INTRODUCTION

The aim of the neuropsychological assessment is to analyze the relations between brain structure and processes and behavioral events. In the neuropsychological assessment process, the scores of individuals with neurological and/or psychiatric diseases obtained from psychometrically valid, reliable and standardized neuropsychological tests are compared with the normative values of healthy ones. Thus, it can be determined objectively that which cognitive functions are affected and how they are affected. Neuropsychological tests, which allow objective assessment of cognitive functions, are important tools that assist clinicians in diagnosis and differential diagnosis of some psychiatric, neurological and developmental diseases (1-2). Moreover, neuropsychological tests are widely used in many different fields such as forensic medicine/science, pilot training, cognitive rehabilitation in the world as well as in our country (3-4).

According to the Cognitive Developmental Theory of the well-known developmental psychologist Piaget, the age-related development in children goes through these developmental stages in the same order. Nevertheless, environmental factors such as education level and experiences can also affect the speed of cognitive development (5). In addition to cultural and environmental factors, traumatic brain injury, stroke, autism spectrum disorder, cerebral palsy and some neurodegenerative diseases also have the potential to affect cognitive functions.

Incidence studies in childhood stroke have increased especially in the last 20 years. The incidence of hemorrhagic stroke was 1.89/100000, and the incidence of ischemic stroke was reported as 0.63/100000 between 1965-1974 (6). Broderick et al. (7) reported these incidences as 1.5/100000 and 1.2/100000, respectively. This rate was found as about 150/100000 in children and adolescents hospitalized with a diagnosis of pediatric traumatic brain injury (PTBI) (8). Disruption in attention and executive functions after PTBI is among the most destructive and persistent symptoms. These cognitive impairments may persist in about 50% of cases into the post-injury years and adulthood (9). Losses in attention, memory and executive functions are closely related to education level and cause impairment in academic, social and behavioral areas (10). Neuropsychological tests are widely used in the assessment of impaired
cognitive functions in a wide range of disease such as attention deficit and hyperactivity disorder, postpartum depression, learning difficulties, developmental coordination disorder and frontal lobe epilepsy in children and adolescents.

The Clock Drawing Test (CDT) and Trail Making Test (TMT) are used to evaluate different components of executive functions. It has been shown that executive functions are important for emotional experiences, motor functions and social interaction as well as academic success (e.g., 11). It is also known that cognitive flexibility, one of the key components of executive functions, has critical role on the imagination ability which contributes to daily planning and achieving goals (12). It is reported that TMT is a powerful neuropsychological assessment tool for executive functions especially due to its sensitivity to brain dysfunction in children. Reitan and Wolfson (13), for example, reported that children with brain damage between ages of 9-14 spent three times as much time to complete the test compared to their healthy control group. Therefore, researchers suggested that the TMT test, especially form B, is a useful neuropsychological assessment tool for children who need comprehensive neuropsychological evaluation. Since, TMT and CDT are tests that evaluate different components of the executive functions which are crucial for cognitive functioning, it makes it an important need to determine culture-specific normative values of these test for both childhood and adolescence.

Moreover, memory functions are known to be negatively affected from disorders such as post-traumatic stress disorder, attention deficit and hyperactivity disorder (14). Even if, Enhanced Cued Recall Test (ECRT) used for memory testing developed for older people, it is also applicable for children and young people.

Neuropsychological tests which are used to evaluate cognitive functions such as executive functions and memory with scientific methods in both children and adults, are determinant in planning effective intervention programs as well as accurate diagnosis and realistic treatment practices. It is known that neuropsychological tests, regardless of their verbal nature or not, are not culture-independent, and therefore, normative values appropriate for the cultures they will be used must be determined. In this regard, it is extremely important to have tests with culture-specific norms to be used for evaluation of cognitive processes in health children and cognitive assessment to assist clinical diagnosis for children with psychiatric/neurological/developmental diseases.

To sum up, the main purpose of our study was to determine the normative values of three neuropsychological tests, namely the TMT, CMT and ECRT in Turkish sample aged 6-18 years, according to age/education level and gender. In this context, it was aimed to compare middle-late childhood (6-11 years) and adolescence period (12-18 years) (5) among general developmental stages and to create corresponding norm tables. In addition to this comparison, the adolescence period was grouped as early (12-13 years), middle (14-15 years) and late (16+ years) adolescence as suggested by Berk (15) and test performances of sub-periods of adolescence was compared and the corresponding normative values were determined.

