Türk Psikiyatri Dergisi 2008; 19(3)
Turkish Journal of Psychiatry

Change with Age of Information Processing Meta-Operations in Children

Kizbes YALÇIN, Sirel KARAKAŞ

Abstract

Objective: *The aim of this study was to examine meta-systems of cognition and their development,and the pattern of relationships between types of information processing, executive functions, mental ability, and level of cognitive development in children.*

Method: *The sample consisted of 80 healthy children (39 female and 41 male). Meta-cognition was measured with the Word List and Evaluation of the Degree of Correctness of Knowledge, Feeling of Knowing, and Criterion Test. Executive functions were assessed using the Wisconsin Card Sorting Test (WCST) and the TBAG form of the Stroop Test. Mental ability was assessed using Raven's Standard Progressive Matrices (RSPM). Level of cognitive development was assessed using the Logical Reasoning Test (LRT).*

Results: *MANOVA and correlation analyses showed that meta-memory, executive functions, mental ability, and level of cognitive development increased up to the age of 11 years. There were low correlations between executive function and meta-memory test scores, and LRT. There was a low correlation between meta-cognition score and LRT score. There was a low to medium correlation between meta-cognition score and RSPM score. Principal component analysis showed that by 11 years of age, cognitive patterns in the children began to resemble those of adults.*

Conclusion: *The study showed that the cognitive structure of the children was different from that of adults, as executive functions and meta-cognitive processes in children were similar, but not identical. These processes did not entirely match the Piagetian stages of cognitive development. The results of this study are discussed within the context of the related literature.*

Key Words: *Meta-cognition, executive functions, cognitive development, age, gender*

INTRODUCTION

An effective cognitive system is able to protect schemata and related cognitive elements, and to change/arrange or recreate these elements as needed. It should be resistant to the debilitating effects of the environment, scan the memory and track memory cues and play a role in planning cognitive processes (Karakaş and Karakaş 2000). All of these operations are a part of human information processing, collectively referred to as executive functions. Executive functions are involved in abstraction processes, such as conceptualization, perseveration, ability to maintain cognitive configurations, and learning (Heaton, 1981; Spreen and Strauss, 1991; Lezak, 1995).

A similar concept rooted in the cognitive-experimental literature–meta-cognition–involves one's awareness of his/her mental operations and his/her ability to direct them towards goals (Dienes and Perner, 1999; Crick, 2000). The target-level launches and completes the operations in meta-cognition. Meta-cognition is at the top of the cognitive system hierarchy and monitors operations in the target-level. This monitoring and awareness allow

Received: 23.03.2007 – **Accepted:** 04.12.2007

Kızbes Yalçın MD., e-mail: *kyalcin2004@yahoo.com*

individuals to "know what is known". Meta-cognition provides both retrospective monitoring and prospective monitoring (Nelson and Narens, 1990). It consists of a cognition type that is widely studied in the field of cognitive psychology area–memory. Memory processes involve retrospective monitoring, such as recognition and recall, as well as prospective monitoring processes such as feeling of knowing (FOK). The FOK paradigm is one's judgment about whether s/he can recall a memory in some future memory test that s/he does not currently recall.

According to Piaget's theory of cognitive development, the abstraction stage of development is marked by cognitive abilities, such as cognitive flexibility and abstraction, mentally testing hypotheses, reasoning, and problem solving (Gander and Gardiner, 1998; Ergenç, 2001). Another characteristic of this stage is thinking for the sake of thinking (Aydın, 1997). These characteristics of abstract reasoning are involved in executive functions and meta-cognitive processes. At a specific point of cognitive development (which is adolescence according to Piaget) it is possible one to process on what s/he is thinking/processing mentally. This ability develops with age and as age increases, meta-cognitive abilities evolve (Koriat, 1993). Moreover, researchers indicate that FOK judgment improves from childhood to adolescence (Zabrucky and Ratner, 1986); however, some researchers (Butterfield et al., 1988; Lockl and Schneider, 2002) argue that the quality of FOK judgment does not follow a developmental trend.

