Normative Scores on the Trail Making Test for the Icelandic Population

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Abstract

The purpose of this study was to bring about normative scores for the Trail Making Test for the Icelandic population because until now, specialists administering the test for Icelandic patients had been using normative scores from foreign nations to evaluate their performance. The aim was to demonstrate the affect age, gender and education had on the performance time in the Trail Making Test. The initial sample was recruited from another study conducted by Decode Genetics, and the division of psychiatry at Landspitali University Hospital. After excluding the participants that suffered from neurological or psychiatric disease and head trauma, the participants who had no educational information and those in the 18-19 and 60-65 age range, the final normative sample that was used in the analysis consisted of 400 participants. Factorial Analysis of Variance was used to demonstrate the affect age, gender and education had on the performance time in the Trail Making Test. The result indicates that age and education affect participant's performances time on the test. As participants grew older the performance time increases and as their level of education got higher their performance time decreased. Gender had no significant effect on the performance time in the test.

Keywords: The Trail Making Test, age, gender, education.

Útdráttur

Markmiðið með þessari rannsókn var að búa til íslensk viðmið fyrir árangur í Slóðarprófi því hingað til hafa sérfræðingar sem leggja prófið fyrir á Íslandi þurft að bera frammistöðu sjúklinga sinna við erlend viðmið til að meta frammistöðu þeirra. Úrtakið í rannsókninni var fengið úr rannsókn á vegum Íslenskrar Erfðagreiningar, Geðsviðs Landspítala-Háskólasjúkrahúss og fleiri aðila. Þegar búið var að taka út þá þátttakendur sem þjáðust af tauga- eða geðsjúkdómum, þá sem höfðu orðið fyrir höfuðáverkum, þá sem höfðu ekki upplýsingar um menntunarstig og þá sem voru í yngsta (18-19ára) og elsta (60-65ára) aldursbilinu var viðmiðsúrtakið 400 þátttakendur. Marghliða dreifigreining var notuð til að finna út hvaða áhrif aldur, kyn og menntun hafa á frammistöðu þátttakenda í slóðarprófinu. Niðurstöðurnar sýndu að aldur og menntun höfðu áhrif á frammistöðu þátttakenda en kyn hafði engin marktæk áhrif. Áhrif aldurs voru þau að eftir því sem þeir urðu eldri þá jókst tíminn sem það þurfti til að klára prófið. Áhrif menntunar voru á þann veg að eftir því sem þátttakendur höfðu lokið hærra menntunarstigi því minni tíma þurftu þeir til að ljúka prófinu.

Lykilorð: Slóðarpróf, aldur, kyn, menntun.

Normative Scores on the Trail Making Test for the Icelandic Population

The Trail Making test is a neuropsychological assessment instrument and its purpose is to assess an individual task-switching and visual attention (Lezak, Howieson, & Loring, 2004). Normative data for the Trail Making Test has not been available yet for the Icelandic population. Until now, specialists administering the Trail Making Test for Icelandic patients have been using normative scores from foreign nations in their assessment of patient abilities. The purpose of this study is to bring about normative data for the Icelandic population and hopefully make the assessment more accurate.

The origin of the Trail Making Test derives from a test called *Taylor Number Series* where the task is to connect 50 numbers correctly from the highest to the lowest on a sheet of paper by drawing a line between them. In 1938 the test was renamed by John E. Partington as *The Divided Attention Test* and shortly after it got the name *Partington Pathway Test* but the task remained the same as before (Brown, Casey, Fisch & Neuringer, 1958). When scores on the *Partington Pathway Test* were compared to scores on an intelligence test it showed a correlation between the two. This finding was thought to indicate that the test measured general mental ability. By that conclusion the *Partington Pathway Test* became a part of *the Army Individual Test Battery* where the name was changed again, this time it was called the Trail Making Test. In the army, the Trail Making Test was used to examine intellectual capacity and replaced group tests that had served this role before because its assessment was thought to be more accurate (Brown et al., 1958). The Trail Making Test was adapted to the Halstead-Reitan Neuropsychological Battery which is still used to assess brain injury in modern times (Bauman, 2008). The administration of the test will be described accurately in the next chapter.

The Trail Making Test is very frequently administered in clinical practice which is mostly derived from its ease of administration and how sensitive it is to brain injury in general. The test has been used to evaluate various cognitive deficits such as visual conceptual abilities, cognitive flexibility, set shifting, sequencing ability, visual-motor tracking and visual spatial functioning (Golden, Espe-Pfeifer &Wachsler-Felder, 2000). Studies have been conducted to confirm the validity of the test regarding detection of brain damage. Reitan (1955) had this goal in mind when he conducted a study on the Trail Making Test. The test was implemented to 54 participants, 27 of them had suffered from brain damage and another 27 were in the control group. The performance time was converted into scores where high score represented longer performance time. The results showed that the mean score on the Trail Making Test differed significantly between the two groups, where the brain damage group scored lower (mean=8.44) than the control group (mean=14.70). This finding confirmed the validation of the test to detect brain damage among patients, according to the author at the time the test was developed (Reitan, 1955).

