



The influence of cognitive abilities and anxiety on academic achievement among 10 and 11 year old children in elementary school

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Abstract - English

An important topic in psychology is the prediction of academic achievement. Studies have shown that there are many different psychological and cognitive components that influence academic achievement. Cognitive ability tests that measure verbal comprehension, spatial ability, working memory span and more have been shown to relate to different skills in the academic environment. Anxiety is another component that has been shown to correlate strongly with academic achievement and especially on scores on mathematical exams. The main aim of the present study is to examine how well cognitive tests and anxiety predict performance on exams measured at different time intervals. Participants were 67 children (28 males and 39 females) at the age of 10 to 11 from an elementary school in Iceland called Hofsstaðaskóli. Participants were measured on four cognitive tests, two tests from Wechsler Intelligence Scale for Children (WISC), Raven's progressive matrices and Operation Span Task (OSPAN). Anxiety measures were questions that participants answered at three different time intervals. According to the results, the best predictors of scores on mathematics exams was OSPAN task and the best predictor for Icelandic exams was a WISC similarity test. Anxiety was the best predictor of scores on a mathematics exam from the spring of 2012.

Abstract - Icelandic

Algengt umfjöllunarefni í sálfræði er spáin um það hvernig góður námsárangur fæst. Rannsóknir hafa sýnt að það eru margir mismunandi sálfræðilegir og hugrænir þættir sem hafa áhrif á námsárangur. Hugræn próf sem mæla orðskilning, rúmfræðilega getu, vinnsluminnisspönn og fleira sýna tengsl við mismunandi færni í akademísku umhverfi. Sýnt hefur verið fram á að kvíði tengist námsárangri og sérstaklega einkunnum í stærðfræði. Markmið rannsóknarinnar var að kanna hversu vel hugræn próf og kvíði geta spáð fyrir um námsárangur. Þátttakendur voru 67 börn (28 drengir og 39 stúlkur) á aldrinum 10 til 11 ára úr grunnskóla á Íslandi, Hofsstaðaskóla. Þátttakendur fóru í fjögur hugræn próf, tvö greindarpróf (e. Wechsler Intelligence Scale for Children), rúmfræðilegt rökhugsunarpróf (e. Raven's progressive matrices test) og vinnsluminnispróf (e. OSPAN task). Kvíðinn var mældur með spurningalista á þremur mismunandi tímum. Niðurstöður sýndu að þegar stjórnað var fyrir aðrar mælingar spáði vinnsluminnisspönnin (OSPAN task) best fyrir um einkunnir í stærðfræði og vinnsluminnispróf sem mældi orðskilning (WISC 2) best fyrir um einkunnir í íslensku. Kvíði spáði best fyrir um einkunnir í stærðfræðiþrófi frá vorinu 2012.

Foreword and Acknowledgement

Submitted in partial fulfillment of the requirements of the BSc Psychology degree, Reykjavík University, this thesis is presented in the style of an article for submission to a peer-reviewed journal.

First and foremost, I wish to thank my supervisor, Kamilla Rún Jóhannsdóttir, for all the advice and support in completing this study. I also wish to thank the members of the research team – Arnar Ingi Friðriksson, Erla María Tölgyens, Haukur Ingimarsson and Silja Runólfsdóttir. At last I wish to thank the members of Skema for all the preparation work before the study took place.

An important topic in psychology is the prediction of academic achievement (Boekaerts, 1995; Furnham & Chamorro-Premuzic, 2004). Many different psychological constructs have been shown to relate to academic achievement and psychometric intelligence is the one that some think of as the best predictor (Kuncel, Hezlett & Ones, 2001). Studies have also shown that measures of cognitive abilities like processing speed and working memory (WM) correlate significantly with academic achievement (Daneman & Carpenter, 1980). Rohde and Thompson (2007) however point out that the relationship between general cognitive abilities and academic achievement is not well understood and needs to be explored further. In particular, more research is needed to understand which aspects of general cognitive abilities predict academic achievement. Furthermore, they point out that general cognitive abilities only account for less than 50 % of the variance in academic achievement and therefore other factors must play a role as well.

The aim of the present study is to examine which components of general cognitive abilities are important in predicting academic achievement. Specifically, the present study will examine the influence of WM span and verbal WM on academic achievements in mathematics and Icelandic. The influence of spatial reasoning abilities on achievements in mathematics and Icelandic will also be examined as well as the potential impact of anxiety. It is important to examine the relationship between cognitive abilities and academic achievement in order to provide a better insight of the abilities that can predict and enhance academic achievements among children. In predicting this academic achievement, anxiety could be a factor that influences academic achievement as well and possibly reduces scores on exams (Alpert & Haber, 1960).