It has been suggested that there is a relationship between performance in abstract operations and general intelligence (Hooper et al., 1985), and working memory (Taylor, 1998). Shute and Huertas (1990) reported that there is a strong relationship between abstract operations and executive functions.

During memory performance, 2 potential responses are possible: remembering and not remembering, in other words, knowing (K+) and not knowing (K-). One's evaluation of his/her memory performance (meta-memory) has 3 possible responses in retrospective meta-cognition. In retrospective memory, there are two components: one is the evaluation of the correctness of responses (correct or incorrect or undecided) and other is the correctness of the responses based on reality (correct or incorrect).

In this way, if a person is confident of what s/he knows, s/he might know what s/he knows (K+ K+) (1). If not confident, this means s/he does not know what s/he knows(K+ K-) (1). If one cannot evaluate what s/he knows, but provides a correct response, then it means s/he cannot accurately judge his/her knowledge, (K+ K0) (1). If one is confident of his/her answer, which is actually incorrect, this means s/he does not know what s/he knows, (K- K-) (1). If not confident with the accuracy of the response, it means s/he knows what s/he does not know (K- K+) (1). If a person does not evaluate his/her knowledge and gives an incorrect response, then it is (K- K0) (1).

Prospective meta-cognitions are presented in Table II. During memory performance there can be 2 potential responses: knowing (K+) and not knowing (K-). FOK judgment involves 3 responses: the first 2 are decisions about whether the response is correct or incorrect and the other is lack of an evaluation of one's own knowledge. These response probabilities make a 2 × 3 matrix. The correctness of the response involves correct or incorrect responses, while the judgement of FOK involves participant's reactions in test of feeling of knowing in the recognition test.

In this way, if one reports a high degree of FOK and gives a correct response on CT, s/he knows what s/he will know (K+ K+) (2). If one reports a low degree of FOK and gives an incorrect response on CT, s/he knows what s/he will not know (K- K+) (2). If one has no judgment about whether s/he will give correct information, but gives a correct response, s/he cannot evaluate what s/he knows (K+ K0) (2). If one reports a low degree of FOK, but gives a correct response, then s/he does not know what s/he knows (K + K-) (2). If one reports a high degree of FOK, but gives an incorrect response, s/he does not know what s/he will not know (K- K-) (2). If one has no judgment about FOK and gives an incorrect response, s/he does not evaluate what s/he can know and gives an incorrect response (K- K0) (2) (Karakaş et al., 2003; Bekçi and Karakaş, 2006).

A search of the literature did reveal any studies that focused on both executive function and cognitive development in addition to meta-cognition in children. The sub-types of meta-cognition were previously studied in adults (Karakaş et al. 2003, Bekçi and Karakaş 2006), but the development of these sub-types has not been studied in children. The present study aimed to examine the cognitive meta-systems and their development in children, and to investigate the pattern of relationships between the types of information processing, executive functions, and level of Piagetian cognitive development in children.

Table I. Conditional combination of meta-cognitive reactions and correctness of the recalled information (retrospective meta-cognition).

Participant's evaluation ofthe correctness of his/her response	Correctness of the response in reality: Correct	Correctness of the response in reality: Incorrect
Correct	Knows what s/he knows K+ K+ (1)	Does not know what s/he does not know K- K- (1)
Undecided	No evaluation, but correct response K+ K0 (1)	No evaluation, but incorrect response K- K0 (1)
Incorrect	Does not know what s/he knows K+ K- (1)	Knows what s/he does not know K- K+ (1)

METHOD

Participants

The study included 84 children (42 female, 42 male) aged between 8 and 14 years. They were selected from among students attending primary schools in Mamak and Çankaya in Ankara, Turkey. The outliers were extracted from the study and, thus, the sample consisted of 80 children (39 female and 41 male). There were 11 children in 2nd grade (13.8%), 9 in 3rd grade (11.3%), 12 children each in 4th, 5th, 6th, and 7th grades (15%), and 12 children in 8th grade (15%). The socioeconomic level (SES) of the participants was determined with the codes that reflected the socioeconomic status of the districts in which they lived (DIE, 2000). There were 27 children (33.8%) with a high SES, 26 children with a medium SES (32.5%), and 27 children (33.8%) with a low SES.