Studies have been conducted on the Trail Making Test in order to provide normative scores based on demographic information. One of them was a study by Tombaugh (2004) where the purpose was to stratify norms in relation to age and educational level. The participants were 911 in total and were divided into 11 age groups. The results showed that age was positively correlated with performance time on both part A (r = 0.58) and part B (r = 0.62) in the Trail Making Test. This result indicates that the performance time on the test will increase as participants get older. These findings were confirmed by another study conducted by Salthouse, Fristoe and Rhee (1996). Their study sought to examine to what extent age was related to different measurements that are used to evaluate the function of the brain. There were 259 participants in their study, aged 18-94 years in healthy physical condition which had

number of assessments implemented for them, including the Trail Making Test. The results indicated that performance on part B was more sensitive to age than part A which means that the participants score on part B decreased faster as they got older compared to part A (Rhee, 1996).

Tombaugh (2004) also examined the effects education can have on participant's scores in the test. The results showed that education was negatively correlated with performance on both part A (r = -0.17) and B (r = -0.25) in the Trail Making Test. These are not high correlation figures but they show that there is some relationship between education levels and scores on the test. The relationship indicates that with higher level of education the time it takes to finish the test decreases. These findings by Tombaugh (2004) are confirmed by another study conducted by Finlayson, Johnson, and Reitan (1977) where they examined the affects education can have on performance on the Trail Making Test. The subjects in the study were 102 male individuals who were equally divided into experimental and control groups. The participants in the experimental group were individuals who had suffered from brain injury and the control group consisted of healthy individuals. They were also divided into subgroups based on their level of education. In summary, the result showed that level of education influenced the performance on the Trail Making Test where the participants with a higher educational level outperformed those with lower levels of education. The influences were stronger for the control group compared to the experimental group (Finlayson et al., 1977).

The results from these two studies show that level of education affects the subject's performance in the Trail Making Test. These studies show consistent findings where they both conclude that the level of education does affect the scores on the Trail Making Test but they are not decisive. In the former study, conducted by Tombaugh (2004), the correlation

between the level of education and scores on tests show low figures of relationship and furthermore findings from Finlayson et al. (1977) only conclude that the highest level of education overtops the other two levels in part A and only the middle level in part B.

Many studies have been conducted to provide norms for the Trail Making Test with these three variables (Heaton, Miller, Taylor, & Grant, 2004, as cited in Lezak et al., 2004). In their study they calculated the normative scores by age, gender and education for Caucasians and African Americans with data collected from several studies (Heaton et al., 2004, as cited in Lezak et al., 2004).

The aim of this study is to provide normative scores for the Icelandic population by using age, gender and education as independent variables for the performance time on the Trail Making Test. Before the normative scores can be calculated it has to be examined how well the sample represents the population in order to provide useful normative data.

Method

Participants

The sample of participants that was used in this study came from another project implemented by Decode Genetics, the division of psychiatry at Landspitali University Hospital in collaboration with both domestic and foreign partners. The objective of the project was to evaluate the effects of genetic variation on schizophrenia, neurological and developmental disorders. The initial sample consisted of 1300 participants, that were selected randomly from a group of 120 000 participant in earlier studies by Decode Genetics, and data collection took place from September 2009 until April 2012. Furthermore, all participants signed informed consent and could choose between payment in the amount of 10,000 ISK for as a compensation for their loss from work and travelling cost or a present of the same value.

The normative sample was formed by excluding the participants that suffered from neurological or psychiatric disease and head trauma. By excluding this group of individuals the total sample was decreased to 752 individuals. The age span was 20-59 years (mean: 44.80 SD: 11.98). One participant did not have information about age. A comparison of the gender proportion for the normative sample and the Icelandic population is shown in table 1. The proportion of women in the sample is higher than in the population, approximately 60% in the sample versus 50% in the population.

Table 1

Comparison of the Gender Proportion in the Normative Sample and the Icelandic Population (Hagstofa Íslands, n.d.a).