The relationship between general cognitive abilities and performance has for a long time been speculated theoretically and the subject of applied research (Anderson, Ones, Sinangil & Viswesvaran, 2001). There are three cognitive constructs that are considered to be

important components of general cognitive ability and relate to academic achievement (Rohde and Thompson, 2007). Those components are working memory, spatial ability and processing speed. According to Rohde and Thompson (2007), general cognitive ability and academic achievement cannot perfectly predict one another and more than 50% of the variance in academic achievement is not explained by general cognitive ability alone. In their study, the aim was to understand the role that specific cognitive abilities play in academic achievement and to see whether a combination of specific cognitive abilities and general cognitive abilities predicted better academic achievement of undergraduate students. The results showed that a spatial reasoning ability test (Raven's test) and a vocabulary measure were better predictors of Scholastic Assessment Test (SAT) verbal scores than measures of processing speed, WM span and spatial ability that were better predictors for the SAT math scores. Another study showed that Raven's test correlated significantly with Scholastic Assessment Test (SAT) scores (Frey & Detterman, 2013) and in the study of Koenig, Frey and Detterman (2008), scores on Raven's test showed a high correlation with scores on American College Test (ACT) measuring English, mathematics, science and reading. The correlation was higher for math ACT scores than verbal ACT scores.

In predicting scores on language comprehension and reading abilities, studies have shown that verbal WM tasks are good predictors of scores on language and reading comprehension exams (Dickerson Mayes & Calhoun, 2003; Dickerson Mayes & Calhoun, 2007). A study by Dickerson Mayes & Calhoun (2003) examined the relationship between verbal WM tasks and language comprehension among children with autism and according to the results, lower verbal WM scores predicted lower scores on language comprehension tests.

WM span tasks are widely used measures of WM capacity (Turner and Engle, 1989) and children with low scores on these tasks have been found to perform worse on exams (Gathercole & Pickering, 2000). In a study by Gathercole, Alloway Willis & Adams (2006),

low scores on WM span tasks were related to deficits in mathematics and reading skills.

According to the results, WM span tasks were the strongest predictors of mathematics and reading scores. Another study showed that scores on WM span tasks had a high correlation with mathematical performance among children with mathematical difficulties (Andersson & Lyxell, 2007).

Gathercole and Pickering (2000) also examined the relationship between students WM abilities and their performance on exams. Specifically, scores on vocabulary, mathematics and literacy tests were assessed. The results showed that skills on WM span tasks associated with performance on literacy, vocabulary and arithmetic tests (Gathercole & Pickering, 2000).

Another study by Gathercole, Pickering, Knight & Stegmann, (2004) showed similar results. Children that were good in mathematics and English had better WM skills than those who were worse in those subjects. Correlations were particularly high between mathematics and science attainment levels and WM span tasks. The correlation of English and these measures was less strong.

While there is a strong association between general cognitive ability and academic achievement, there is still somewhat of 51% to 75% variance in academic achievement that is unaccounted for by measures of general cognitive ability alone (Rohde, Thompson, 2007). Anxiety is another factor that might predict academic achievement and studies show that worrying is a component that correlates strongly with academic performance (Culler & Holahan, 1980). Students that have a high test anxiety become preoccupied with these worrying responses and as a result, they're attention is less devoted to the exam that they are taking. Studies that examine the influence of test anxiety on academic performance generally support the finding that test anxiety is associated with worse academic performance (Alpert & Haber, 1960; Allen, Lerner, Wayne & Hinrichsen, 1972). A study by Culler and Holahan (1980) investigated the relationship between test anxiety and academic performance in college

students and differences in study-related behaviors between individuals that were high and low on test anxiety. A significant decrement was found in academic performance among those who were high on test anxiety compared to those who measured with low test anxiety.

There are two types of anxiety, trait and state and those who have trait anxiety feel anxious in all situations rather than in state anxiety where it is only experienced in specific stressful situations (Sorg & Whitney, 1992). Studies have shown that both state and trait anxiety can affect performance on tasks (MacLeod & Donnellan, 1993; Leon & Revelle, 1985). The effect of state and trait anxiety on WM has also been examined and results show that those who have high scores on trait anxiety suffer from deficits in WM and poorer performance in stressful conditions (Sorg and Whitney, 1992). Miller and Bichsel (2004) investigated the influence of math anxiety on math performance and WM skills and according to the results, math anxiety was the strongest predictor of math performance and it influenced scores on WM tasks.

In light of previous studies, the present research aims to examine the correlation between academic achievement and spatial reasoning, verbal reasoning and WM span. The aim is also to examine the role that anxiety may play in predicting academic achievement. There are four hypotheses, 1) higher scores on the OSPAN task (measuring WM span) and WISC letter and number ordering task predict higher scores on exams in mathematics and Icelandic, 2) higher scores on WISC similarity test (measuring verbal comprehension) predict higher scores on Icelandic exams, 3) higher scores on the Raven's test (measuring spatial reasoning abilities) predict higher scores on mathematics exams and 4) higher scores on anxiety predict lower scores on the exams.

Method

Participants

A total of 67 children (28 males and 39 females) from an elementary school in Iceland participated in the study which took place in August to December 2012. Of the total 67 children that began participation, 14 were not included in the study due to being sick during the data collection or because of missing data. Scores from the exams were obtained from about 50 participants (different number of participants in the exams). Two schools agreed to participate in the study; the data used in the present study is based on Hofsstaðaskóli situated in Garðabær. To be eligible for the study, participants had to be attending school at the time the study took place, able to speak Icelandic, without a mental disability and at the age of ten or eleven years (in fifth grade).