Participants were selected from among children that had no psychiatric or neurological disorder, no visual, auditory,or speech impairment, and those that did not use any medication that might have affected their cognitive ability. Students that had these qualities and at least average academic performance were included in the study.

INSTRUMENTS

Wisconsin Card Sorting Test (WCST)

WCST measures the ability to deduce a classification principle based on ongoing feedback about the correctness of the responses, and the abilility to dismiss this principle when it leads to aversive behavioural consequences. Moreover, it assesses the ability to selectively attend to 1 part of a stimulus and to abandon the principle when receiving feedback about the incorrectness of his/her responses (King and Snow, 1981; Pendleton and Heaton, 1982; Karakaş and Başar, 1993).

TBAG Form of Stroop Test

The Stroop Test assesses the ability to flexibly direct attention to the presence of a distraction, inhibit a habitual behavioral pattern, and display non-usual behavior (Spreen and Strauss ,1991).

Raven's Standard Progressive Matrices Test (RSPM)

RSPM measures non-verbal analytical thinking, working memory, analytical investigation, problem solving, systematic thinking, abstraction, and speed of mental operations. As such, it measures some aspects of executive functioning (Karakaş, 2004).

Logical Reasoning Test (LRT)

LRT was developed by Burney (1974) based on original questions of Piaget and his colleagues. It is a self-report paper and pencil test. The level of cognitive development can be predicted from the total score obtained (Ardaç, 1984).

Functions of Meta-cognition

Word List and the Evaluation of the Degree of Correctness of Knowledge (EDCK): We utilized a list that consisted of word pairs, each of which was presented to participants for 2 seconds (Bekçi, 2004). After a practice session, the first words were given orally and subjects were requested to provide the second words. Subjects were required to verbally evaluate the correctness of each of their responses (i.e. word) on a 5-point-Likert-type scale.

Feeling of Knowing (FOK): The first words on the word list were presented to the participants on a sheet. They were then asked to make a verbal judgment about their FOK for each non-remembered word on a 5-point Likert-type scale.

Criterion Test (CT): In accord with the literature (Tekcan and Aktürk, 2001), we provided participants with a multiple choice recognition test (CT). This test measures the ability to recognize the second word of each

Table II. Conditional combination of meta-cognitive reactions and correctness of the information that will be recognized (prospective meta-cognition).

Participant's feeling of knowing the correctness of his/her response	Correctness of the response in reality: Correct	Correctness of the response in reality: Incorrect
Correct	Knows what s/he will know K+ K+ (2)	Does not know what s/he will not know K- K- (2)
Undecided	No evaluation, but correct response K+ K0 (2)	No evaluation, but incorrect response K- K0 (2)
Incorrect	Does not know what s/he will know K+ K- (2)	Knows what s/he will not know K- K+ (2)

word pair on the list. It consists of 1 correct answer (i.e. second word on the word list) and 3 incorrect answers.

All the participants were also evaluated with the Information Form on Healthy Child Sample (Karakaş, 2004).

PROCEDURE

One researcher administered all the tests to each child individually in 3 sessions. In 1 session, RSPM and LRT were administered, WCST in another session,and in the third session Stroop Test TBAG form, Word List, FOK, and CT were administered in a counter-balanced order. The order of the sessions was also counter-balanced.

Considering that 11-12 years of age marks the beginning of the abstract operation stage, we conducted separate analyses for children younger than 11 years and for those older than 11 years. The first group consisted of 40 children (17 female, 23 male) aged 90-132 months (mean: 100.85 ± 13.10 months, 8-11 years old). The second group included 40 children (22 female, 18 male) aged 132-172 months (mean: 152.70 ± 12.13 months, 11-14 years old). We conducted independent sample t-tests to examine the differences between males and females, in terms of each test score. We utilized multivariate analysis of variance (MANOVA), Pearson's correlation analysis, and principle component analysis to investigate the relationships between the test scores.