	Male		Female	
Age range	Sample	Population	Sample	Population
20-34 years	40.69%	50.99%	59.31%	49.01%
35-44 years	38.12%	50.66%	61.88%	49.34%
45-49 years	41.41%	49.86%	58.59%	50.14%
50-54 years	30.14%	50.69%	69.86%	49.31%
55-59 years	42.11%	55.54%	57.89%	44.46%

The normative data was divided into seven age groups for analysis (see Table 2). The age ranges were determined with respect to the decay of the brain and the lowest age ranges represent longer age spans than the higher ones. This is done in order to make the age ranges more sensitive to the decay of the brain and therefore make scores for this particular group of individuals more accurate. The initial sample consisted of an age span from 18-65 years but the age range 18-19 years and 60-65years was made up by just over 30 participants each. Therefore it was decided to exclude these two age ranges from the analysis of the data.

Table 2

The Division of Participants That Make Up the five Age Ranges.

Age range	Frequency	Percentage
20-34 years	145	17.58%
35-44 years	181	21.94%
45-49 years	128	15.52%
50-54 years	146	17.70%
55-59 years	152	18.42%

The normative sample was also divided into three levels, depending on the level of education that each participant had achieved. The first level represents education up to elementary school, the second level represents college education and the third level represents a university degree or higher. There was no educational information available for 312 participants and therefore are these three educational levels are made up by 513 participants. The educational level within each age range in the normative sample is similar to the comparable age ranges in the Icelandic population (see table 3). The data for the educational level of the Icelandic population comes from the Icelandic bureau of statistics. (Hagstofa Íslands, n.d.a., n.d.b.).

After excluding the participants that suffered from neurological or psychiatric disease and head trauma, the participants that had no information about their level of education and those in the 18-19 and 60-65 age range, the final normative sample consisted of 400 participants.

Table 3

A Comparison Between Educational Levels Achieved by Participants Within Each Age Range in the Normative Sample and the Icelandic Population (Hagstofa Íslands, n.d.a).

	Elementary graduates		College graduate		University degree	
Age range	Sample	Population	Sample	Population	Sample	Population
20-34 years	43.90 %	43.17%[a]	29.27%	53.74%[a]	26.83%	3.08%[a]
		25.70%[b]		40.65%[b]		33.64%[b]
35-44 years	31.06%	26.18%[c]	36.36%	34.79%[c]	32.58%	39.03%[c]
45-49 years	30.00%	26.18%[c]	33.75%	34.79%[c]	36.25%	39.03%[c]
50-54 years	27.59%	35.62%[d]	45.98%	38.34%[d]	26.44%	26.04%[d]
55-59 years	29.41%	35.62%[d]	38.24%	38.34%[d]	32.35%	26.04%[d]

Notes: The values represent the proportion (percentage, %) of participants within each age range that have achieved particular level of education.

[a] 20-24 years, [b] 25-29 years, [c] 30-49 years, [d] 50-64 years.

Measures

The Trail Making Test was administered to all participants in the normative sample but one of the objectives with this instrument is to evaluate cognitive flexibility, attention and psychomotor speed. To measure the performance of each participant the psychologist measures the time in seconds it takes to finish the assignment. The performance time is measured separately for part A and B.

Parallel to the administration of the Trail Making Test, few other neuropsychological tests were also implemented; among them were the Stroop Test and Word Fluency. The Mini-International Neuropsychiatric Interview (M.I.N.I.) was administered to participants to look out for symptoms of e.g. depression, anxiety and other psychological disorders. Furthermore,

the Wechsler Abbreviated Scale of Intelligence (WASI) was implemented to the participants. The overall administration of these tests took 2-3 hours to complete with short breaks in between.

Research design

In this study the aim is to administer the Trail Making Test for the normative sample to make Icelandic norms for the Icelandic population. The independent variables are age, gender and education and the aim is to evaluate the effect they have on the dependent variable, which is the performance in part A and B of the Trail Making test.

Procedure

The Trail Making Test was administered for each participant separately by psychologists who had been specially trained to do so. At the beginning of each session the psychologist showed the participant a practice sheet of the test to figure out how it works. On that sheet the participant was told to draw a line between the numbers that were spread over the sheet in correct order and the psychologist pointed at the spot where to begin, where the next number was and so on. The participant was informed that the time it took him to draw a line between all the numbers would be measured and he should try to finish the test as fast as possible and never to take the pencil of the paper. If the participant made a mistake drawing a line between the numbers in a correct order the psychologist would let him know and would do so until he made a correct connection between the numbers. If needed the psychologist would move the participant's hand with the pencil to show the right connection. The participant did not start on part A of the Trail Making Test until he had finished the example sheet in the right manner.