**METHOD**

**Participants**

Every year in our country, the children who complete 66th month of age at the end of September and the children with 60-66 months of age who are decided to be ready for primary school in terms of their development and whose family had written request are enrolled in the first grade of primary schools (16). Considering this information, the research sample consisted of a total of 249 volunteer primary or secondary school students living in Ankara, between ages of 6 and 18, studying in the state and/or private schools in three districts (Mamak, Keçiören and Çankaya) representing different socio-economic levels. Written consent was obtained from the students and their parents before the application of the tests. Snowball sampling method was used in the selection of participants. Participants who do not have any known neurological and/or psychiatric diseases, whose native language is Turkish, who do not have visual/hearing problems or have these problems corrected were included in the study. The extreme data of two participants were not included to the further analyses.

**Materials**

**Trail Making Test (TMT):** It is used to evaluate executive functions, which are also defined as functions of frontal region such as visual tracking, mental flexibility, sustainable attention, concentration, visual-motor conceptual scanning, motor speed, planning, numerical information, abstract thinking, response inhibition, set shifting and tolerance to inhibition. TMT was developed by Reitan (17). The norm study of the TMT for those between ages of 20 and 49 (18) and standardization, validity and reliability study of TMT for those over ages of 50 (19-20) have been conducted. The test consists of two form, namely, TMT-A and TMT-B. Form A consists only numbers from 1 to 25, Form B, on the other hand, consists of numbers from 1 to 13 and the first 12 letters (A-I) of the alphabet. In the Form A, the participants are asked to combine all the numbers by drawing lines in consecutive order, starting from the number 1 (from 1 to 2, from 2 to 3 and so on). In the Form B, on the other hand, participants are asked to combine numbers and letters by drawing lines in order of one number and one letter (from 1 to A, from A to 2, from 2 to B and so on). Participants are reminded to be as fast as possible and always to keep the pencil on the paper in both form. The implementation of TMT takes approximately 10 minutes.

**Enhanced Cued Recall Test (ECRT):** The test was developed by Grober et al. (21) to distinguish the memory performance of healthy elderly from the performance of dementia patients. Adaptation and validity study on Turkish sample was conducted by Saka et al. (22). The ECRT consists of 16 black and white drawings. The test material is a booklet consisting of a total of 4 cards with 4 drawings each. Each card is shown one by one and the participant is asked to name the drawings that matches the “semantic cue” given. When all cards are shown, three recall tests are given. Each of these recall test consists of free recall and cued recall tests in which cues are presented only for the unremembered drawings in free recall part. The implementation of ECRT takes approximately 15 minutes.

**Clock Drawing Test (CDT):** CDT was used for the first time as part of the Boston Aphasia Battery (23). CDT evaluates functions such as comprehension, planning, visual memory, reconstruction, visual spatial abilities, motor planning, numerical information, abstract thinking, inhibition of tendency created by the physical properties of the stimulus itself and tolerance to inhibition. In summary, it is a neuropsychological test that can provide general information about intellectual and perceptual skills and is widely used to distinguish healthy adults from those with cognitive impairments (especially Alzheimer’s dementia and other type of dementia) and easily and quickly applied. There are different versions of CDT that differ in terms of material, application and scoring. In this study, the 4-point version was used, in which the clock circle was not given ready and a drawing of a clock showing ten past eleven (clock 11:10) was asked. The norm and validity-reliability study of this version for healthy elderly sample aged 50 years and over were performed for our country (24). The implementation of CDT takes approximately 5 minutes.

**Procedure**

Ethical approval was obtained from Hacettepe University Ethical
Committee for this current study (decision date: 04.05.2016 and decision number: 16969557-340).

**Preliminary Study:** As stated before, ECRT is a neuropsychological test developed for the sample above 60 years of age and due to its nature, it has the potential to be affected by cultural and age-related factors. For this reason, a preliminary study was conducted before collecting the norm data to test the familiarity of the original drawings (black-white object drawings) used for the elderly sample for the children and young people who constitute the sample of the current study. For this purpose, ECRT drawings were presented in a single session to a total of 54 volunteer students educating in the third (n = 17), fourth (n = 17) and fifth (n = 17) grades of primary school. Then, the familiarity of the drawings was analyzed (see Table 1). The families of these students who were not involved in the main norm study approved their children’s participation of these preliminary study.

