they all knew that badge was the correct answer. Therefore, it seems that at the very beginning, language seems to help children in future thinking (positive relation between story-telling and future-prediction task) but later at age 5, irrespective of their language ability, children could state the correct answer, "badge" (zero or weak relation between story-telling and future-prediction task at older ages). This more detailed, individual analysis helps us discern what intrinsic relation the two tasks have, beyond the fact that children generally improve greatly in both tasks across time. The strong common age variance as revealed by the regression analysis, establishes an extrinsic relation between the two tasks, but may camouflage the more meaningful intrinsic relation between the two. In the results chapter, when presenting in the age-related regression, it was shown that 3- and 4-year old children's scores for the story-telling task predicted the main tasks of these children separately, i.e., the scores for the www task and the future-prediction task. However, this was not the case for 5-year-olds. These results also confirm the previous findings at the individual level. In addition, it would be good to test particular populations with special language conditions (e.g., children with Specific

Language Impairment, deaf children) in order to learn more about the effect of language on episodic cognition.

The previous discussion on the significance of the specific spatio-temporal contextual frames in the present thesis can be extended to the “frame problem” which is a more general topic in AI and Cognitive Science, as outlined in the Introduction. As stated earlier, self-consciousness, besides space and time, is another aspect of episodic memory (Tulving, 1985). The content of the memory in the private spatio-temporal coordinate system of the individual is located by the spatio-temporal frame of that memory. This capability of frames to subserve self-consciousness has been aimed to be studied in an agent model with episodic memory (e.g., Nuxoll & Lairdi, 2012). In addition, agents with the ability to understand emotion have also started to emerge (e.g., Kazemifard, Ghasem-Aghaee, Koenig, Ören, 2011; Kazemifard & Ören, 2013). Emotion is also an important aspect of episodic memory while one unconsciously constructs one’s own episodic memories and can be considered as another context. For instance, Lim, Aylett, Ho, Dias (2011) developed a model which reflects the general features of episodic memory such that memories that provide answers for direct or indirect questions about the context are retrieved by taking into consideration the emotional content and goal-directedness. These recent improvements in theorizing might indicate that the frame problem in artificial intelligence has been extended to include the possibility of using contextual information of various sorts in the environment like human beings do in episodic cognition in general and in episodic memory in particular. What can be learnt from episodic cognition here is that certain frames, namely spatial, temporal, and emotional ones, play a special role in human cognition. They are particularly relevant – as opposed to the many irrelevant frames, as in the AI frame problem. Their role is constitutional and facilitating for memory and other cognitive processes, as opposed to hindering and overwhelming as in AI. They help “grounding” those cognitive processes in dimensions that are most fundamental to humans. The present thesis takes a developmental perspective on the shaping of these most important frames of human cognition during preschool years. Furthermore, this thesis addresses the problem of tracking information across space and time – in our tasks, recent past, present, and near future are concerned. While in the frame problem AI agents struggle with tracking and updating the content of a vast number of mostly irrelevant frames, human cognition may have resorted to mental time travel in order to alleviate this burden. Mental time travel, into the past and future, is an experiential, simulative mechanism by which the individual can mentally re-live or pre-live some event, respectively. The content can be factual or counter-factual, likewise, as in our www, future prediction, story-telling, and counter-factual thinking tasks. Spatio-temporal frames are highly suitable for this mechanism since they are the constitutive and grounding frames for humans. Other frames that do not have this property are not crucial for mental time travel. During cognitive development, between the ages of 3-5 years, which is the age range studied here, these major frames emerge and begin to shape children’s cognitive processing.