In Part A the instructions was the same as for the practice sheet and the participant was showed a sheet of paper with numbered circles from 1-25. He was told to use the same procedure as before by drawing a line between the numbers in a correct order as fast as possible. If he made mistakes in this part the psychologist intervened until he draw the line correctly. If needed, the psychologist would move the participants hand with the pencil to show the right connection.

In part B the process is equal to that in part A except for now the test sheet also has circles with letters, randomly spread among the circles with numbers. In this part the participant is informed that he supposed to draw a line between the numbers and letters in a correct order (1-A-2-B) for all the 26 circles, 13 circles with a number and 13 circles with a letter.

Results

To begin with it is interesting to determine the relationship between age, gender and education. To do so Pearson's *r* was calculated for age, gender, education, performance time in part A and B of the Trail Making Test.

The correlation between age, gender, education and the performance time in part A and B of the Trail Making Test was calculated and the outcome revealed that age was positively correlated with performance time in part A ($r = 0.314$) and B ($r = 0.321$). This outcome indicates that performance gets worse as participants get older. The participant's education had a negative correlation with the performance time in the Trail Making Test and the negative relation was weaker for part A ($r = -0.156$) compared to part B ($r = 0.236$). This negative relation indicates that as the participant's level of education gets higher the performance time in both part A and B decreases. This outcome therefore indicates that those people with a higher level of education perform better than those with lower levels. The

Pearson's *r* for the relation between gender and performance time in the Trial Making Test was not significant. Likewise, gender has a negative correlation with the performance on part A and B and indicates that women are performing better than men on both part A and B (table 4). This negative relation can be explained as follows; as the value of the gender variable is lower, the score on the test increases. On the gender variable men have the value 1 and women have the value 2. Therefore it can be concluded that women outscore men on both part A and B of the Trail Making Test.

Table 4

The Correlation Between Age, Gender, Education and the Performance Time in Part A and B of the Trail Making Test.

	Part A		Part B	
	Pearson's *r*	*p*	Pearson's *r*	*p*
Age	.314	.<.001	.321	<.001
Gender	-.105	.036	-.095	.029
Education	-.156	.002	-.236	<.001

Factorial Analysis of Variance (FANOVA)

The Trail Making Test Part A

The FANOVA model was used to determine if there was a difference in performance time between groups regarding age, gender or education. The scores were divided into five age groups and three educational levels which resulted in a 5x3x1 design.

The outcome of the FANOVA revealed that there was a significant main effect of age on the performance time in part A of the Trail Making Test, F (4, 370) = 8.98, p = < .001.

This indicates that the age influenced the time participants took to finish part A of the Trail Making Test. The model also revealed significant main effect of education on the performance time, F (2, 370) = 5.58, p = < .005, which indicates that the level of education participants have achieved influences their performance time in part A of the Trail Making Test.

The result from the FANOVA model demonstrated no significant main effect of gender on the performance time in part A of the Trail Making test, F (1, 370) = 3.84, p = .051. Likewise, there were no significant interactions between age and gender (F (4, 370) = 1.39, p = .238), age and education (F (8, 370) = .526, p = .837), gender and education (F (2, 370) = .413, p = .662) or age, gender and education (F (8, 370) = .927, p = .494) on the performance time in part A.

Table 5

The Main Effect of Age, Gender and Education on Performance Time in Part A.

	df	F	*p*
Age	4	8.98	.001
Education	2	5.58	.004

The Bonferroni *post hoc* test revealed that the performance time in part A for participants in the 20-34 age range was significantly lower compared to the three highest age ranges (45-49, 50-54, 55-59 years). Furthermore, the performance time for the 35-44 age range was significantly lower than the two highest age ranges (50-54 and 55-59 years). (see table 6).

Table 6

The Bonferroni *Post Hoc* Test Reveals Where the Significant Difference Between Age Ranges is Found in Part A.

Age range	Mean	SD	N
20-34 years	23.29[abc]	6.68	75
35-44 years	26.03[de]	9.08	75
45-49 years	28.63[a]	10.70	75
50-54 years	30.11[bd]	10.12	75
55-59 years	32.89[ce]	11.33	64

Note: [a] $p < .005$ [b] $p < .001$ [c] $p < .001$ [d] $p < .05$ [e] $p < .001$.

The Bonferroni *post hoc* test demonstrated a significant difference in performance time in part A of the Trail Making Test regarding the level of education that participants had achieved. The performance time showed by elementary graduates (educational level 1) was significantly higher than the performance time shown by university graduates (educational level 3). Likewise, the college graduates' performance time was significantly higher than performance time shown by the university graduates (educational level 3).

Table 7

The Bonferroni *Post Hoc* Test Reveals Where the Significant Difference Between Levels of Education is found in Part A.