Stimuli and materials

Materials. Participants were required to solve four different cognitive tasks that tested different working memory skills and other cognitive abilities. The tests were two Wechsler intelligence scales for children (WISC 2 and 7), Raven's progressive matrices test and an operation span task (OSPAN).

WISC 2 is a verbal comprehension task that consists of 23 word pairs where each word pair has some similarities that the participants are supposed to see (Wechsler, 1991). The experimenter says two words (shirt-shoe) out loud and asks how these two words are related and the participants either give an answer or do not answer and receive different scoring depending on the answer. WISC 7 is a working memory index where the experimenter reads out loud a mix of numbers and letters (9-H-K) and the participants have to repeat out loud and arrange the numbers and letters in the right order, the numbers in size order and letters in alphabet order. At first there is only one letter and one number but later on, more letters and numbers are added to the mix.

Raven's progressive matrices test is one of the most used intelligence test (Court & Raven, 1995). It is nonverbal and measures spatial reasoning skills (Pind, Gunnarsdóttir & Jóhannesson, 2001). It consists of 60 images that are all comparable types but differ in their difficulty. In the present study, the Raven's test was divided into two separate tests, both with 30 projects divided by odd numbers (images number 1, 3, 5, etc.) and even numbers. The tests were randomly divided between the children. The images in the test contain several drawings or patterns with one drawing or part of the pattern missing. The participant's task is to pick one drawing/part of a pattern out of six to eight choices, that fits best into the empty spot on the image. Raven's idea with this test is that the participant would have to find the rule in every image in order to solve it

The OSPAN task (Turner & Engle, 1989) measures the working memory span. In the task, the participants read out loud a math problem ($9 + 7 = 16$ band), state whether the given answer to the math problem is right or wrong and then say out loud an unrelated word that comes after. When participants are presented with a blank page, they write down the words on a piece of paper and have to remember them in the right order (see Appendix C). The grades that were assessed were the participants' grades from standardized tests in the spring of 2012 in mathematics and Icelandic and grades from fall and winter exams in 2012 in mathematics and Icelandic.

Questionnaire. In this study, only four questions were used concerning anxiety. One of the anxiety questions that were used was: "have you experienced any of this below for the last seven days?" – "Dizziness" (see Appendix A). Participants answered from 1 (never) to 5 (frequently). Participants were measured three times on the anxiety questions at different times and dates. The measures were in the beginning of the term in August/September, perhaps 4 weeks into the term and at the end of the term in December.

Equipment. A computer was used for all of the tasks except the Raven's task that was solved on a paper. All of the participants answered a questionnaire on a computer in a classroom where one to two experimenters were available if they had any questions.

Design and data analysis

A correlation was done to examine the relationship between the cognitive tests, anxiety measure and scores on exams. A linear regression analysis was then used to predict the relative influence of each independent variable (cognitive ability tests and anxiety measures) when controlling for the other variables on academic achievement (dependent variable). An independent t-test was done to examine if there was a difference between mean scores of the exams based on low and high scores on the OSPAN task and anxiety. In the independent t-test, high and low scores on OSPAN and anxiety were found by finding out the median. The median of the OSPAN task scores was 20. Scores that were lower or equal to 20 were "low OSPAN scores" and scores that were higher than 20 were "high OSPAN scores". The median of the anxiety scores was 5 and scores that were lower or equal to 5 were "low anxiety scores" and scores higher than 5 were "higher anxiety scores".

Scores for WISC similarity task ranged from 0 to 2. The participants got 0 for a wrong answer and 1 or 2 if they answered according to a list of right answers the experimenter had beside him. For an example, if a participant was asked how a shirt and a shoe were related, the participant could have said that a shirt and a shoe are both clothes. Then he would have got two points. If he said for an example that a shirt and a shoe were both something you could wear, he got one point. If the answer was not in the list the experimenter had, the participant got no points for that answer.

In WISC letter and number ordering task, numbers should first be said out loud in the right size order and then the letters should be said out loud in alphabetical order. However, the participants got points as long as the numbers and letters were in the right order and numbers

were together and letters together (1-3-D-J or D-J-1-3). Participants either got 0 or 1 for their answers, 1 for a right answer and 0 for a wrong answer.

The scores on Ravens were from 1 to 30 depending on how many of the projects the participants got right. The scoring for the operation span task was from 1 to 42 depending on the number of words the participants remembered in right order. Participants did not get a score if the words were not in the right order as presented on the computer screen. Anxiety scores ranged from 4 to 20 with 4 being the lowest anxiety scores and 20 the highest. Grades on the exams were from 0 to 10 with 0 being the lowest grade and 10 the highest.

Procedure

Parents of the participants' in the study were sent a permission slip in the form of an email. The parents and participants were all aware that they were allowed to withdraw their participation at any time. Parents were also asked to fill out a brief questionnaire following the data collection to see how their children were feeling after participating in various cognitive tests. Each participant solved the tasks in an empty and closed room or a classroom where no disruption was nearby and only one experimenter and one participant were in the room during testing. The time it took to solve all of the cognitive ability tests was from 30 minutes up to an hour and it took about 10 minutes to answer a questionnaire of 49 questions.