The results of the experiments can also be meaningfully discussed in the light of the Global Workspace Theory (GWT; Baars, 1988; Baars, 1997; Shanahan & Baars, 2005). In this theory, it is stated that one may get access to any component of the brain (i.e., the unconscious parts) by the help of one's consciousness. First, the specialized modules working unconsciously and in parallel compete for access to the global workspace and the winner may place the outcome of its computation on the global workbench. This content is then "broadcast" back to the various modules of the mind. However, since consciousness is in the area of working memory (Baars, 1997) and children's working memory is limited, the processes of accessing the global workspace and broadcasting its content back might not be as efficient in children as it is in adults. In GWT, it is claimed that the unconscious systems of the brain shape the objects in one's working memory. Still, in children, this shaping might not be as efficient as it is in adults. One problem may be the fact that the concept of "self" which is the experiential "agent" that integrates the results of the mental computations is still developing in children. Note that autonoesis is a defining feature of episodic cognition as well. When the sense of self starts developing, it would be easier for a child to use some relevant information on the event and relating it to her own self. In our experiment, this pertains to giving answers to the "where" and "when" questions. Since there are explicit clues about "where" and "when" such as "on the other side of the table" and "tomorrow" in the future-prediction task, they might activate the correct frame in the child's mind. In addition, according to the GWT, the objects in one's consciousness are selected from the most significant pieces of information in the environment. Thus, we may argue that during the experiments children could focus on the information that was salient for them, however, some were not indeed relevant to answering the tasks. For instance, in the future-prediction task, instead of selecting the ball (the correct answer), older children selected other football-related items more than the younger ones. Also, in the GWT, it is argued that what is currently in the working memory should be conscious, e.g., input, output, and changed information. However, because of the immaturity of children's concepts, there may be no clear, sharp representations of what is asked to the child. For example, a young child will hardly understand what is meant when s/he is asked about what s/he should select when s/he plays the game "tomorrow" and "on the other side of the table". What is more, in the GWT, it is argued that there is a competition between different images, sensations, and thoughts which try to gain access to working memory. There might be some competition in the child's mind during our experiment, as well. It might be argued that this competition was less than it was in adults since there could be less information in the working memory of a child. However, the easiness of attention disturbance in children might make this competition stronger. Lastly, in the GWT, it is indicated that conscious experience could activate unconscious context which might help to clarify these conscious objects later. In one of our main experiments, namely, in the future-prediction task, the indirect/implicit question about the "space" ("on the other side") and "time" ("right now, tomorrow") should help the child to give an answer regarding "where" and "when" of the event. Overall, it can be argued that the Global Workspace Theory is a suitable cognitive science framework that helps us understand the processes underlying the reasoning of children during our experiments.

The regression results for the future-prediction task, considering each age group separately, indicated a different developmental pattern. 3-year-olds may mostly recruit executive (Day-Night Stroop task) and spatial memory abilities (Corsi-block tapping task), but the negative predictive power of the episodic questionnaire (related to past episodic memory) might show that 3-year-olds engage contrastive processes for episodic past and future thinking. That is, children who get high scores for past episodic cognition tend to get low scores for future episodic cognition. Similarly, the story telling task, i.e., knowledge of future linguistic terms, is marginally predictive for future episodic thinking in this age group which might indicate that mental time travel into the future is not yet supported by linguistic ability. The predictive factors disappear completely at age 4 indicating that episodic future thinking might be in the process of re-organization. This finding is similar to Russell et al.'s (2010) findings showing that age 4 is an intermediate age in respect of mental time travel. At age 5, the linguistic task becomes the main predictor that might show that there is growing importance of language for episodic future thinking and mental time travel. Episodic past memory, however, is negative which might indicate that cognitive abilities underlying past episodic memory are distinct from and contrary to cognitive abilities underlying episodic future thinking.

The results of the age-specific regressions for the future-prediction task depict two systems, one early and one later, which are recruited for episodic future thinking. The early system is composed of executive working memory and visuo-spatial abilities, while the later system is composed of language abilities. The early system was also found in Russell et al. (2010) study in which they argued that episodic future thinking must constitute a spatial dimension which is the proof of imagistic mental time travel. This system could be observed in our study as well, however, only in the youngest age group. The second, language-based system emerges in the oldest age group which can predict episodic future thinking better at that later developmental stage. The relation between the two systems could be explained in two ways. First, the later system might develop after the earlier one and supersede it. However, since mental time travel is inseparably spatial, this claim is not very likely true. Rather, in a second account, spatial and executive abilities still have roles in mental time travel and the language-based system is added to the earlier system, allowing the child to now use symbolic language for a guide in their mental time travel. Suddendorf & Corballis' (2007, 2008) view which states that language is important for episodic future thinking is also in line with our findings. Construing the development of episodic future thinking in terms of two systems, is also related to recent accounts of theory of mind which has been claimed to be related to episodic cognition. In these accounts, it is argued that humans have two systems to track beliefs (Apperly, 2011; Apperly & Butterfill, 2009; de Bruin & Newen, 2011). Apperly (2011) states that the first system includes "low-level" processing systems which depend on perception, perspective-taking, interactive alignment, and social scripts, and is working fast and automatic; while the second system includes "higher-level" language-based mind-reading processes and works slower, however, is more general and flexible. Similarly, a difference between "implicit" perception-based and "explicit" language-based aspects of false-belief understanding has also been put forward (Low, 2010; Low & Perner, 2012). Regarding the development of future episodic cognition and mental time travel, a similar account might be given which is consistent with our findings. Summarizing, our findings suggest that there could be an early developing system based on spatial cognition and executive functioning which could be overlaid and complemented by a later developing language-based system. This two-system account of episodic future cognition needs to be supported by further evidence. Taking a developmental perspective is advantageous since it allows us to study young children's episodic future cognition based only on the first system (3-year-olds), before re-organization occurs (4-year-olds) and the second system emerges (5-year-olds).