As a result of the preliminary study, drawings (“sailboat”, “pan/container” and “carriage”) with a recognition percentage less than 70 at any grade level were determined. In the main study “ice cream” “tv remote” and “umbrella” was used instead of “sailboat”, “carriage” and “pan/container” respectively. For the new drawings, difficulty and discrimination values were determined by Ekinci Soylu and Cangöz (25) in the Boston Naming Test-Turkish Version (BAT-TR). However, they were chosen among alternative images that were not used in the mentioned study. The distinctiveness and difficulty levels of the three selected drawings were summarized in Table 2.

**Main Study**
Special care was taken to have participants from all grade levels from 1st to 12th in order to represent all of the different educational levels in the developmental stages we examined. Application of the tests were carried out as face to face in an environment quiet and suitable for testing. Informed consent form was obtained from the participants and their families, and after the demographical information form, TMT, ECRT and CDT were applied in random order in a single session. Neuropsychological tests were administered by three experienced researchers who had graduate-level training in applying and scoring these tests. The distribution of the participants as a function of developmental stages and adolescence sub-stages is summarized in Table 3 and Table 4.

### Table 1. Participants’ Recognition Ratio of the Drawings in the Original Version of the ECRT

| Grade | Grape | Tiger | Foot | Table | Screwdriver | Shoe | Guitar | Motorcycle | Spinning Top | Tomato | Spider | Pan/Container | Sailboat | Door | Eagle | Carriage |
|-------|-------|-------|------|-------|------------|------|--------|------------|-------------|--------|--------|-------------|---------|------|-------|---------|
| 3     | 100   | 76    | 94   | 76    | 94         | 100  | 94     | 88         | 94          | 94     | 88     | 70          | 41      | 94   | 76    | 47      |
| 4     | 100   | 94    | 94   | 70    | 100        | 94   | 100    | 94         | 94          | 100    | 94     | 64          | 70      | 94   | 70    | 52      |
| 5     | 100   | 95    | 95   | 70    | 95         | 100  | 100    | 90         | 80          | 95     | 95     | 65          | 40      | 95   | 85    | 40      |
| M     | 100   | 89    | 94   | 72    | 96         | 98   | 98     | 90         | 89          | 96     | 93     | 67          | 50      | 94   | 78    | 46      |

Note. M = Mean. The values given are percentages.

### Table 2. Discrimination and Difficulty Levels of New Drawings Added to ECRT.

| Discrimination | Difficulty |
|----------------|------------|
| Ice cream      | Very good  | Quite Easy |
| Tv remote      | Very good  | Quite Easy |
| Umbrella       | Very poor  | Very Easy  |

### Table 3. Mean Age of the Participants by Developmental Stage and Gender

| Developmental Stage                  | Male       | Female     | Total      |
|-------------------------------------|------------|------------|------------|
| Middle-Late Childhood (6-11 age)    | n = 54; M = 8.72, SD = 1.43 | n = 57; M = 8.87, SD = 1.56 | n = 111; M = 8.80, SD = 1.49 |
| Adolescent (12-18 age)              | n = 67; M = 14.79, SD = 1.75 | n = 69; M = 14.87, SD = 1.81 | n = 136; M = 14.83, SD = 1.77 |

Note. M = Mean, SD = Standard Deviation

### Table 4. Mean Age of the Participants by Adolescence Sub-Stage and Gender

| Adolescence Sub-Stages              | Male       | Female     | Total      |
|-------------------------------------|------------|------------|------------|
| Early (12-13 years of age)          | n = 18; M = 12.44, SD = 0.51 | n = 20; M = 12.60, SD = 0.50 | n = 38; M = 12.53, SD = 0.51 |
| Middle (14-15 years of age)         | n = 23; M = 14.61, SD = 0.50 | n = 20; M = 14.50, SD = 0.51 | n = 43; M = 14.56, SD = 0.50 |
| Late (16+ years of age)             | n = 26; M = 16.58, SD = 0.64 | n = 29; M = 16.69, SD = 0.60 | n = 55; M = 16.64, SD = 0.62 |

Total n = 121 n = 126 N = 247
Note. M = Mean, SD = Standard Deviation
Free Recall (1st Trial), Cued Recall (1st Trial), Free Recall (2nd Trial), Cued Recall (2nd Trial), Free Recall (3rd Trial), Cued Recall (3rd Trial), Total Free Recall, Total Cued Recall and Total Recall. Finally, a total of nineteen, one dependent variable for CDT, was used as the dependent variables. Pairwise comparisons for the significant effects of ANOVA (for the tests with single dependent score) or MANOVA (for the tests with more than one dependent score) analyzes were reported as Bonferroni corrected.