When the participants arrived to the rooms where the tasks were solved, they were informed that these tasks were not exams and that none of the scores could be traced back to them. The first task they performed on was a WISC similarity test (WISC 2) examining verbal comprehension. After completing WISC 2, participants solved another WISC test (WISC 7). The next task was the Raven's test where the subject had to solve 30 problems in the form of pictures. The participants were informed about the task and told that they were allowed to ask questions at any given time and that experimenter helped them with the first pictures if it was requested (see Appendix B). The fourth and last task was the operation span task. The

experimenter read out loud instructions about the task that were presented to the subject on a computer screen. Then the participants were allowed to practice with some practice problems and only when they fully understood the task, the real task could begin. After the testing period, the experimenter asked the participants to go back to their class room.

Results

The study examined the correlation between academic achievement tests, cognitive ability tests and anxiety measures. A linear regression was used to examine the relative effect of each independent variable when controlling for the other variables. The alpha level of significance was set at .05.

Cognitive ability tests

Table 1 shows the mean, standard deviation, minimum, maximum and median scores for the cognitive ability tests. The maximum score on the similarity test (WISC 2) was 27 out of 42 possible scores. On the letters and number ordering test (WISC 7), the highest score a participant could get was 30 and the maximum score the participants got was 21. On Raven's test, the participants scored a maximum of 25 scores out of 30 possible scores. In the operation span task, the maximum score was 41 of a total 42 scores.

Table 1

Descriptive statistics for measures of academic achievement

Scores on cognitive ability tests	N	Mean	SD	Min	Max	Median
WISC 2, similarity test	51	15.69	4.893	6	27	17
WISC 7, letter and number ordering test	51	15.24	3.433	6	21	16
Raven's test	53	18.30	3.729	7	25	19
Operation span task	53	19.00	10.082	1	41	20

Anxiety

In table 2, scores for measures on anxiety at three different times are shown. The mean for the baseline measures of anxiety was 6.06 which mean that on average, participants answered that they did never or almost never tremble, feel dizzy, suddenly scared or unpleasantly uptight for the last seven days. The maximum possible score was 20. The minimum score for the baseline measures was 4, which means that those participants answered that they never felt these anxious feelings the past seven days. The maximum score was 12 which mean that some participants answered that they seldom or sometimes felt these anxious feelings the past seven days. In the second anxiety measures, the scores were similar to the scores of the baseline. However, in the third measures, the maximum score was slightly higher or 15.

Table 2

Descriptive statistics for measures on anxiety

Measures on anxiety	N	Mean	SD	Min	Max	Median
Anxiety baseline	63	6.06	2.50	4	12	5
Anxiety 2 nd measure	64	5.88	2.69	4	13	5
Anxiety 3 rd measure	47	5.55	2.19	4	15	5

Scores on academic achievement tests: exams in mathematics and Icelandic

According to table 3, the exam that had the highest mean was the Icelandic exam in winter 2012 and the lowest mean scores was on the standardized Icelandic exam. Out of the three math exams, the standardized math exam had the lowest minimum score or 3. The math exam that had the highest minimum score was the math exam from the fall of 2012. The

lowest minimum score for the Icelandic exams was the standardized Icelandic exam with 4 being the lowest minimum score.

Table 3

Descriptive statistics for measures of academic achievement

Scores on exams	N	Mean	SD	Min	Max	Median
Standardized math exam	47	7.44	1.405	3	10	8.0
Math exam, fall 2012	49	8.55	1.168	6	10	9.0
Math exam, winter 2012	51	7.99	1.293	5	10	8.3
Standardized Icelandic exam	48	6.98	1.203	4	9	7.25
Icelandic exam, fall 2012	51	8.72	0.857	7	10	9.0
Icelandic grammar exam, winter 2012	49	8.86	1.054	6	10	9.1

Relationship between cognitive tests, anxiety and academic performance

As seen in table 4, most of the cognitive tests correlated significantly with the Icelandic and math exams. The highest correlation was between the OSPAN task and math exam in fall 2012 and WISC similarity test and standardized Icelandic exam. The WISC and Raven's tests had the highest correlation with the math exams. Not all of the anxiety measures were significantly correlated with the exams. The highest correlation of the anxiety measures was between anxiety and math exam from the fall of 2012.

Table 4

Correlation table showing the relationship between cognitive tests, anxiety and exams

	Standard- ized math exam	Math exam in fall 2012	Math exam in winter 2012	Standard -ized Icelandic exam	Icelandic exam in fall 2012	Icelandic exam in winter 2012
WISC similarity test	.370**	.235	.414**	.504**	.334**	.141
WISC letter and number ordering test	.427**	.459**	.332**	.363**	.395**	.223
Raven's	.364**	.303*	.251*	.293*	.269*	.188
OSPAN	.423**	.565**	.401**	.269*	.392**	.459**
Anxiety baseline	-.444**	-.438*	-.278**	-.305*	-.338**	-.107
Anxiety 2 nd measure	-.173	-.153	-.007	-.218	-.151	-.124
Anxiety 3 rd measure	-.485**	-.493**	-.122	-.216	-.358*	-.001

* $p < .05$, ** $p < .001$

Cognitive tests and anxiety as predictors of academic performance

The relative influence of each independent variable was examined on performance on spring, fall and winter exams when controlling for the other independent variables. The influence of anxiety on the standardized exams in mathematics and Icelandic was not examined because those exams were in the spring of 2012 and anxiety was measured in the fall and winter of 2012.