Complexity differences between the components of the www task and between the www task and the future-prediction task

When the complexity of the www task and the future-prediction task is compared, it can be observed that the future-prediction task was harder than the www task. This may have been so for the following reasons. First, in the www task the experiment were carried out with familiar objects for children (i.e., a toy car, a ball) while in the future-prediction task, children played with a mini-football game set which they might not have seen until then. Secondly, in the www task, the task was a relatively easy task for children since they just played a hiding game with which they are presumably familiar. However, in the future-prediction task, they played a game which they might not have played until then. Thirdly, in the www task, children were asked the what-where-when questions separately while this was not the case for the future-prediction task. In the future-prediction task, one question included all aspects of the www, i.e., what, where, and when. Fourthly, the future prediction task is more complex than the www task because it involves future rather than past which is harder for children (Busby Grant & Suddendorf, 2005). Lastly, in the future prediction task children had to imagine a change in perspective (other side) and an ensuing change in the badges which make this task harder than the www task.

5.1.2 Results of the Additional Tasks

The Day-Night Stroop task shows a regular development over 3-5 years. Also, it reaches ceiling at age 5. This task might be hard for children because they are both required to remember the two rules, the "novel" rule (saying "night" when seeing the picture of the sun and "day" when seeing the picture of the moon and stars) and the "familiar" rule, which, in addition, they have to suppress in the current task (Gerstadt et al., 1994). In order to do so, executive abilities are needed of which older children have more than younger ones.

Children also showed a significant development in the Corsi-Block Tapping task. Specifically, there was hardly any development between 3 and 4 but then a sudden development was observed between 4 and 5 years of age. Pickering (2001) also stated that the increase in the performance of this task might be either because of development in the capacity of the visuospatial sketchpad or a change in strategic activity. Thus, older children might partially recruit language abilities such as counting or verbal rehearsal which are not available for younger children. In the story-telling task, children developed significantly from nearly zero through the age period of 3-5 years. Still, the performance of older children did not reach the maximum value. This finding might be due to the fact that using "present tense" is always another option for giving an answer for a future question. A "present tense" answer is a pragmatically legitimate answer which renders the results somewhat ambiguous. A child answering in present tense may do so because she does not know the future tense yet or – although she perfectly knows the future tense form – does not use it because she is competent in her pragmatic use of present tense for indicating future. Yet, there was a clear developmental trend for older children to use more future tense than the younger ones.

In the counter-factual thinking task, children also developed significantly. Like in the story-telling task, performance in the counter-factual thinking task also developed from very low values to high values. However, it did not reach ceiling at 5 years. In addition, it was observed that the future counter-factual question ("If I had not drawn on the piece of paper, which box would it be in?") was answered less correctly than the hypothetical one ("If I erase the drawing I just did, which box will the paper go in?").

Lastly, children's performance in the episodic memory questionnaire developed significantly. However, children were very good at both the "where" component and the "what" component which is different from the results of the www task. In the www task, only the "what" component was recalled best. The reason behind this might be the fact that the www information is distributed in the episodic memory questionnaire where each question asks about only one component as compared to the www task where all three components are asked for a single item.

5.1.3 The Results of the Regression Analyses

5.1.3.1 The www task

Overall, the www task was predicted by the Day-Night Stroop task, the story-telling task, and the episodic memory questionnaire. The www task could be predicted by the Day-Night Stroop task because in both tasks children may have needed to focus their attention in order to select the correct answer. They need to memorize the instruction and selective attention to report the exact what/where/when information for any given items but not any other, at each new item, hence, some inhibition over a prolonged period of time is necessary. Also the Stroop Task shows the same developmental trajectory as does the www task; hence a positive correlation can show up in the regression. In addition, it must be that within any age group this positive relation also holds across some range of variability such that the entire variance in the overall regression is not fully consumed by the age factor.

