STUDENTS' STUBBORNNESS TO CHANGE

TESTING CHOICES

By

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Abstract

This paper examines interventions to increase the use of testing as a study strategy. Previous research has examined the testing effect, which is the notion that actively recalling material through testing leads to improved recall of the material later (Karpicke and Roediger, 2007). The increased effectiveness should lead to increased use, but this may not always be the case. Using theory of intelligence and memory controllability research, we designed two interventions to promote the use of testing rather than restudying. A third intervention that explicitly described the benefits of testing was also implemented. Participants learned Swahili-English word pairs and were given the option to restudy or be tested on the material. None of the interventions successfully increased the proportion of words participants chose to be tested on rather than to restudy, revealing the stubbornness of students' study strategy choices.

Keywords: theory of intelligence, memory controllability, testing effect

Students' Stubbornness to Change Study Choices

Different study strategies have been shown to have different effectiveness (Karpicke & Roediger, 2007). For example, "testing" or actively recalling material promotes greater later recall than "restudying" or just being re-exposed to the material (2007). This is known as the testing effect, and the uniquely robust benefits have been shown inside and outside of the laboratory (McDaniel, Anderson, Derbish, & Morrisette, 2007). Although the effectiveness has been demonstrated, it may not be a widely adopted strategy. People may not use testing as a strategy enough or efficiently, and therefore do not reap the benefits.

There are several potential explanations for the underuse of testing as a study strategy. First, it may be due to a perceived increase in mental effort that recall during testing requires compared to rereading or re-exposing. This additional effort may differentially dissuade students looking to avoid extra effort from using this technique.

Using testing as a study strategy can be frustrating. Not only does it require more effort, but it can also feel less effective, since it reveals exactly what you do not know. Although incorrect answers actually lead to greater retention, the feeling of being "wrong" may dissuade students from using the strategy. A study strategy like rereading does not reveal gaps in knowledge and students may mistake familiarity with the material as knowing it. Testing also leads to a more dynamic understanding of the material that allows students to access the information in different ways (Roediger & Butler, 2011). Most assessments that students take require a deeper understanding of the material than the recognition that comes from reading material, so testing is an important study strategy.

Beyond the additional effort and potential for feeling "wrong," an additional explanation for students not using testing is that they do not know about its benefits. Perhaps testing is mostly seen as an assessment tool and not a study strategy, or, even if someone sees it as a study strategy, they do not know it is more effective than rereading (Roediger & Karpicke, 2006; Tullis, Finley, & Benjamin, 2016). If the benefits are unknown, it is unlikely to be used.

There are several potential reasons people do not fully use testing as a study strategy. Our aim in the following three studies is to examine whether manipulating theories of intelligence, manipulating the views of memory controllability, and emphasizing the effectiveness of testing will impact study strategies, specifically the use of testing versus restudying. Possible implications include a better understanding of how to promote success in students not using effective study strategies.

Experiment 1

Introduction

Students interpret effort in learning differently. The Theory of Intelligence (TOI) categorizes people as either believing that effort can increase intelligence or that effort has no impact on intelligence (Dweck, 2000). Those who believe intelligence is malleable are called incrementalists, while those who believe intelligence is fixed are called entitists. Much like the study strategies used, the mindset of a student may have important implications for their success (Claro, Paunesku, & Dweck, 2016). For example, holding the view that intelligence is malleable and that effort leads to learning may act as a shield against the harmful effects of poverty on young students (Claro et al., 2016). Miele and Molden (2010) found that a person's TOI could be manipulated and that this manipulation led to different perceptions of comprehension or understanding. In one experiment, the researchers manipulated participants' TOIs and then presented them with texts in either coherent or incoherent sentence order. Although both groups demonstrated equal levels of comprehension, incrementalists reported higher levels, whereas entitists reported lower. This may be due to incrementalists perceiving the extra effort of unjumbling the sentence order as increased learning and comprehension.

In a similar set of experiments, Miele, Finn, and Molden (2011) presented participants with a foreign and English word pair that was either easy to remember (high fluency) or difficult to remember (low fluency). Participants rated their judgment of learning (JOL) for each item, completed the TOI scale, and then completed a recall test. Although final performance on the recall task was not different between the groups, the groups differed in their estimations of learning for pairs that required more or less effort. These results indicate that the two groups have differing beliefs in how effort influences learning. This might lead them to choose study strategies based on the effort involved. Additional research by Peng and Tullis (2018) found that manipulating participants' TOI to believe intelligence is malleable changed participants' study choices. Specifically, participants with malleable views were more likely to re-study items they felt they had not learned very well and scored higher on the final recall test. This reveals that TOI interventions can impact study choices. Testing is a more effortful strategy than rereading so different views of effort may lead to different study strategy choices. The first study will examine how manipulating a participant's TOI impacts whether participants choose to restudy word pairs or choose to be tested on them.

Method

Participants.

Participants were recruited from the Psychology online subject pool of college students enrolled in an introductory psychology course at a public university. A total of sixty-one participants were recruited. Participants received course credit for their participation.

Instruments/Materials.