The results from the model summary show that R^2 is .352, $F(4, 40) = 5.442$, $p = .001$. The cognitive ability tests explain 35.2% in the variance of the standardized math exam. When controlling for the other cognitive ability tests, the operation span task significantly explains the variance in the scores on the standardized math exam, $p = .031$ (see table 5).

Table 5

Coefficients for cognitive ability measures and standardized math test in spring 2012

	N	B	Std. Error	Beta	Sig.
Constant		3.536	1.065		.002
WISC similarity test	45	.066	.040	.237	.105
WISC letter and number ordering test	45	.075	.062	.181	.234
Raven's test	45	.046	.054	.120	.407
Operation span task	45	.047	.021	.322	.031

For the influence of cognitive abilities and anxiety on math exam in the fall of 2012, R^2 is 0.497 and the statistical test shows that $F(5, 39) = 7.716, p = .000$. Cognitive ability tests and anxiety explain in total 49.7% in the variance of the math exam. When controlling for the other cognitive ability tests and anxiety measure, the operation span task was significant ($p = .002$) along with anxiety ($p = .049$) (see table 6).

Table 6

Coefficients for cognitive ability tests, anxiety and math exam in fall 2012

	N	B	Std. Error	Beta	Sig.
Constant		6.775	0.899		.000
WISC similarity test	45	0.025	0.029	0.106	.406
WISC letter and number ordering test	45	0.047	0.047	0.142	.318
Raven's test	45	0.021	0.038	0.068	.588
Operation span task	45	0.053	0.016	0.447	.002
Anxiety	45	-0.117	0.058	-0.244	.049

The model summary's results for the influence of cognitive ability and anxiety on a math exam in the winter of 2012 shows that R^2 is 0.325. The statistical test shows that $F(5, 41) = 3.951, p = .005$. Cognitive ability tests and anxiety explain 32.5% in the variance of the math exam. When controlling for the other measures, the WISC similarity test and the operation span task are statistically significant ($p = .015, p = .010$) (see table 7).

Table 7

Coefficients for cognitive ability tests, anxiety and math exam in winter 2012

	N	B	Std. Error	Beta	Sig.
Constant		5.065	1.125		.000
WISC similarity test	47	.091	.036	.357	.015
WISC letter and number ordering test	47	.054	.056	.146	.339
Raven's test	47	-.036	.052	-.098	.497
Operation span task	47	.049	.019	.378	.010
Anxiety	47	.065	.075	.115	.396

Cognitive ability, anxiety and Icelandic exams

When examining the influence of cognitive ability tests on standardized Icelandic exam in 2012, R^2 is 0.317 and $F(4, 41) = 4.764, p = .003$. Cognitive ability tests explain 31.7% in the variance of the standardized Icelandic exam and. Table 8 shows that WISC similarity test significantly explains the variance in the standardized Icelandic exam when controlling for the other cognitive ability tests ($p = .005$).

Table 8

Coefficients for cognitive ability tests and standardized Icelandic exam in spring 2012

	N	B	Std. Error	Beta	Sig.
Constant		3.886	.923		.000
WISC similarity test	46	.104	.035	.429	.005
WISC letter and number ordering test	46	.039	.053	.112	.468
Raven's test	46	.030	.047	.095	.518
Operation span task	46	.017	.018	.139	.355

Another Icelandic language exam was examined or an exam from the fall of 2012. In that exam, R^2 is .344 and $F(5, 41) = 4.298$, $p = .003$. The cognitive ability tests and anxiety explain 34.4% in the variance of the Icelandic exam from fall 2012. As seen in table 9, none of the cognitive ability tests is statistically significant nor the anxiety measure ($p > .05$). However, since there is a directional hypothesis that higher scores on the OSPAN task predict higher scores on exams, the OSPAN task and WISC similarity task are significant when .099 is divided by 2 ($p = .0495$) and .110 is divided by 2 ($p = .055$).

Table 9

Coefficients for cognitive ability tests, anxiety and Icelandic exam in the fall of 2012

	N	B	Std. Error	Beta	Sig.
Constant		7.302	.725		.000
WISC similarity test	47	.038	.023	.228	.110
WISC letter and number ordering test	47	.044	.035	.186	.220
Raven's test	47	.010	.031	.044	.753
Operation span task	47	.021	.012	.254	.099
Anxiety	47	-.070	.046	-.202	.140

At last, the influence of cognitive ability tests and anxiety on an Icelandic exam in the winter of 2012 was examined and according to the model summary, R^2 is .049 and $F(5, 29) = 0.297, p = .911$. Cognitive ability tests and anxiety only explain 4.9% in the variance of the exam and are not statistically significant.

The results show that when controlling for the other cognitive ability tests, the operation span task and the WISC similarity test were the only cognitive test that significantly explained the variance in the scores on the exams in the mathematics and Icelandic. Anxiety significantly explained the variance in only one exam, the mathematics exam from fall 2012.