The story-telling task is also a good predictor for the www task because of its reference to time and order. There is a “time line” in the www task as well: which item came first, which second, which third. They are all in the past, however, the earlier ones are more remote in the past than the later ones, so when children start recalling the first item and then continue, they are going “forward in time” – which is similar to the past-present-future direction. Also, the developmental trajectory of this task is the same as in the www task; hence the same positive relation between the two tasks may manifest itself across and also within age groups.

The episodic memory questionnaire is a good predictor for the www task, as expected, because both have the same www components, although they are combined in the www task but distributed in the episodic memory questionnaire. Thus, they cross-validate each other.

5.1.3.2 The future-prediction task

The future-prediction task was predicted marginally by the story-telling task or by the counter-factual thinking task, respectively. The reason behind the fact that the story telling task predicted the future-prediction task (at least marginally) might be because of the fact that knowledge of the linguistic forms of future tense are helpful for succeeding in the future prediction task in particular. A child who has command over psychological and linguistic aspects of the time concept (in particular: future tense) will straightforwardly know what she is asked about when the experimenter asks about playing the game on the other side “right now” or “tomorrow”, and will be able to give proper answers, in terms of the time concept and choice of the correct linguistic form. In addition, the story-telling task may be a good predictor for the future-prediction task because of its episodic and mental time travel aspect. Children, when asked “what will Ayse do?” in the story-telling task, may also engage in future mental time travel and imagine Ayse going on a picnic.

The counterfactual thinking task also predicted the future-prediction task (marginally). This might be due to the fact that these two tasks have a similar structure. Like in the counterfactual thinking task (collapsed over the various sub-questions), in the future prediction task, in both conditions (present and even more, future) children have to imagine themselves in a situation which is different from the current situation. In addition, both tasks rely on some linguistic knowledge about time and on the ability to mentalize episodes in which different conditions hold. Lastly, they show the same developmental trajectory, allowing that a positive correlation among them across and within age groups arises.

Our findings are consistent with the literature which indicates that language ability explains significant variation in children's counterfactual thinking (Beck, Riggs, & Gorniak, 2009). Therefore, it is not surprising that the future-prediction task could be explained both by both the story telling task and by the counterfactual thinking task, respectively.

5.2 Conclusion

To conclude, it can be stated that the main tasks and the additional tasks of this study are suitable tests for episodic cognition and, additionally, they are also valuable from a cognitive science point of view. In particular, the www task and the future-prediction task predicted the regular development of preschool children for episodic cognition. Furthermore, the effects of additional tasks on the main tasks revealed that the www task had some executive, linguistic aspect and the future-prediction task had linguistic as well as counterfactual aspects.

All experiments carried out in this study require some conscious processes that are in the area of working memory. As the Global Workspace Theory (GWT) puts forward, there is unconscious contextual information in the brain which has effects on the conscious processes in working memory. This unconscious data also includes the mental representation of time. Since the representation of time seems to be working massively parallel, it could be represented by a connectionist network. In simple recurrent connectionist networks, time is represented indirectly and when one is asked about anything that is related to time, one would be giving an answer by using one's unconscious contextual information. Thus, this temporal aspect could be represented implicitly in a connectionist network. In young children this unconscious contextual data which might be used in the experiments may lack resources, or might not be there at all because of the immaturity of the developing child's brain. In that case, the connection between the conscious and unconscious parts of the brain will not have developed yet which may lead to unsuccessful experimental results.

While carrying out the experiments, one of the most important requirements was that the child should update his/her beliefs when there is a necessity of change in the task. For instance, in the future-prediction task, the child is asked about the other day and the other side of the table which indicates a clear change in the task. This issue can be considered in relation with the Bayesian models of belief updating which entails belief updating in a rational agent when it encounters new data (Griffiths et al., 2008). This area of study has strong relations with Artificial Intelligence (AI). Some AI models have been developed which try to model episodic memory (e.g., Lim, Aylett, Ho, and Dias, 2011). However, in these kinds of models it is not very clear whether episodic memory is really episodic since there is no real sense-of-self in the model. Also, to the best of our knowledge, there is no mental time travel in this kind of AI models. The present study strongly suggests relating studies in the area of episodic cognition and AI models which thereby could be developed more efficiently. Taking a developmental perspective is valuable since it sheds light on the emergence of the most fundamental cognitive frames of mind, namely spatial and temporal ones. Within these frames humans reason about events, track them, and update their beliefs about them. This tracking and updating might be accomplished *via* mental time travel during which the individual moves along those mental frames, as an integrated agent, a self that experiences and simulates those events in the past, present, or future.