Educational level	Mean	SD	N
Level 1	29.28[a]	11.98	141
Level 2	28.25[b]	8.74	154
Level 3	25.32[ab]	8.66	104

Note: Level 1: Elementary graduates, Level 2: College graduates, Level 3: University degree.

[a] p <.005 [b] p <.05.

The Trail Making Test Part B

The FANOVA model revealed main effect for age (F (4, 370) = 11.16, p = < .001) and for education (F (2, 370) = 14.57, p = < .001) on the performance in part B of the Trail Making Test. That means that the age influenced the time it took participants to finish part B of the Trail Making Test. Likewise, the education influences the performance time shown by participants in part B of the test. There was no significant main effect for gender on the performance in part B of the Trail Making Test, F (1, 370) = 2.50, p = .115.

Table 8

The Main Effect of Age and Education on Performance Time in Part B.

	df	F	*p*
Age	4	11.16	.000
Education	2	14.57	.000

The Bonferroni *post hoc* test revealed a significantly different performance in part B between the participants' age ranges. This significant difference between age ranges demonstrates that as the participants get older, their performance time increases. The performance time for participants in the 20-34 age range was significantly lower than three (45-49, 50-54 and 55-59 years) of the total four other age ranges. The performance time for the 35-44 age range was significantly lower than the two highest age ranges (50-54 and 55-59 years) and the participants in the 45-49 age range showed significantly better performance than participants in the 55-59 age range (see table 9).

Table 9

The Bonferroni *Post Hoc* Test Reveals Where the Significant Difference Between Age Ranges is found in Part B.

Age range	Mean	SD	N
20-34 years	57.21[abc]	18.24	75
35-44 years	65.69[de]	21.47	75
45-49 years	69.64[af]	26.64	75
50-54 years	77.39[bd]	32.92	75
55-59 years	84.42[cef]	31.74	64

Note: [a] $p < .05$ [b] $p < .001$ [c] $p < .001$ [d] $p < .05$ [e] $p < .001$ [f] $p < .01$

The Bonferroni *post hoc* test demonstrated that the participants' educational level affects their performance time in that way that higher educational level represents better performance on part B of the TMT. The performance time for the elementary graduates group in part B of the TMT was significantly higher than performance time among college graduated participants. Furthermore, the college graduates' performance time was significantly higher than with the university graduates (see table 10).

Table 10

The Bonferroni Post Hoc Test Reveals Where the Significant Difference Between Educational Levels is Found in Part B.

Educational level	Mean	SD	N
Level 1	77.33[ab]	35.16	141
Level 2	69.79[ac]	22.64	154
Level 3	60.53[bc]	18.22	105

Note: Level 1 = Elementary graduates, Level 2 = College graduates, Level 3 = University degree).

[a] $p < .05$ [b] $p < .001$ [c] $p < .05$.

Normative data

These analyses above demonstrate that age accounts for most of the variance of the performance time in the Trail Making Test but education has weaker affect. Figure 1 shows how the performance in part A and B differs in relation to both age and education. As can be seen on the left hand side of the figure, the performance time increases as the participants get older. Furthermore, there is little variance in the performance time regarding the level of education among the participants. This reflects the small influence that education has on the performance time in part A of the TMT. On the right hand side of figure 1 the performance time in part B is shown. The linear trend shows clearly the effect age and education has on the performance. It is noteworthy how the performance time in the 20-34 and 55-59 age ranges is similar between educational level 2 and 3. Likewise, there is a little variance on the performance time in the 45-49 age range. This topic will be discussed further in the next chapter.