Scores on exams according to high or low scores on OSPAN task and anxiety

Since the working memory span (OSPAN task) and anxiety were statistically significant in explaining scores on some of the exams, it was decided to examine the difference of performance on exams according to high or low scores on OSPAN and anxiety. The results were obtained by making an independent t-test. According to figure 1, participants that had on average, higher scores on the OSPAN task ($M = 6.94, SE = .292$), had significantly higher scores on the standardized math exam than those with lower scores on the OSPAN task ($M = 8.1, SE = .204$).

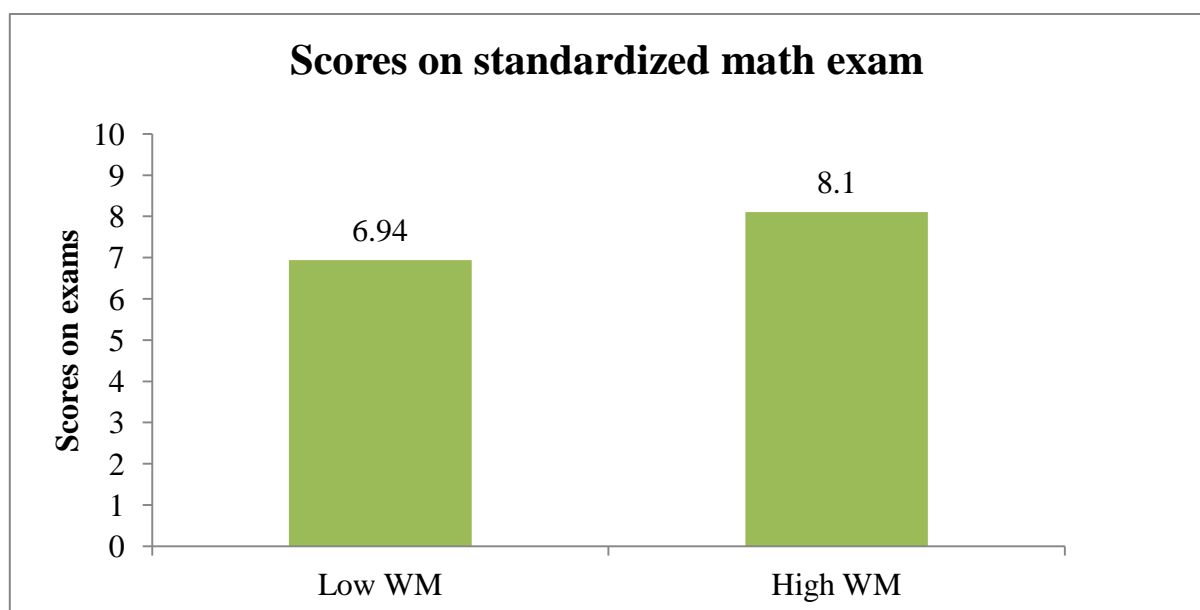


Figure 1. Scores on standardized math exam according to low/high scores on OSPAN task.

On average, scores on the math exam from fall 2012 were significantly higher for participants that had higher scores on the OSPAN task ($M = 9.18$, $SE = .158$) than for participants that scored lower on the OSPAN task ($M = 8.08$, $SE = .231$) (see figure 2).

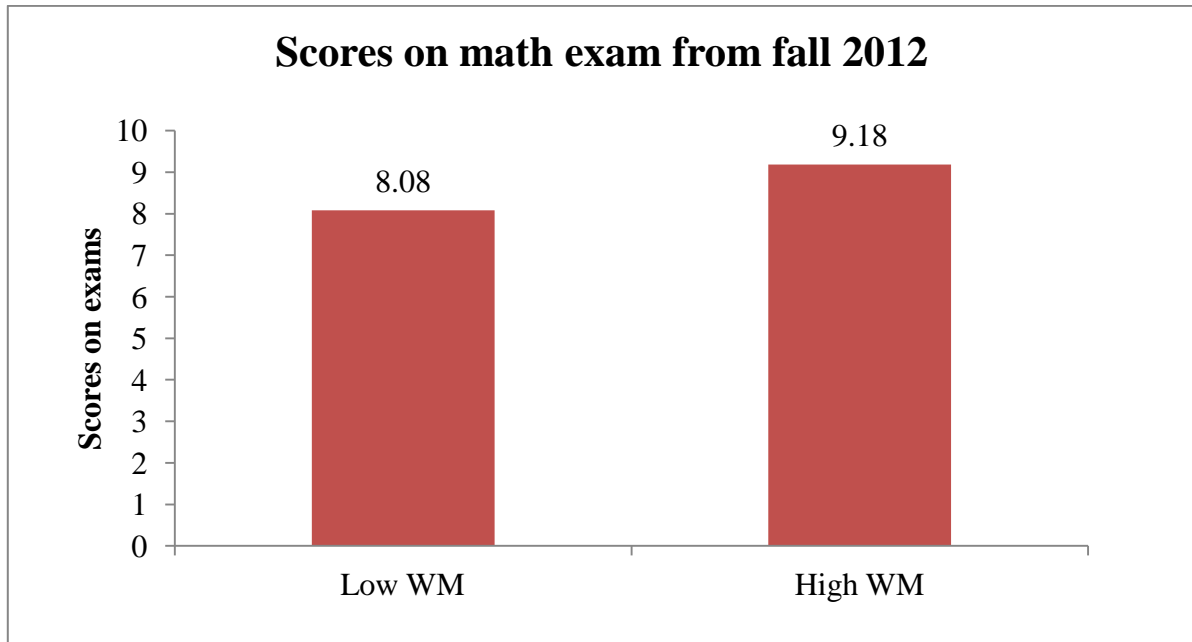


Figure 2. Scores on math exam from fall 2012 according to low/high scores on OSPAN task.