Regarding the age-specific regressions, the results indicated that for the www task while initially executive functioning and visuo-spatial abilities are predictive for the 3- and 4-year-olds, this situation changes for the 5-year-olds. That is, none of the additional tasks could predict the www task anymore. These results suggest that episodic memory of past might depend mainly on working memory abilities for younger children, but for older ones it is not since these abilities reach ceiling at that age. For the future-prediction task, the results revealed that for younger children executive functioning and visuo-spatial abilities may be recruited for episodic future thinking, whereas for older children linguistic abilities seem to become more crucial. This finding is consistent with a two-systems approach to future episodic cognition where an early visuo-spatial-based working memory system is complemented by a later language-based system.

In conclusion, this study in general aimed to shed light on the novel and still strongly developing areas of cognitive science, i.e. episodic cognition and mental time travel, from a developmental perspective. It was concerned in particular with the development of the reasoning and/or simulation ability of children across different temporal distances. With its inter-disciplinary scope, this study goes beyond developmental psychology and aims to also contribute to the field of cognitive science.

5.3 Limitations and Future Research

5.3.1 Limitations of the Study

Although the age range from 3-5 years was properly chosen, in some tasks children did not reach ceiling yet, e.g., in the story-telling task and in the future condition of the future prediction task. In particular, in the latter, it would have been important to know at what age the representational demand for answering correctly in the future condition would have been decreased to the extent that the proper episodic item would have been chosen. Extending the study to include 6-7-year old children would therefore be a good idea.

With regard to the future prediction task we cannot be fully sure whether the episodic item was retrieved through semantic or episodic memory processes. A solution how to resolve this remaining ambiguity will be suggested below.

Another limitation of this study was of more practical nature: there was no single experimental room but it varied from kindergarten to kindergarten. It would have been easier, also in terms of formulating the items of the incidental episodic memory questionnaire, if a room that is the same for everyone, would have been available.

A final limitation was that in the future-prediction task, the football game had been chosen. On the one hand, it was good for motivational reasons and for reasons of familiarity with the game. On the other hand, the game could be different (e.g., less well-known) than the football game so that children are not affected by their prior knowledge of the game.

5.3.2 Suggestions for Future Research

First of all, since we cannot be sure whether the episodic item in the future prediction task is retrieved through semantic or episodic memory, there may have to be other, additional, measures that hint at the episodic mode of processing in the future prediction task, e.g., one may have ask the children how they arrived at their answer: did they imagine being on the other side, or did they know it? A carefully conducted post-experimental interview could provide valuable information for resolving this remaining ambiguity.

Secondly, the "other" condition of Russell et al. (2010) could be added to the future-prediction task in order to investigate why, at the age of 4 years, it may be easier to answer the future question for another person than for oneself: "What does the other person need in order to play the game on this side tomorrow?" This is relevant to the eminently important questions whether understanding oneself occurs before understanding the other or understanding the other occurs before understanding one-self (Prinz, 2012).

Thirdly, the www task may also be used for future cognition: instead of asking the child to remember where the items had been hidden, one may ask the child to remember, where, sometime later, we want to hide the items (i.e., "prospective memory": remembering to do something at some later point in time). This might be very hard for children, but it is a very important aspect of future-based cognition.

Fourthly, since all tasks are language-based to some extent, using the Turkish version of the CDI (Child Development Inventory; e.g., Acarlar, Aksu-Koç, Küntay, Maviş, Sofu, Topbaş, Turan, 2009) might have helped to assess children's general language ability and factor this aspect out.

Lastly, like with our story-telling task, the linguistic categories of time (past – present – future) can be explored more experimentally: at what age do Turkish children comprehend and produce the various temporal markers (adverbs, tense morphemes, etc.)? Subsequently, the effect of these categories on episodic cognition and mental time travel should be investigated.

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APPENDICES

APPENDIX A: EXPERIMENTS

The Pictures Used in the Story-Telling Task

The List of Classical Episodic Memory Questionnaire

1. (What): Can you tell me the names of the items that we did not use during the toy-hiding game?
2. (What): What was the color of shoes/whistle/hat/t-shirt in our football game?
3. (What): What was the name of girl in our story-telling game?
4. (Where): In the football game, in which side did you play the game?
5. (Where): Where did Ayşe and her mother go after they went to picnic in our story-telling game?
6. (Where): Where was the ball before we played the football game?
7. (When): Did we play the day/night game before, or the football game before?
8. (When): Did Ayşe play basketball first or fly a kite in our story-telling game?
9. (When): Did I or you wear the badge first?