RESULTS

As presented in Table III, we observed that some cognitive test scores increased and reaction times decreased as age increased.

As given in Table IV, we observed that recognition performance of the girls was better than that of the boys, whereas, boys gave fewer incorrect responses than the girls and had better judgment of their performance.

Participants in the medium SES group had better test scores than those in the high and low SES groups (Table V).

Relationship Between Age and Test Scores

There were significant relationships observed between age, and K+ K+ (1) ($r = 0.30$, $P < .01$), K- K- (1) ($r = –0.30$, $P<0.01$), and K- K- (2) ($r = –0.26$, $P<0.05$). Age had a significant positive correlation with the total number of correct recallson the Word List Test and the number of words that were phonetically/semantically similar to correct words.

There was a significantly positive relationship between age, and WCST 3 ($r = 0.33$, $P<0.01$), WCST 4 ($r = 0.47$, $P<0.01$), WCST 10 ($r = 0.36$, $P<0.01$), and WCST 11 ($r = 0.42$, $P<0.01$), whereas there was a significant negative correlation between age, and WCST 1 ($r = –0.38$, $P<0.01$), WCST 2 ($r = –0.46$, $P<0.01$), WCST 5 ($r = –0.39$, $P<0.01$), WCST 6 ($r = –0.40$, $P<0.01$), and WCST 8 ($r = –0.39$, $P<0.01$). Age had significant negative correlations with duration of the Stroop Test TBAG form section 1 ($r = –0.54$, $P<0.01$), section 2 ($r = –0.34$, $P<0.01$), section 3 ($r = –0.49$, $P<0.01$), section 4 ($r = –0.59$, $P<0.01$), and section 5 ($r = –0.50$, $P<0.01$). We observed significant negative correlations between age and the number of errors in section 5 ($r = –0.23$, $P<0.05$), and the number of corrected responses in section 5 ($r = –0.23$, $P<0.05$) of the Stroop Test TBAG form.

There were also significant positive relationships between age, and RSPM A ($r = 0.39$, $P<0.01$), RSPM B ($r = 0.50$, $P <0.01$), RSPM C ($r = 0.40$, $P <0.01$), RSPM D ($r = 0.55$, $P <0.01$), and RSPM E ($r = 0.49$, $P <0.01$). Age was negatively correlated with RSPM duration ($r = –0.79$, $P <0.01$). We also observed asignificant relationship between age and LRT score ($r =0.47$, $P <0.01$).

Relationship Between Executive Functions and Meta-Cognitive Functions

We observed significant relationships between WCST 4 and K- K- (1), between WCST 7 and K- K0 (1), between WCST 5 and K+ K0, and between WCST 8 and K+ K0. There were significant relationships be-

Table III. The effect of age (younger than 11 years and older than 11 years) on tests scores: Results of multivariate analysis of variance (MANOVA).

Tests	Total squares	SD	Average squares	F	Significance level	Post Hoc Analysis
Stroop 1. section duration	80.4	1	80.4	18.30	0.000	Older< Younger***
Stroop 2. section duration	472	1	472	6.52	0.013	Older< Younger*
Stroop 3. section duration	85.2	1	85.2	7.93	0.007	Older < Younger**
Stroop 4. section duration	336.7	1	336.7	8.44	0.005	Older < Younger**
Stroop 5. section duration	1298.3	1	1298.3	10.36	0.002	Older < Younger**
RSPM B	58.6	1	58.6	7.92	0.007	Younger < Older**
RSPM C	69.3	1	69.3	9.92	0.003	Younger < Older**
RSPM D	59.4	1	59.4	7.67	0.008	Younger < Older**
RSPM E	38.77	1	38.77	7.52	0.008	Younger < Older**
RSPM Duration	1301.4	1	1301.4	51.6	0.000	Older < Younger***
WCST 1	825.1	1	825.1	5.51	0.022	Older< Younger*
LRT	81.8	1	81.8	6.56	0.013	Younger < Older*
K- K- (2)	69.2	1	69.2	4.09	0.048	Older< Younger*

tween K+ K0, and WCST 1 (r= -.36, p<.01), WCST 2 (r = –0.24, P <0.05), and WCST 4 (r = 0.23, P <0.05)(2). The number of correct and incorrect responses to the Word List Test had significant but weak relationships with WCST 1, WCST 2, WCST 4, WCST 7, WCST 9, and WCST 11 scores.