Scores on the mathematics exam from fall 2012 were also statistically significantly higher for those who had higher scores on OSPAN scores ($M = 7.59$, $SE = .221$) than those who scored lower on the task ($M = 8.47$, $SE = .269$). None of the scores on the Icelandic exams were statistically significant.

Figure 3 shows that on average, scores on the mathematics fall exam were significantly higher for participants that had lower scores on anxiety ($M = 8.83$, $SE = .184$) than for those who had higher scores on anxiety ($M = 8.14$, $SE = .331$). None of the other exams were statistically significant.

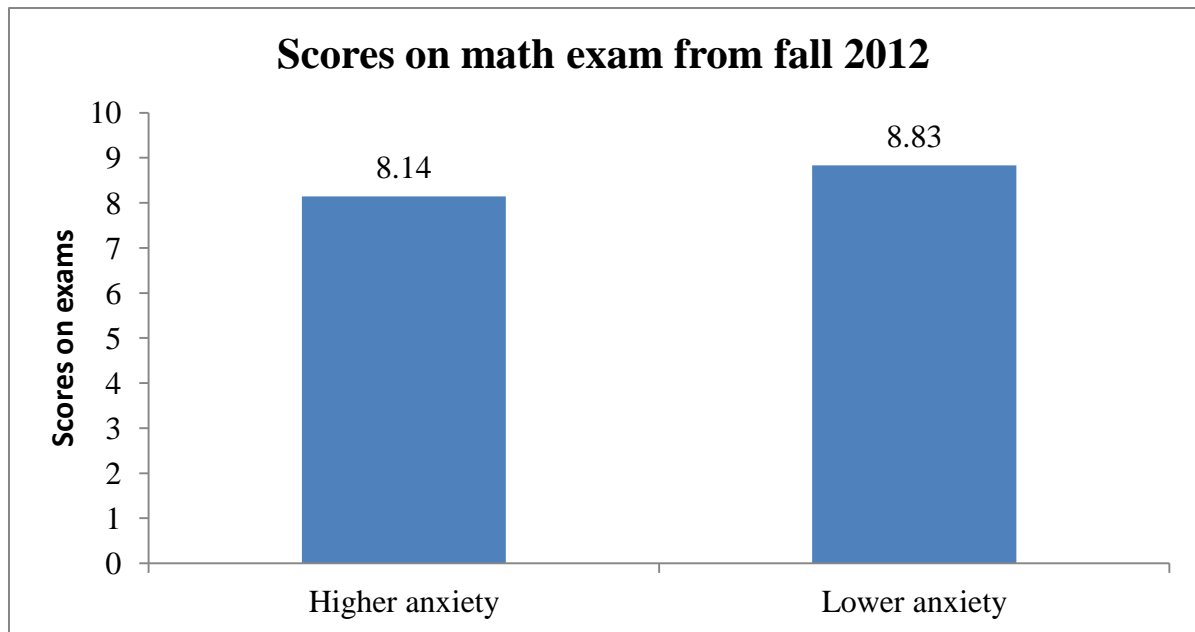


Figure 3. Scores on math exam according to higher or lower scores on anxiety.

The results reveal in whole that the working memory span (OSPAN task) was a good predictor of scores on the exams and especially on scores in mathematics. Verbal comprehension (WISC 2) was a good predictor of scores on Icelandic exams and anxiety predicted lower scores on the mathematics fall exam. The independent t-test revealed that higher working memory span predicted higher scores on mathematics exams and higher scores on anxiety predicted lower scores on the mathematics exam from fall 2012.

Discussions

The purpose of the present study was to examine the influence of different cognitive ability tests and anxiety on grades on exams in mathematics and Icelandic. The results from the correlation measure show that most of the cognitive tests correlate significantly with all of the exams. However, there seems that the correlation was usually higher for the mathematics exams. The highest correlation was between the OSPAN task and the math exam from fall 2012 and the WISC similarity test and standardized Icelandic exam. There was a higher correlation between anxiety and math exams than anxiety and Icelandic exams.

Cognitive ability tests and anxiety explained about 33% to about 50% in the variance of the math exams and from about 32% to about 34% in the variance of the Icelandic exams. That is consistent with a study by Rohde and Thompson (2007) where general cognitive ability and academic performance could not predict one another more than 50%.