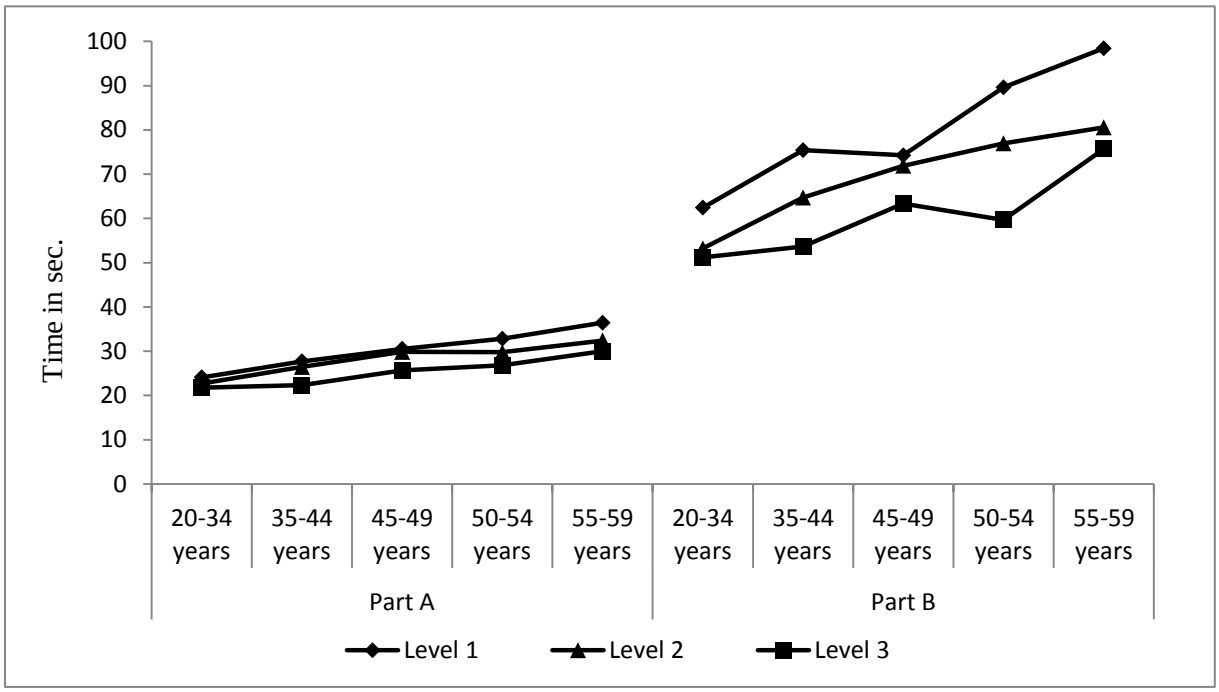

Figure 1. The relationship between age, education and performance time in part A and B of the TMT. (Level 1=Elementary graduates, Level 2=College graduates, Level 3=University degree or higher).

These analyses above demonstrate that age accounts for most of the variance of the performance in the Trail Making Test. Arguably, a new set of norms for the test is needed and in the table (Table 11) below the mean and standard deviation for the performance time in part A and B of the test is presented by age and level of education.

Table 11

The Normative Scores on Part A and B Calculated by Age and Education.

	Statistics	Education level		
Age range	Mean (S.D.)	Mean (S.D.)		
Age 20-34 (*n* = 133)		Level 1	Level 2	Level 3
Age	28.15 (4.76)			
TMT-A	23.19 (6.68)	24.11 (6.80)	22.74 (7,06)	21.75 (5.87)
TMT-B	57.21 (18.24)	62.44 (22.15)	53.22 (9,84)	51.19 (15.02)
Age 35-44 (*n* = 154)				
Age	40.38 (2.90)			
TMT-A	26.03 (9.08)	2772 (8.10)	26.44 (10.35)	23.04 (7.78)
TMT-B	65.69 (21.47)	75.43 (23.05)	64.72 (19.99)	53.69 (14.21)
Age 45-49 (*n* = 115)				
Age	47.68 (1.40)			
TMT-A	28.63 (10.70)	30.54 (13.21)	29.84 (6.78)	25.69 (10.98)
TMT-B	69.64 (26.64)	74.26 (35.41)	71.92 (24.65)	63.35 (17.86)
Age 50-54 (*n* = 131)				

Age	52.47 (1.46)			
TMT-A	30.11 (10.12)	32.83 (14,88)	29.76 (7,27)	26.80 (5.78)
TMT-B	77.39 (32.92)	89.61 (46,17)	76.97 (24,06)	59.67 (17.57)
Age 55-59 (*n* = 138)				
Age	57.43 (1.47)			
TMT-A	32.89 (11.33)	36.42 (16,23)	32.42 (8,13)	30.00 (8.49)
TMT-B	84.42 (31.74)	98.42 (47,38)	80.58 (21,59)	75.68 (18.04)

Discussion

The result of the analysis demonstrated that age and education are two factors that influence the performance time in the Trail Making Test. A correlation and factorial analysis of variance was calculated to demonstrate in which way age, gender and education affect the performance time in part A and B of the TMT. The result showed that the performance time increases parallel to the aging process. In other words, as the participants grow older, their performance time in part A and B increases. The level of education affects the performance time in another way. As the educational level increases, the performance time decreases and therefore we can say that the participants with high educational achievement perform better than those who have achieved lower level of education.

The influences that age had on the performance time in both part A and B of the TMT are consistent with studies on the same topic where the performance time increases as the participants gets older (Salthouse et al., 1996; Tombaugh, 2004). The same can be applied about the influences of education on the performance in part A and B of the TMT. The influences are not as strong as when it comes to age, but still it affects the performance shown by the participants. This outcome is therefore in line with other studies that reveal that as participants achieve higher educational level, their performance time decreases (Finlayson et al., 1977; Tombaugh, 2004). In other words, well educated participants perform better than participants with lower level of education on part A and B of the TMT.