**RESULTS**

**Results for Comparisons between Middle-Late Childhood and Adolescence**

**Results for TMT:** A 2 (Developmental Stage: Middle-Late Childhood and Adolescence) x 2 (Gender: Female and Male) multivariate analyses of variance (MANOVA) was used to analyze TMT scores. According to the results the main effect of the gender (Pillai’s Trace=0.04; $F_{(1,243)}=1.41$, $p>0.05$, $\eta^2_p=0.04$) and the interaction of developmental stage and gender were non-significant (Pillai’s Trace=0.31; $F_{(2,237)}=1.08$, $p>0.05$, $\eta^2_p=0.03$). The main effect of developmental stage, on the other hand, was significant (Pillai’s Trace=0.36; $F_{(2,237)}=19.40$, $p<0.001$, $\eta^2_p=0.36$). The scores on which developmental stage had a main effect were TMT-A Correction ($F_{(2,237)}=4.30$, $p<0.05$, $\eta^2_p=0.02$), TMT-A Time ($F_{(2,237)}=115.22$, $p<0.001$, $\eta^2_p=0.32$), TMT-B Time ($F_{(2,237)}=44.65$, $p<0.001$, $\eta^2_p=0.15$), TMT-B Time – TMT-A Time ($F_{(2,237)}=24.98$, $p<0.001$, $\eta^2_p=0.09$) and TMT-B Time + TMT-A Time ($F_{(2,237)}=62.22$, $p<0.001$, $\eta^2_p=0.20$). When these results were examined, it was observed that the performance of the individuals in adolescence stage were better than the individuals in middle-late childhood stage in all of scores listed above. Since the main effect of gender was not significant the genders were combined in the TMT norm table (see Table 5).

**Results for ECRT:** A 2 (Developmental Stage: Middle-Late Childhood and Adolescence) x 2 (Gender: Female and Male) multivariate analyses of variance (MANOVA) was used to analyze ECRT scores. Results indicated that only the developmental stage main effect was significant (Pillai’s Trace=0.19; $F_{(2,237)}=8.20$, $p<0.001$, $\eta^2_p=0.19$). This variable had main effect on the scores of Free Recall (1st Trial) ($F_{(1,243)}=20.60$, $p<0.001$, $\eta^2_p=0.08$), Cued Recall (1st Trial) ($F_{(1,243)}=5.42$, $p<0.05$, $\eta^2_p=0.02$), Free Recall (2nd Trial) ($F_{(1,243)}=12.69$, $p<0.01$, $\eta^2_p=0.05$), Free Recall (3rd Trial) ($F_{(1,243)}=44.55$, $p<0.001$, $\eta^2_p=0.15$), Cued Recall (3rd Trial) ($F_{(1,243)}=13.26$, $p<0.001$, $\eta^2_p=0.05$), Free Recall Total ($F_{(1,243)}=39.26$, $p<0.001$, $\eta^2_p=0.14$), Cued Recall Total ($F_{(1,243)}=8.90$, $p<0.01$, $\eta^2_p=0.03$) and Total Recall ($F_{(1,243)}=32.70$, $p<0.001$, $\eta^2_p=0.12$) except Cued Recall (2nd trial). Main effect of gender (Pillai’s Trace=0.04; $F_{(2,237)}=1.57$, $p>0.05$, $\eta^2_p=0.04$) and the interaction of gender and developmental stage (Pillai’s Trace=0.04; $F_{(2,237)}=1.49$, $p>0.05$, $\eta^2_p=0.04$), on the other hand, was not significant. Thus, genders were combined in the norm table of ECRT (see Table 6). Results indicated that adolescents are less dependent on cue to remember what they have learned than those in middle-late childhood stage.