When controlling for the other cognitive tests, the OSPAN task was the strongest predictor for the scores on math exams along with WISC similarity test in one of the math exams (winter exam). Those results are consistent with the hypothesis that higher scores on the OSPAN task predict higher scores on exams. Other studies have shown that achievements in mathematics relate to the working memory span (Gathercole et. al., 2004; Gathercole and Pickering, 2000; Rohde and Thompson, 2007) and the study of Rohde and Thompson (2007) showed that the working memory span was a better predictor for math scores than verbal scores. Since WISC similarity test was a good predictor of one math exam it could be explained by the fact that math problems are both in the form of numbers and in a verbal form. In that sense, verbal comprehension can be important in order to understand the math problems.

In predicting scores on the Icelandic exams when the other measures were controlled for, WISC similarity test was the strongest predictor along with the OSPAN task in one of the Icelandic exam (winter exam). These results are consistent with the hypothesis that higher scores on WISC similarity test predict higher scores on Icelandic exams. Other studies have also shown that verbal WM tasks are good predictors of scores on language and reading comprehension exams (Dickerson Mayes & Calhoun, 2003; Dickerson Mayes & Calhoun, 2007).

The influence of Raven's test on the exams was never statistically significant which is contrary to a study by Koenig, Frey and Detterman (2008), where scores on Raven's test showed a high correlation with math ACT scores. In that sense, the hypothesis was not

supported that higher scores on Raven's test predict higher scores on mathematics exams. When controlling for the other measures, anxiety was a significant predictor of scores on one of the mathematics exams from the fall of 2012. Anxiety influencing academic achievement is consistent with the hypothesis that higher scores on anxiety predict lower scores on exams and previous studies showed that higher anxiety scores resulted in worse academic performance (Alpert & Haber, 1960; Allen, Lerner, Wayne & Hinrichsen, 1972).

The present study has some limitations. One limitation is the number of participants that was rather small with some of the data missing from participants. There were seven different researchers that tested the participants on the cognitive ability tests, increasing the variability in testing measures. The testing period was rather time consuming which could have influenced the participant's concentration. The measures of anxiety were only four questions and more about general anxiety than test anxiety which would have been more accurate.

The results in whole show the strong relationship between the working memory span (OSPAN) and math performance on one hand and working memory verbal skills (WISC) and language performance on the other. It seems that there have not been done many studies in Iceland on this content and the present study offers the possibilities of Icelandic elementary schools to see what kind of abilities explain and can enhance children's academic achievement. That raises the question of how cognitive abilities can be trained in the best way in order to achieve better scores on exams. As the results show, the working memory span is a very important factor in academic achievement and must be explored further. The results also show that anxiety is a factor that influences scores on exams and that it is important to examine it better with other measures. The cognitive ability tests and anxiety could not explain more than 50% of the variance in the exams which still leaves us with the question of what factors are missing in explaining academic achievement. For further research, it would

be interesting to add in more cognitive factors, like processing speed. It would also be interesting to explore if test anxiety influences scores on exams more than scores on WM tasks and to see if those who have more anxiety have higher WM scores and therefore, higher scores on exams.

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Appendix A.

Kvíðaspurningar

Hefur þú fundið fyrir einhverju af þessu hér að neðan síðustu sjö daga? – Svima

Aldrei/ Næstum aldrei/ Sjaldan/ Stundum/ Oft

Hefur þú fundið fyrir einhverju af þessu hér að neðan síðustu sjö daga? – Skjálfta

Aldrei/ Næstum aldrei/ Sjaldan/ Stundum/ Oft

Hefur þú fundið fyrir einhverju af þessu hér að neðan síðustu sjö daga? - Skyndilega hrædd/ur

Aldrei/ Næstum aldrei/ Sjaldan/ Stundum/ Oft

Hefur þú fundið fyrir einhverju af þessu hér að neðan síðustu sjö daga? – Óþægilega
uppspenntur

Aldrei/ Næstum aldrei/ Sjaldan/ Stundum/ Oft

Appendix B.**Raven's fyrirlögn og fyrirmæli****Fyrirlögnin**

Verkefni er lagt fyrir nemanda og honum er sýnt með hvaða hætti hann á að merkja við rétt svar. Nemandi fær aðstoð ef hann biður um hana en einungis í fyrstu fimm myndunum. Aðstoðin felst í því að spurja nemandann hvaða bútur honum finnst passa best inní myndina. Prófandi situr nálægt nemandanum og er hlutlaus í viðmóti en ef nemandinn biður um aðstoð þegar hann er kominn lengra á leið með verkefnið skal prófandi einungis segja honum að velja þann búta sem honum finnst passa best inn í myndina.

Fyrirmæli

Í þessu verkefni sérðu 30 myndir. Á hverri mynd má sjá að það vantar búta inn í hana. Fyrir neðan hverja mynd eru sex til átta bútar með mismunandi mynstri eða formi. Veldu einn af sex til átta bútum til þess að fylla inn í myndina. Merktu við þann part sem þér finnst eiga best við myndina hverju sinni.

Appendix C.

Þátttakandi:

Dagsetning:

Fyrirlagnaaðili:

Orðalisti

Orðalisti 1

Orðalisti 5

Orðalisti 9

Orðalisti 2

Orðalisti 6

Orðalisti 10

Orðalisti 3

Orðalisti 7

Orðalisti 11

Orðalisti 4

Orðalisti 8

Orðalisti 12