With this information in mind it was rational to use these two variables to calculate the normative scores for the Trail Making Test. Other studies that have been conducted to make normative scores for the Trail Making Test in order to reflect particular populations have come to the conclusion that these two variables are suitable (Heaton et al., 2004, as cited in Lezak et al., 2004; Tombaugh, 2004). In his study, Tombaugh (2004) learned that age and

education influenced the performance time among the Canadian participants and therefore used these two factors to calculate normative scores for that population. Another study, conducted by Heaton et al. (2004, as cited in Lezak et al., 2004) also used age and education and added the gender variable to calculate normative scores for their sample of Caucasians and African Americans.

When the normative scores are compared to the scores that Tombaugh (2004) provided in his study for equivalent age ranges, the scores are rather similar overall. First of all it is worth mentioning that the age ranges are not exactly comparable between these two studies as the age ranges used by Tombaugh (2004) are made up by participants aged 18-69 years old. When the normative scores in these two studies are compared it shows that the score for the lowest age ranges is very similar but as the age ranges get higher the difference between the scores in the studies increases. The standard deviation for the performance time is also high in this study which indicates a great variance in the time it took participants to finish the assignment. This difference can be explained to certain extent by the different age range division used in these studies. This difference can also be due to other factors such as the level of education or some unknown factors regarding the recruitment of the samples that cannot be discussed here.

There are several shortcomings in the study. The number of participants that had no information about their educational level excluded a big proportion of the sample out of the analysis. When figure 1 is analyzed it can be seen that there is little difference in the performance time shown by participants' educational level in two age ranges (20-34 and 45-49 years). This can be due to the fact that the educational level in these two groups is homogenous and therefore is not representative for the population in this category.

It is also noteworthy that the administration of the Trail Making Test was very precise and accurate because all of the participants were in the same conditions when the test was implemented by specially trained psychologists. There are not many studies that have been conducted with the aim to provide a normative score for a big population and when these studies have been conducted it often gathers information from several other studies that are administered in different conditions and not in a good controlled situation. On the other hand, the implementation of the Trail Making Test in this study took 2-3 hours to complete and participants had to come to the facilities and some of them had to take time away from work to participate in the study. Due to this fact there is a possibility that the sample does not completely represent all the people that would take part if the implementation of the test had not coincided with working hours.

With all this information in mind it would be interesting to reconstruct this study and use a bigger sample that has a better representation of the educational level of the population because that would hopefully give a more accurate result on the performance in the Trail Making Test.

References

Bauman, W. L. (2008). *Executive Functioning in Children and Adolescents with Traumatic Brain Injuries: Utilization of the Comprehensive Trail Making Test*. Ann Arbor: ProQuest.

Brown, E. C., Casey, A., Fisch, R. I., & Neuringer, C. (1958). Trail Making Test as a Screening Device for the Detection of Brain Damage. *Journal of Consulting Psychology*, 22(6), 469–474.

Finlayson, M. A., Johnson, K. A., & Reitan, R. M. (1977). Relationship of Level of Education to Neuropsychological Measures in Brain-damaged and Non-brain-damaged Adults. *Journal of Consulting and Clinical Psychology*, 45(4), 536–542.

Golden, C. J., Espe-Pfeifer, P., & Wachsler-Felder, J. (2000). *Neuropsychological Interpretations of Objective Psychological Tests*. New York: Springer.

Hagstofa Íslands. (n.d.a). *Vinnumarkaðsrannsókn Hagstofu Íslands*. Retrieved on April 30, 2013 from http://hagstofan.is/temp/Dialog/varval.asp?ma=SKO00009&ti=Mannfj%F6ldi%20eftir%20menntunarst%F6%F0u%202003-2011%20%20&path=../Database/skolamal/yfirlit/&lang=3&units=Fj%F6ldi

Hagstofa Íslands. (n.d.b). *Mannfjöldi eftir kyni og aldri 1841-2013.*Retrieved on April 30, 2013 from http://www.hagstofa.is/?PageID=2593&src=https://rannsokn.hagstofa.is/pxis/Dialog/varval.asp?ma=MAN00101%26ti=Mannfj%F6ldi+eftir+kyni+og+aldri+1841%2D2013+++++++%26path=../Database/mannfjoldi/Yfirlit/%26lang=3%26units=Fj%F6ldi

Heaton, R. K., Miller, S. W., Taylor, M. J., & Grant, I. (2004). *Revised Comprehensive Norms for an Expanded Halstead-Reitan Battery: Demographically Adjusted Norms for African American and Caucasian Adults*. Lutz: Psychological Assessment Resources.