**Results for Comparisons of Adolescence Sub-Stages**

**Results for TMT:** According to the results of the 3 (Adolescence Sub-Stages: Early, Middle and Late) x 2 (Gender: Female and Male) analyses of variance (MANOVA) the main effect of the gender (Pillai’s Trace=0.05; $F_{(2,130)}=0.98$, $p>0.05$, $\eta^2_p=0.05$) and the interaction of developmental stage was not significant (Pillai’s Trace=0.02). The main effect of gender ($F_{(2,130)}=5.30$, $p<0.05$, $\eta^2_p=0.00$) and the interaction of gender and developmental stage ($F_{(2,130)}=5.00$, $p<0.05$, $\eta^2_p=0.00$) were not significant for CDT scores. Thus, genders were combined in the norm table of CDT (see Table 7).

### Table 5. TMT Norm Table for the Developmental Stages

| Developmental Stage       | TMT-A Corr. (M, SD) | TMT-A Error (M, SD) | TMT-A Time (M, SD) | TMT-B Corr. (M, SD) | TMT-B Error (M, SD) | TMT-B Time (M, SD) | B-A (M, SD) | B+B (M, SD) | B/A (M, SD) |
|---------------------------|---------------------|---------------------|-------------------|-------------------|-------------------|-------------------|-------------|-------------|-------------|
| Middle-Late Childhood     | 0.20 (± 0.57)       | 0.11 (± 0.31)       | 51.82 (± 20.63)   | 0.25 (± 0.92)     | 0.95 (± 1.59)     | 152.75 (± 113.65) | 100.93 (± 103.40) | 204.57 (± 126.47) | 2.96 (± 1.57) |
| Adolescence (n = 136)     | 0.08 (± 0.28)       | 0.12 (± 0.37)       | 29.68 (± 10.98)   | 0.25 (± 0.64)     | 0.94 (± 1.31)     | 82.67 (± 39.69)   | 52.99 (± 37.11)  | 112.35 (± 44.88) | 2.89 (± 1.28) |

Note. $\text{M} = \text{Mean}, \text{SS} = \text{Standard Deviation}, \text{B-A} = \text{TMT-B Time - TMT-A Time}, \text{B+B} = \text{TMT-B Time + TMT-A Time}, \text{B/A} = \text{TMT-B Time / TMT-A Time}, \text{Corr.} = \text{Correction}.$

### Table 6. CRT Norm Table for the Developmental Stages

| Developmental Stage       | F.R. (1) (M, SD) | C.R. (1) (M, SD) | F.R. (2) (M, SD) | C.R. (2) (M, SD) | F.R. (3) (M, SD) | C.R. (3) (M, SD) | F.R. Tot. (M, SD) | C.R. Tot. (M, SD) | TOT. R. (M, SD) |
|---------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------------|------------------|-----------------|
| Middle-Late Childhood     | 8.28 (± 1.88)   | 6.22 (± 1.87)   | 10.44 (± 2.24)  | 3.87 (± 1.85)   | 10.60 (± 2.54)  | 3.59 (± 2.01)   | 29.32 (± 5.09)   | 13.68 (± 4.31)   | 42.99 (± 4.27)   |
| Adolescence (n = 136)     | 9.39 (± 1.94)   | 5.67 (± 1.83)   | 11.46 (± 2.28)  | 3.64 (± 2.00)   | 12.60 (± 2.18)  | 2.74 (± 1.69)   | 33.45 (± 5.24)   | 12.05 (± 4.26)   | 45.51 (± 2.60)   |

Note. $\text{M} = \text{Mean}, \text{SD} = \text{Standard Deviation}, \text{F.R.} = \text{Free Recall}, \text{C.R. = Cued Recall}, \text{TOT.} = \text{Total}, \text{TOT. R.} = \text{Total Recall}. \text{Numbers in parentheses indicate the number of trials}.$
Because the main effect of gender was not significant, genders were combined in the norm table of TMT (see Table 9).

**Results for ECRT:** According to 3 ( Adolescence Sub-Stages: Early, Middle and Late) x 2 (Gender: Female and Male) multivariate analyses of variance (MANOVA) the main effect of the gender ($\eta^2 = 0.12$) and the interaction of developmental stage and gender were non-significant ($\eta^2 = 0.00$). However, in order to be ensure consistency throughout the text, the norm values for CDT were given on the basis of adolescence sub-stages by combining the genders (see Table 12).