APPENDIX B: MORE INFORMATION ABOUT COLLINEARITY

Collinearity information related to the regression of the www task and the predicting tasks (Day-Night Stroop task, Corsi-Block Tapping task, story-telling task, and episodic questionnaire)

Table 59 represents the collinearity diagnostic results for the www task and the additional tasks (i.e., Day-Night Stroop task, Corsi-Block Tapping task, and episodic questionnaire). Ideally, collinearity is zero (or low), indicating that the factors explain separate parts of variance and combine linearly. In Table 59, age loads highly (99%) on a single dimension. However, all other additional tasks share dimensions, thus showing a somewhat hybrid character. For instance, on the 5th dimension, the Day-Night Stroop task and the total of the episodic questionnaire explain common variance as they predict the www task. Also, on the 4th dimension, the episodic questionnaire and the story-telling task share similar proportions. All these might indicate that these tasks were correlated to various degrees since they all develop by the age factor. Also, it is clear that except the story-telling task all other tasks also load somewhat on the 6th dimension "age".

Table 59 The collinearity diagnostics results for the www task (criterion) and the predicting tasks

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions: (Constant)	Age of the child	Day-night stroop task	Corsi-block tapping task – total # of correct answers	Story-telling task – total # of future tense used	Total of questionnaire
1	1	1,980	1,000	,01	,01				
	2	,020	9,900	,99	,99				
2	1	5,595	1,000	,00	,00	,00	,00	,01	,00
	2	,285	4,434	,01	,00	,00	,01	,61	,00
	3	,062	9,523	,11	,00	,01	,72	,00	,00
	4	,036	12,517	,26	,00	,01	,07	,38	,49
	5	,017	18,356	,32	,00	,70	,01	,00	,35
	6	,007	28,541	,29	,99	,27	,20	,00	,15

Collinearity information related to the regression of www task and the predicting tasks (Day-Night Stroop task, story-telling task, and episodic questionnaire)

Table 60 represents the collinearity diagnostic results for the www task and some additional tasks (i.e., Day-Night Stroop task, story-telling task, and episodic questionnaire). This table also indicates that the Day-Night Stroop task shares some of its variance with age on the 5th dimension and story-telling task and episodic memory questionnaire share similar proportions on the 3rd dimension. In addition, on the 4th dimension, the episodic questionnaire and the Day-Night Stroop task have some proportions in common which might mean that focusing on some episodic questions requires executive functioning.

Table 60 The collinearity diagnostics results for the www task (criterion) and the predicting tasks

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions				
				(Constant)	Age of the child	Day-night stroop task	Story-telling task – total # of future tense used	Total of questionnaire
1	1	1,980	1,000	,01	,01			
	2	,020	9,900	,99	,99			
2	1	4,664	1,000	,00	,00	,00	,01	,00
	2	,274	4,124	,02	,00	,00	,60	,00
	3	,037	11,215	,37	,00	,00	,38	,42
	4	,017	16,714	,35	,01	,66	,00	,39
	5	,008	23,687	,26	,99	,34	,01	,19

APPENDIX C: INFORMED CONSENTS FOR ALL EXPERIMENTS

Sayın Veli,

Orta Doğu Teknik Üniversitesi Enformatik Enstitüsü Bilişsel Bilimler Bölümü'nde doktora öğrencisiyim. Doktora tezim kapsamında "Okul Öncesi Türk Çocuklarında Olaysal Biliş ve Zihinsel Zaman Yolculuğunun Gelişimi: Ne, Nerede, ve Ne Zaman" başlıklı bir tez çalışması yürütmekteyim. Bu çalışmada, amacımız, Olaysal Bellek ve Zihinsel Zaman Yolculuğu'nun gelişimini ve bunların İşler Bellek ile olan ilişkisini okul öncesi çocuklarda incelemektir. Bu amacı gerçekleştirebilmek için çocuklarınızla bazı "davranışsal hafıza deneyleri" yapmaya ihtiyaç duymaktayım.