Some relationships were observed between correct and incorrect responses to Word List Test, and the duration of time and error scores of the first 5sections of the Stroop Test TBAG form. There were significant relationships between duration of section 2 of the Stroop Test and K- K+ (2) (r = 0.24, P <0.05), between error score of section 4 and K- K0 (2) (r = 0.26, P <0.05), and between correction scores of section 4 and K- K0 (2) (r = 0.24, P <0.05). We observed a weak significant correlation between CT score and Stroop Test score.

Relationship Between RSPM and Meta-Cognitive Functions

There were significant relationships between K+ K + (1), and RSPM A (r = 0.29, P<0.05), RSPM B (r = 41, P<0.01), RSPM C (r = 0.35, P< .01), RSPM D (r = 0.36, P<0.01), and RSPM E (r = 0.41, P<0.01). Similarly, we observed significant relationships between correct and incorrect responses on the Word List Test, and between RSPM sub-test score and K- K- (1).

K- K- (2) was significantly correlated with RSPM A (r = –0.25, P<0.05), RSPM B (r = –0.28, P<0.05), RSPM C (r = –0.43, P<0.01), and RSPM D (r = –0.24, P<0.05). There were significant relationships between the number of correctly recognized words on CT, and RSPM B (r = 0.26, P<0.05), RSPM C (r = 0.33, P<0.01), RSPM D (r = 0.24, P<0.05), and RSPM E (r = 0.26, P<0.05).

Relationship Between Cognitive Development and Meta-Cognitive Functions

We observed significant relationships between LRT, and K+ K+ (1) and the number of correct and incorrect responses on the Word List Test (r = 0.23, P<0.05).

Table IV. The effect of gender on test scores: Results of multivariate analysis of variance (MANOVA).

Tests	Total squares	SD	Average squares	F	Significance level	Post Hoc Analysis
STROOP section 2 ERROR	0.680	1	0.680	4.451	0.039	BOY < GIRL*
STROOP section 2 CORRECTION	0.680	1	0.680	4.451	0.039	BOY < GIRL*
K- K+ (2)	36.363	1	36.363	4.287	0.043	GIRL< BOY*
K+ K0 (2)	38.428	1	38.428	4.005	0.050	BOY < GIRL*
correct irrelevant recall	12.422	1	12.422	4.014	0.050	BOY < GIRL*
incorrect irrelevant recall	13.143	1	13.143	4.177	0.046	GIRL < BOY*

Factor Structures

Principle component analysis of the scores of the children younger than 11 years revealed 6 factors with Eigenvalues >4, which explained 63.24% of the total variance. WCST scores (except WCST 7 and WCST 9) and K- K+ (2) loaded on the first factor, which explained 15.82% of the total variance. The number of correct and incorrect phonetic, semantic, and total words on the Word List Test, and K+ K+ (1), K- K- (1), WCST 7, and RSPM C scores loaded on the second factor. The number of errors and corrections in section 2 of the Stroop Test, scores on some components of meta-cognition for recalled and recognized words, Word List Test recall score,and recognition performance on CT loaded on factor 3. Some Stroop Test scores and all RSPM scores, except RSPM A, LRT, FOK, and correctly and incorrectly recalled irrelevant words on the Word List Test loaded on factor 4. Some Stroop Test scores, K+ K- (1), correctly and incorrectly recalled semantic words, and WCST 9 loaded on factor 5. Some Stroop Test scores, K- K+ (1), and K- K0 (1) loaded on the sixth factor.