Lezak, M. D., Howieson, D. B., & Loring, D. W. (2004). *Neuropsychological Assessment*. New York: Oxford University Press.

Reitan, R. M. (1955). The Relation of the Trail Making Test to Organic Brain Damage. *Journal of Consulting Psychology*, 19(5), 393–394.

Salthouse, T. A., Fristoe, N., & Rhee, S. H. (1996). How Localized are Ge-related Effects on Neuropsychological Measures? *Neuropsychology*, 10(2), 272.

Tombaugh, T. N. (2004). Trail Making Test A and B: Normative Data Stratified by Age and Education. *Archives of Clinical Neuropsychology*, 19(2), 203–214.

Appendix

SAMÞYKKISYFIRLÝSING
VÍSINDARANNSÓKN Á VEGUM ÍE OG SAMSTARFSAÐILA

ÁHRIF EINTAKABREYTILEIKA Í ERFÐAMENGINU

1. Með undirskrift minni hér að neðan staðfesti ég vilja minn til þátttöku í ofannefndri rannsókn. Nota má sýni og upplýsingar frá mér til rannsókna á hlut eintakabreytileika í þroskaröskunum, geðröskunum og heilkennamyndun, hafi viðkomandi rannsóknir hlotið samþykki Persónuverndar og Vísindasiðanefndar.

2. Ég staðfesti að hafa kynnt mér meðfylgjandi upplýsingablöð um rannsóknina þar sem m.a. eðli, tilgangur, áhætta og skilmálar þátttöku eru kynntir og að mér hafi verið gefinn nægur tími til að kynna mér efni þeirra og þessarar samþykkisyfirlýsingar og fengið viðunandi svör við spurningum mínum.

3. Ég samþykki að dregnir verði úr mér 50ml af bláæðablóði í þeim tilgangi að einangra úr því erfðaefnið (kjarnsýru/DNA) og hvítar blóðfrumur til ræktunar. Einnig samþykki ég að nota megi til sömu rannsókna önnur lífsýni sem frá mér stafa og aflað hefur verið til greiningar eða meðferðar á hjartsláttartruflunum eða öðrum sjúkdómum.

4. Ég heimila að ópersónuauðkennd sýni verði send erlendis til greiningar eða mælinga sé þess þörf vegna rannsóknanna.

5. Ég samþykki að leitað verði, með minni aðstoð eða skv. minni tilnefningu, eftir þátttöku ættingja minna í rannsókninni, sé þess þörf.

6. Ég heimila ábyrgðarmönnum rannsóknarinnar að afla upplýsinga sem nauðsynlegar eru framgangi rannsóknarinnar úr sjúkraskrám mínum hjá þeim stofnunum sem koma að rannsókninni.

7. Ég samþykki að hafa megi samband við mig ef þörf er frekari upplýsinga eða sýna vegna rannsóknarinnar. Jafnframt að kynna megi fyrir mér framhaldsrannsóknir eða nýjar rannsóknir sem byggjast á gögnum þessarar rannsóknar, þar með talið arfgerð minni, öðrum mældum eiginleikum á lífsýnum úr mér eða upplýsingum sem ég hef veitt.

8. Lífsýni og gögn frá mér verða varðveitt í lífsýnasafni Íslenskrar erfðagreiningar ef ég samþykki það með undirritun sérstakrar samþykkisyfirlýsingar þar að lútandi. Annars verður öllum gögnum og sýnum sem stafa frá mér, ásamt kóða þeim er gerir kleift að rekja niðurstöður til mín eytt við lok rannsóknarinnar og þá ekki má nota neitt af því til annarra rannsókna en

þeirra sem ég hef samþykkt. Ég geri mér grein fyrir því að hafa má samband við mig til að kynna fyrir mér nýjar óskyldar rannsóknir.

9. Með undirskrift minni hér að neðan afsala ég mér öllum kröfum til mögulegs fjárhagslegs hagnaðar af þessum rannsóknum.

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Staðfesting þátttakanda á að hafa lesið þessar upplýsingar og að hann sé samþykkur þátttöku dags.

Nafn og kennitala ritað eigin hendi

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Undirskrift forráðamanns og kennitala ef um er að ræða þátttöku barns eða ólögráða einstaklings dags.

Tilgreinið skyldleika/tengsl forráðamanns við þátttakanda

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Staðfesting á að hafa kynnt ofangreindum þátttakanda eðli og tilgang rannsóknarinnar dags.

og hann telji upplýsingarnar fullnægjandi.