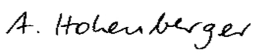
Bu çalışmada çocuklara 6 farklı davranışsal hafıza deneyi ve 1 tane de anket yapılacaktır. Ana deney olarak ne-nerede-ne zaman (saklambaç) deneyi ve geleceği tahmin etme deneyi yapılacaktır. Ne-nerede-ne zaman deneyinde çocuklardan bölmeleri olan bir kutuya üç tane oyuncak saklamaları istenecek ve sakladıktan sonra oyuncakların hangisini, nereye, ne zaman sakladıklarını bulmaları istenecektir. Geleceği tahmin etme deneyinde, çocuklar, kolay bir masa futbolu oyunu oyuncaklar, oyunda kırmızı ya da yeşil taraf olacaklar ve oyun bittikten sonra eğer ertesi gün karşı tarafa geçip oynasalardı ne yapmaları gerektikleri sorulacaktır. Ek olarak, çocukların gelecek zamanı anlamalarını inceleyen bir hikaye anlatma deneyi ve karşıolgusal düşünce gelişimini inceleyen bir deney yapılacaktır. Bunların dışında, beynin yönetici fonksiyonlarını ölçen diğer 2 deney (Gündüz/Gece Stroop Testi ve Corsi Blok Tıklama Testi) ve test seansı ile ilgili olaylar hakkında tesadüfi Olaysal Zaman soruları içeren anket de yapılacaktır. Deney toplam 15 dakika sürmektedir.

Çalışmaya katılım tamamıyla gönüllülük çerçevesindedir. Hem sizin onayınız hem de bu çalışmaya katılması için çocuğunuzun gönüllü olması bir ön şarttır. Katılmasına izin verdiğiniz takdirde deneyleri kreşte oyun saatinde gerçekleştireceğiz. Çocuğunuzun katılacağı deneylerin onun psikolojik gelişimine olumsuz etkisi olmayacağından emin olabilirsiniz. Çocuğunuz bu deneylerdeki cevapları kesinlikle gizli tutulacak ve bu cevaplar sadece bilimsel araştırma amacıyla kullanılacaktır. Katılım sonunda, herhangi bir maddi yarar sağlanmamaktadır. Bu formu imzaladıktan sonra çocuğunuz katılımcılıktan ayrılma hakkına sahiptir. Çalışma sırasında da çocuğunuz herhangi bir sebepten ötürü çalışmayı yarıda bırakmakta serbesttir.

Çocuğunuzun deneylere katılarak bize sağlayacağı bilgiler çocukların bilişsel gelişimlerini incelemek adına önemli katkılarda bulunacaktır. Araştırmayla ilgili sorularınızı aşağıdaki e-posta adresini veya telefon numarasını kullanarak bize yöneltebilirsiniz.

Saygılarımızla,

İmza



Dr. Annette Hohenberger

İmza

Gülten Ünal

Lütfen bu araştırmaya çocuğunuzun katılması konusundaki tercihinizi aşağıdaki seçeneklerden size en uygun geleni daire içine alarak ve *imzanızı atarak belirtiniz ve bu formu çocuğunuzla kreşe geri gönderiniz.*

Yukarıda açıklamasını okuduğum çalışmaya, oğlum/kızım ____________________’nin katılımına izin veriyorum/ izin vermiyorum. Ebeveynin:

Adı, soyadı: _________________ İmzası: ___________ Tarih: _____________

Araştırmacının Adresi:

Bilişsel Bilimler Bölümü Öğretim Üyesi

Orta Doğu Teknik Üniversitesi, Ankara

Tel: 0 312 210 3789

e-posta: hohenberger@ii.metu.edu.tr

Araştırmacının Adresi:

Bilişsel Bilimler Bölümü Doktora Öğrencisi

Orta Doğu Teknik Üniversitesi, Ankara

Tel: 0 505 499 7548

e-posta: e156776@metu.edu.tr

Çocuğunuzun katılımı ya da haklarının korunmasına yönelik sorularınız varsa ya da çocuğunuz herhangi bir şekilde risk altında olabileceğine, strese maruz kalacağına inanıyorsanız Orta Doğu Teknik Üniversitesi Etik Kuruluna (312) 210-37 29 telefon numarasından ulaşabilirsiniz.

APPENDIX D: CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Ünal, Gülten

Nationality: Turkish (TC)

Date and Place of Birth: 28 Sep 1983, Ankara/TURKEY

Marital Status: Single

Phone: +90 505 499 75 48

E-mail: gultenunal@gmail.com

EDUCATION

Degree	**Institution/Department**	**Year of Graduation**
M.S.	Middle East Technical University, Ankara/ Cognitive Science	2008
B.S.	Atılım University, Ankara/ Computer Engineering	2006

SCHOLARSHIPS

- Scholarship from TÜBİTAK through Ph.D.
- 2008-2009 Academic year METU Best Thesis Award Winner as M.Sc. Thesis
- METU M.Sc. Course Performance Award, Best Student in M.Sc. Program
- Scholarship from TÜBİTAK through M.S.
- Full scholarship during college, Atılım University

LANGUAGES

Turkish: Native
English: Advanced
Ottoman Turkish, Japanese: Beginner

PUBLICATIONS

Papers

Ünal, Gülten and Hohenberger, Annette (2014). The development of episodic cognition and mental time travel in Turkish preschoolers: what, where, and when. Manuscript submitted for publication.