**Results for CDT:** According to 3 ( Adolescence Sub-Stages: Early, Middle and Late) x 2 (Gender: Female and Male) analyses of variance (ANOVA), the main effect of the gender ($\eta^2 = 0.00$), the main effect of adolescence sub-stages ($\eta^2 = 0.00$) and the interaction of developmental stage and gender were non-significant ($\eta^2 = 0.02$). However, in order to be ensure consistency throughout the text, the norm values for CDT were given on the basis of adolescence sub-stages by combining the genders (see Table 12).

### Table 7. CDT Norm Table for the Developmental Stages

| N=247 | CDT Scores |
|-------|------------|
|       | Developmental Stage | M (SD) |
|       | Middle-Late Childhood (n = 111) | 3.23 (± 0.93) |
|       | Adolescence (n = 136) | 3.75 (± 0.46) |

Note: $M =$ Mean, $SD =$ Standard Deviation

### Table 8. Significant Differences Between Adolescence Sub-Stages in terms of TMT Scores

| Test Score | Comparisons | Mean Difference | Standard Error | $p$ | $r$ |
|------------|-------------|----------------|---------------|-----|-----|
| TMT-A Time | Late - Early | -10.77 | 2.16 | < .001 | .40 |
|           | Late - Middle | -5.97 | 2.09 | < .05 | .24 |
| TMT-B Time | Late - Early | -27.26 | 7.84 | < .01 | .29 |
|           | Late - Middle | -19.93 | 7.57 | < .05 | .22 |
| TMT-B Time + TMT-A Time | Late - Early | -38.00 | 8.18 | < .001 | .38 |
|           | Late - Middle | -25.89 | 8.42 | < .01 | .26 |

Note: $r =$ Effect Size

### Table 9. TMT Norm Table for Adolescence Sub-Stages

| N=136 | TMT-A Corr. | TMT-A Error | TMT-A Time | TMT-B Corr. | TMT-B Error | TMT-B Time | B-A | B+A | B/A |
|-------|-------------|-------------|------------|-------------|-------------|------------|-----|-----|-----|
|       | M (SD) | M (SD) | M (SD) | M (SD) | M (SD) | M (SD) | M (SD) | M (SD) | M (SD) |
| Adolescence Sub-Stages | | | | | | | | | |
| Early (n = 38) | 0.10 (± 0.31) | 0.08 (± 0.27) | 35.52 (± 15.53) | 0.16 (± 0.44) | 0.74 (± 1.65) | 95.34 (± 55.00) | 59.82 (± 54.49) | 130.87 (± 59.70) | 2.88 (± 1.88) |
| Middle (n = 43) | 0.12 (± 0.32) | 0.12 (± 0.39) | 30.76 (± 8.65) | 0.28 (± 0.80) | 1.19 (± 1.29) | 89.11 (± 36.09) | 58.35 (± 32.44) | 119.87 (± 41.26) | 2.96 (± 1.03) |
| Late (n = 55) | 0.05 (± 0.23) | 0.16 (± 0.42) | 24.80 (± 5.34) | 0.29 (± 0.63) | 0.89 (± 1.01) | 68.88 (± 22.65) | 44.08 (± 21.31) | 93.68 (± 25.09) | 2.84 (± 0.92) |

Note: $M =$ Mean, $SS =$ Standard Deviation, $B-A =$ TMT-B Time - TMT-A Time, $B+A =$ TMT-B Time + TMT-A Time, $B/A =$ TMT-B Time / TMT-A Time, $Corr.$ = Correction

### Table 10. Significant Differences Between Adolescence Sub-Stages in terms of ECRT Scores

| Test Score | Comparisons | Mean Difference | Standard Error | $p$ | $r$ |
|------------|-------------|----------------|---------------|-----|-----|
| F.R. (1st Trial) | Late - Early | 1.65 | 0.39 | < .001 | .35 |
|           | Middle - Early | 1.15 | 0.41 | < .05 | .24 |
| C.R. (1st Trial) | Late - Early | -1.31 | 0.37 | < .01 | .30 |
|           | Middle - Early | -1.16 | 0.39 | < .05 | .25 |
| F.R. (3rd Trial) | Late - Early | 1.34 | 0.44 | < .01 | .26 |
| F.R. (Total) | Late - Early | 4.04 | 1.05 | < .001 | .32 |
|           | Middle - Early | 2.88 | 1.10 | < .05 | .22 |
| Total Recall | Late - Early | 2.16 | 0.50 | < .001 | .35 |
|           | Middle - Early | 1.45 | 0.53 | < .05 | .23 |