A second principle component analysis of the scores of the children that were older than 11 years indicated 6 factors with Eigenvalues > 4, which explained 62.56% of the total variance. Duration of section 1 of the Stroop Test, all RSPM scores, except RSPM A, LRT, K+ K+ (1), and correct and incorrect responses on the Word List Test loaded on the first factor. All WCST scores, except WCST 9 and WCST 12, and K- K0 (2) loaded on the second factor. K- K- (1), K- K0 (1), K+ K- (2), and the number correct and incorrect phonetic responses of irrelevant and total words on the Word List Test loaded on the third factor. Duration of sections 2, 3,4, and 5 of the Stroop Test, error score on sections 3 and 4 of the Stroop Test, correction score on section 3 of the Stroop Test, duration of RSPM, and K- K+ (2) loaded on the forth factor. Correction score of sections 1 and 2 of the Stroop Test, K+ K0 (1), and the number of correct and incorrect semantically related words on the Word List Test loaded on the sixth factor. When the factor structures for the scores of the 2 age groups were examined, the factor structure of the scores of the older group resembled the pattern seen in adults.

DISCUSSION

Some studies indicate that there are age-related differences in FOK performance among children; however, in line with previous findings (Butterfield et al., 1988; Lockl and Schneider, 2002), the present study showed that age had no significant effect on FOK test scores. When retrospective and prospective meta-cognitive components were examined, knowing what one really knows increased with age and knowing what one cannot know decreased with age. This finding indicates that the effectiveness of meta-cognitive systems increased with the level of cognitive development, as reported in other studies (Koriat, 1993).

WCST performance (an executive function test) in children older than 11 years was previously reported to be similar to the adult profile (Yalçın and Karakaş, 2007) and the present study showed that executive functions increased with age after the age of 11 years. Moreover, previous findings indicate that the interference effect on the Stroop Test decreases with age in children until the age of 18 years (Comalli et al., 1962; MacLeod, 1991), which is in line with our findings. Jorgenson et al. (1981) reported gender differences in performance on the Stroop Test and, similarly, we observed that girls had more incorrect responses than boys. Girls also made more corrections than boys on this test.

Table V. The effect of socioeconomic level (low, medium, and high) on test scores: Results of multivariate analysis of variance (MANOVA).

Tests	Total squares	SD	Average squares	F	Significance level	Post Hoc Analysis
RSPM B	46.91	2	23.46	3.13	0.051	Low < high< medium*
Logical reasoning test	152.46	2	76.23	6.87	0.002	Low < high<medium**
Knows what S/HE knows (K+ K+)	214.45	2	107.23	6.77	0.002	Low < high< medium**
Correct semantic recall	43.52	2	21.76	3.94	0.025	Low < high< medium*
Correct irrelevant recall	7.79	2	3.89	5.72	0.005	Low < high< medium**
Total correct recall	215.13	2	107.56	6.18	0.004	Low < high< medium**
Total correct recognition	85.33	2	42.67	3.54	0.036	High<medium< Low*

In a study of college students (Cesur, 1997) there was no significant relationship observed between age and LRT score. The present study indicates that the level of cognitive development increased with age. We suggest that cognitive abilities develop from childhood to adolescence and stabilize during the young adulthood period.

When the literature was examined we could find no study that investigated all the tests utilized in the current study; thus, we could not discuss the combined results of meta-cognition, executive functioning, cognitive development, and mental ability in relation to the literature.

We observed non-significant relationships between cognitive development and meta-cognition scores, in contrast to previous findings (Koriat, 1993). Irak (2004) posited that meta-cognitive processes and executive functions might involve similar processes. We, however, observed a weak relationship between meta-cognition and executive functions. These results suggest that meta-cognitive operations and executive functions might not be similar processes in children.

Our findings point to significant relationships between executive functioning and cognitive development test scores, as previously reported (Emick and Welsh, 2005). According to the cognitive performance of the children between 8 and 14 years of age, the extent of the understanding of what one knows and the number of correctly recalled words increased with age. The extent of the knowledge of what one did not know, as well as will not know, and the number of correctly recalled semantic words decreased with age. The retrospective monitoring performance of the children was better than their prospective monitoring performance. Accordingly, the children had more knowledge about what they did not know compared to their sense of what they would remember.