Ünal, Gülten and Hohenberger, Annette (2014). Release from proactive interference (RPI) and its relations to executive functions: A developmental study on Turkish children. Manuscript in preparation.

Ünal, Gülten and Hohenberger, Annette (2014). The Turkish Listening Span Test: A methodological developmental study on Turkish school children. Manuscript in preparation.

Oral Presentations

Ünal, Gülten and Hohenberger, Annette (2014). The development of episodic cognition and mental time travel in Turkish preschoolers: what, where, and when. 22nd Annual Meeting of the European Society for Philosophy and Psychology, Noto, Sicily, September 16-19, 2014.

Ünal, Gülten and Hohenberger, Annette (2013). The development of episodic cognition and mental time travel in Turkish preschoolers: what, where, and when. The Fifth International Conference of Cognitive Science, Tehran, Iran, May 7-9, 2013.

Ünal, Gülten (2009). İleriye doğru bozucu etkiden kurtulma ve bunun yönetici fonksiyonlarla olan ilişkileri: Türk çocuklarında gelişimsel bir çalışma. VIII. Ulusal Sinirbilimleri Kongresi, Bolu, Türkiye, 18 – 22 Nisan 2009.

Ünal, Gülten (2008). İleriye doğru bozucu etkiden kurtulma ve bunun yönetici fonksiyonlarla olan ilişkileri: Türk çocuklarında gelişimsel bir çalışma. 2. Psikoloji Lisansüstü Öğrencileri Kongresi, Ilgaz, Türkiye, 26 - 29 Haziran 2008.

Poster Presentations

Ünal, Gülten (2012). The Acquisition and Development of Connectives in Turkish children. Poster presented at the 16th International Conference on Turkish Linguistics, Ankara, Turkey, 18 – 21 September 2012.

Ünal, Gülten and Hohenberger, Annette (2009). Release from proactive interference (RPI) and its relations to executive functions: A developmental study on Turkish children. Poster presented at the XIV European Conference on Developmental Psychology, Vilnius, Lithuania, 18 – 22 August 2009.

Ünal Gülten, Özge Duygu, Hohenberger Annette, and Marinis Theodoros (2009). The Turkish Listening Span Test: A methodological developmental study on Turkish school children. Poster presented at the XIV European Conference on Developmental Psychology, Vilnius, Lithuania, 18 – 22 August 2009.

Ünal Gülten, Özge Duygu, Hohenberger Annette, and Marinis Theodoros (2009). The Turkish Listening Span Test: A methodological developmental study on Turkish school children. Poster presented at the 6th International Cognitive Neuroscience Meeting, Marmaris, Turkey, 14 - 18 April 2009.

Ünal, Gülten and Hohenberger, Annette (2008). Release from proactive interference (RPI) and its relations to executive functions: A developmental study on Turkish children. Frontiers in Human Neuroscience. Conference Abstract: Xth International Conference on Cognitive Neuroscience, Bodrum, Turkey, 1st - 5th September 2008. doi: 10.3389/conf.neuro.09.2009.01.325.

Ünal, Gülten and Hohenberger, Annette (2008). Release from proactive interference (RPI) and its relations to executive functions: A developmental study on Turkish children. Poster presented at the 5th International Cognitive Neuroscience Meeting, Marmaris, Turkey, 17 - 21 May 2008.

TEZ FOTOKOPİ İZİN FORMU

ODTÜ
ENFORMATİK ENSTİTÜSÜ

YAZARIN

Soyadı : ÜNAL

Adı : GÜLTEN

Bölümü : BİLİŞSEL BİLİMLER

TEZİN ADI (İngilizce) : THE DEVELOPMENT OF EPISODIC COGNITION AND MENTAL TIME TRAVEL IN TURKISH PRESCHOOLERS: WHAT, WHERE, AND WHEN

TEZİN TÜRÜ : Yüksek Lisans .... Doktora X

1) Tezimden fotokopi yapılmasına izin vermiyorum. ☐

2) Tezimden dipnot gösterilmek şartıyla bir bölümünün fotokopisi alınabilir. ☐

3) Kaynak gösterilmek şartıyla tezimin tamamının fotokopisi alınabilir. X

Yazarın imzası .... Tarih 08.05.2014