Note: F.R. = Free Recall, C.R. = Cued Recall, $r =$ Effect Size
in childhood and it slows down in adolescence even if it continues to develop. These findings highlight that both sustainable attention and motor speed component may contribute significant difference between adolescents and children for TMT-A performance.

It was observed that adolescence sub-stages differed from each other in terms of time-related TMT scores and that late adolescents completed both TMT-A and TMT-B forms faster than both middle and early adolescents. On the other hand, although it was observed that middle adolescents performed better than early adolescents in terms of time-related scores, these differences did not reach significance. Participants in different adolescence sub-stages had comparable performance in terms of error and correction scores. Different studies have reported that the critical age at which set shifting ability measured by TMT B reaches the level of development in adulthood is 11-12 years of age (27). On the other hand, it is known that the development of the motor speed and sustainable attention measured by TMT-A is mostly completed in childhood. Considering these information, even if the differences between adolescence and childhood period are reasonable, it can be expected that there would be no difference between participants in different adolescence sub-stages. The results of that late adolescents were more successful in both TMT-A and TMT-B form that other groups can be explained by the fact that the participants in the late adolescence group which is known to consist of 11th and 12th grades, are in the preparation period for the exams of Council of Higher Education for which both reaction time an accuracy are important. This preparation can be expected to speed up the overall test performance.

The non-significant results for gender comparisons for TMT were not surprising. Indeed, there are some studies revealed no gender difference in terms of executive functioning measured by TMT (e.g. 31).

When the CDT performance was examined, it was observed that those in middle-late childhood were less successful than adolescents, but there was no difference between adolescence sub-stages. It is known that CDT measures the planning, a component of executive functions. Best et al. (32) emphasize that planning ability generally continue to develop until the late childhood or adolescence. The findings that CDT performance did not differ in adolescence sub-stages but adolescents performed better than those in childhood seems consistent with the developmental processes of planning ability.

On the other hand, when the ECRT results were examined, it was found that individuals in adolescence were better at free recall and total recall performance than those in middle-late childhood. This result indicated that cued recall scores of the participants in middle-late childhood were higher than the adolescents is expected, because the participants were provided cues not for all items, but only for the items that they could not remember in free recall trials. Considering the nature of the test, it can be said that adolescents need less cues when they need to remember the things that they have learnt before than those in middle-late childhood. We found that the difference in free recall performance was also valid between adolescence sub-stages. This results led to the conclusion...
that the development of memory-related brain areas continues after childhood. Indeed, there are findings indicating that temporal areas which are known to be crucial for memory related functions, develop with age (33). Maril et al. (34), on the other hand, demonstrated that episodic encoding in childhood is based on perceptual systems whose development was not yet completed in that stage and that it was based on semantic information and frontal control systems in adulthood. That is, age-related developmental differences in different brain areas may lead to differences in memory strategies. Differences in free recall observed in adolescence sub-stages may be due to the difference in the level of development of the frontal areas and semantic information representations. Similarly, it is known that the difference observed in memory performance depending on age can be associated with the usability of attention and executive control process for memory which are the specific to prefrontal areas that continue to develop with age (35). Nevertheless, the lack of significant difference between late and middle adolescence in terms of free recall performance of the ECRT was interpreted as these two groups used similar memory strategies.

In summary, within the scope of the study, culture specific normative values of three different neuropsychological tests that measure various critical skills related to memory and executive functions for different developmental stages were determined. Considering that executive functions and memory are essential for daily functioning and can be impaired with many different developmental disorders, it is important to have cultural-specific normative values for the individuals in different developmental stages.

Committee Approval: Ethical approval was obtained from Hacettepe University Ethical Committee for this current study (decision date: 04.05.2016 and decision number: 16969557-340).

Informed Consent: Written consent was obtained from the students and their parents before the application of the tests.

Peer-review: Externally peer-reviewed

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