We found that preservative performance of the children and the number of repeated errors decreased after the age of 11 years. Children can inhibit usual behavioral patterns and can perform non-usual behavior. The executive functions of the children that were older than 11 years were enhanced. Children aged above 11 years demonstrated shorter reaction times for non-verbal reasoning, abstraction, increased mental ability, comprehension of knowledge, usage of acquired knowledge, and the generation of new knowledge. They exhibited the beginnings of a scientific thinking style and, thus, they could generate hypotheses and examine possible solutions in a systematic way.

The examination of children's cognitive functioning is generally a part of psychiatric and neurological examinations. We need to understand the cognitive mechanisms of the child's mind for effective examination, diagnosis, and intervention. The cognitive profile of the children in our community sample provides a critical baseline for the cognitive examination of children that present to psychiatric and neurological clinics, because in order to understand the cognitive processes of abnormal children, the cognitive processes of normal children should be known.

The cognitive profile of children specific to different age groups highlights the most appropriate learning method for academic settings and provides information about the appropriate content of academic material and academic plans based on student age. We suggest that academic concepts and subjects that could be understood

in the abstract operational stage should be presented to children above 11 years of age.

Our findings can contribute to the forensic use of children's testimony in courts. According to our findings, information obtained from children older than 11 years is more reliable than that obtained from children younger than 11 years, in terms of their realization and distinction abilities.

Our sample consisted of children aged between 8 and 14 years. We recommend that future studies include children aged above 14 years in order to investigate metacognition, executive functions, cognitive development, and general ability. We also recommend further studies to gather additional information on state-trait anxiety, level of depression, and level of intelligence in children.

REFERENCES

Ardaç D (1984) The Relationship Between Science Achievement And Logical Reasoning Abilities Among Seventh Grade Students. Yayınlanmamış Yüksek Lisans Tezi, Bogaziçi Üniversitesi, İstanbul.

Aydın B (1997) Çocuk ve Ergen Psikolojisi, İstanbul M. Ü. Vakfı Yayınları.

Bekçi B (2004) Üst Bellek Türleriyle Beyin Elektriksel Tepkilerinin İlişkisi. Doktora Tez Önerisi, Hacettepe Üniversitesi, Ankara.

Bekçi B, Karakaş S (2006) Metacognition and executive functions: related or different concepts? 13th World Congress of Psychophysiology. The Olympics of the Brain. International Journal of Psychophysiology, 61: 343.

Burney GM (1974) The Construction and Validation of An Objective Formal Reasoning Instrument. Yayınlanmamış Doktora Tezi, Northern Colorado Üniversitesi.

Butterfield EC, Nelson TO, Peck V (1988) Developmental aspects of the feeling of knowing. Developmental Psychology, 24: 654- 663.

Cesur S (1997) The Relationship Between Cognitive and Moral Development. Yayınlanmamış yüksek lisans tezi, Bogaziçi Üniversitesi, İstanbul.

Comalli PE, Wapner S, Werner H (1962) Interference effects of stroop colour - word test in childhood, adulthood, and aging. Journal of General Psychology, 100: 47–53.

Crick F (2000) Şaşırtan Varsayım (Çev. Sabit Say). TÜBİTAK Yayınları, Ankara,

Devlet İstatistik Enstitüsü (DİE) (2000) Ankara ili Mamak ve Çankaya İlçelerinin Mahallelerine Ait Gelişmişlik Düzeyleri Bilgileri, Ankara, T.C. Başbakanlık Devlet İstatistik Enstitüsü.

Dienes Z, Perner J (1999) A Theory of Implicit and Explicit Knowledge. Cambridge: Cambridge University Pr.

Emick J, Welsh M (2005) Association between formal operational thought and executive function as measured by the tower of hanoi-revised. Learning and Individual Differences. 15: 177–188.

Ergenç H (2001) Piaget ve Türk Çocuklarında Korunum Kavramlarının Gelişimi. Yayına Hazır Kitap, İstanbul.

Gander M.J, Gardiner HW (1998) Çocuk ve Ergen Gelişimi (Çev. B Onur). İmge Yayıncılık, Ankara, 2004.

Heaton RK (1981) Wisconsin Card Sorting Test Manual. Odessa (F.L.): Psychological Assessment Resources.

Hooper FH, Hooper JO, Colbert TK (1985) Personality and memory correlates of intellectual functioning in adulthood: piagetian and psychometric assessments. Human Development, 28: 101–107.

Irak M (2004) İnsanda Dikkatlilik, Üst-Biliş Performansı ve Bellek Türlerinin Oluşturduğu İlişkiler Örüntüsünün İncelenmesi. Yayınlanmamış Doktora Tezi, Hacettepe Üniversitesi, Ankara.

Jorgenson CB, Davis J, Wilbon P et al. (1981) Hemispheric asymmetries in the processing of stroop stimuli: an examination on age and sex differences. International Journal of Neuroscience, 21: 171-174.

Karakaş S, Başar E (1993) Nöropsikolojik Değerlendirme Araçlarının Standardizasyonu, Nöropsikolojik Ölçümlerin Elektrofizyolojik Ölçümlerle İlişkisi. Proje No: TÜBİTAK-TBAG 17-2.

Karakaş S, Karakaş HM (2000) Yönetici işlevlerin ayrıştırılmasında multidisipliner yaklaşım: bilişsel psikolojiden nöroradyolojiye. Klinik Psikiyatri, 3: 215-227.

Karakaş S, Irak M, Bekçi B (2003) Sağlıklı İnsanda Bilgi İşleme Süreçleri: Biliş ve Üst-Biliş. Beyin ve Nöropsikoloji: Temel ve Klinik Bilimler, S Karakaş, C İrkeç, N Yüksel (Ed). Ankara, Çizgi Tıp Yay.

Karakaş S (2004) BİLNOT Bataryası El Kitabı: Nöropsikolojik Testler İçin Araştırma ve Geliştirme Çalışmaları. Ankara, Dizayn Ofset.

King MC, Snow WG (1981) Problem solving task performance in brain damaged subjects. Journal Clinical Psychology, 37: 400-404.

Koriat A (1993) How do we know that we know? the accessibility account of feeling of knowing. Psychological Review, 50: 609-639.

Lezak MD (1995) Neoropsychological Assessment (3.ed.). New York: Oxford Univ. Pr.

Lockl K, Schneider W (2002) Developmental trends in children's feeling-of-knowing judgements. International Journal of Behavioral Development, 26: 327-333.

Macleod CM (1991) Half a century of research on the stroop effect: an integrative review. Psychological Bulletin, 109:162-203.

Nelson TO, Narens L (1990) Metamemory: a theoretical framework and new findings. The Psychology of Learning and Motivation: Advances In Research and Theory,2. baskı, GH Bower (Ed.), San Diego: Academic Pres. S. 125-173.

Pendleton MG, Heaton RK (1982) A comparison of the wisconsin card sorting test and the category test. Journal of Clinical Psychology, 38: 392-396.

Shute GE, Huertas V (1990) Developmental variability in frontal lobe function. Developmental Neuropsychology, 6: 1-12.

Spreen O, Strauss E (1991) A Compendium of Neuropsychological Tests: Administration, Norms and Commentary. New York: Oxford Univ. Pres.

Taylor CS (1998) Differences in formal reasoning in terms of frontal lobe functioning. Dissertation Abstracts International, 58: 5674.

Tekcan Aİ, Aktürk M (2001) Are you sure you forgot? feeling of knowing in directed forgetting. Journal of Experimental Psychology, 27: 1487-1490.

Yalçın K, Karakaş S (2007). Wisconsin Kart Eşleme Testi Performansında Gelişimin Niceliksel ve Niteliksel Etkileri, Çocuk ve Gençlik Ruh Sağlığı Dergisi, 14: 24-32.

Zabrucky K, Ratner HH (1986) Children's comprehension monitoring and recall of inconsistent stories. Child Development, 57: 1401–1418.