One of two articles was presented to students to manipulate their theory of intelligence; one focused on the changeable nature of intelligence while the other focused on the unchangeable nature (see Appendices A and B). A selection of medium difficulty Swahili-English word pairs developed by Nelson and Dunlosky (1994) were given to participants to study and be tested on (see Appendix C). Accompanying each word pair was a JOL scale of one through four; "one" meaning "Definitely Will Not Remember" and "four" meaning "Definitely Will Remember." To measure participants' theory of intelligence (TOI), Dweck's (2000) standardized theory of intelligence scale was administered (see Appendix D). Additionally, items from Lachman, Bandura, Weaver, and Elliott's (2007) standardized memory controllability scale were administered to serve as a manipulation check of participants' views of memory controllability (see Appendix E).

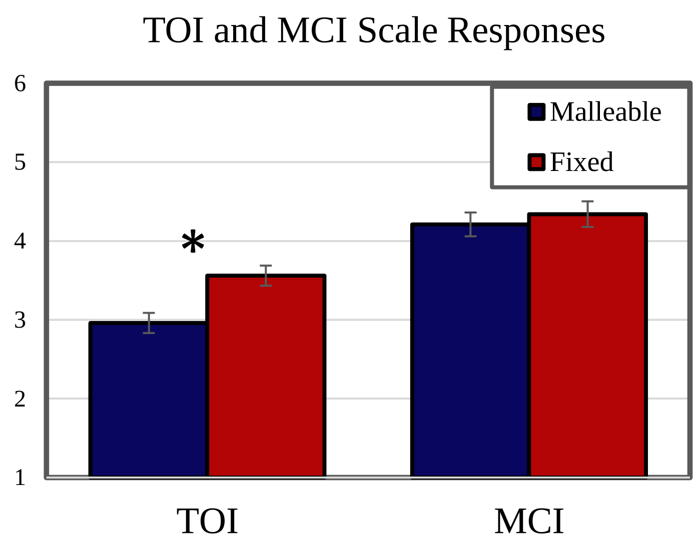
Procedure.

When participants arrived at the lab, they were given a consent form to read and sign if they choose to participate. They were then placed at a computer and told that the instructions are on the screen. On the computer, participants were randomly assigned to either an *incremental intelligence group* or an *entitist intelligence group*. They read one of two theory of intelligence articles (see Appendices A and B) and were asked to answer questions about the articles to ensure comprehension. Participants were then shown forty Swahili-English word pairs one at a time in black 40 pt font on a white screen (see Appendix C). They rated their JOL and decided whether to be tested or to restudy each item. The items were presented again either to restudy or be tested on, depending on the participant's choice. If they chose to be tested on the items, they were given feedback on their response and the correct answer if they were wrong. If they chose to re-study the items, they were presented with the word pairs again and were able to move through them at their own pace. Items from the TOI scale mixed with the items from the Memory Controllability Scale were presented with Likert scale response options (see Appendix E). Following the scales, the final recall test of the word pairs was administered. The Swahili word was presented, and participants were instructed to type the English equivalent. Following the recall test, participants were read and given a debriefing sheet and were offered a copy of the consent form.

Results

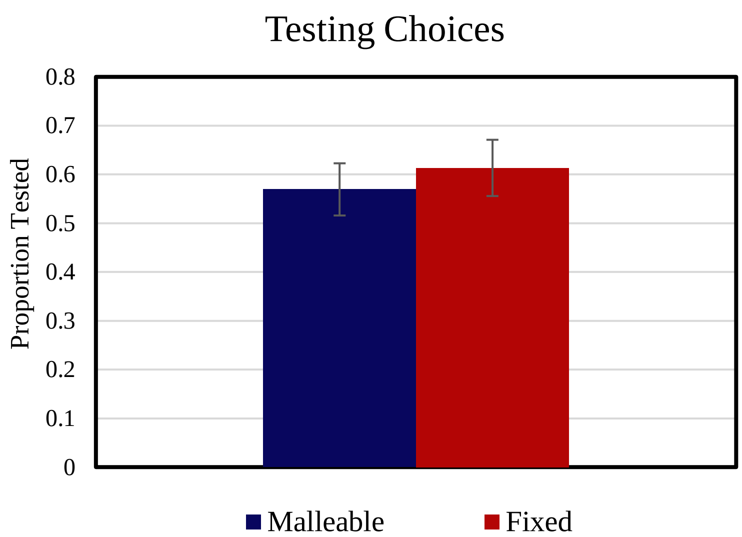
First, we examined survey scores to check if the TOI manipulated affected participants' self-reported beliefs, which are displayed in Figure 1. The fixed intelligence group reported stronger agreement with fixed views ($M = 3.56$, $SD = .86$) than the fixed intelligence group ($M = 2.96$, $SD = .84$; $t(57) = 2.65$, $p = .01$, $d = .71$). Similarly, we examined whether the TOI intervention affected participants' beliefs about memory controllability. Memory controllability beliefs did not differ between the malleable intelligence group ($M = 4.51$, $SD = .71$) and the fixed intelligence group ($M = 4.64$, $SD = .67$; $t(57) = .72$, $p = .47$, $d = .19$).

Figure 1. The average scores on the Theories of Intelligence Scale and the Memory Controllability Inventory as a function of condition. Higher scores indicate greater endorsement of fixed views of intelligence and memory. Error bars indicate one standard error of the mean above and below the sample mean.



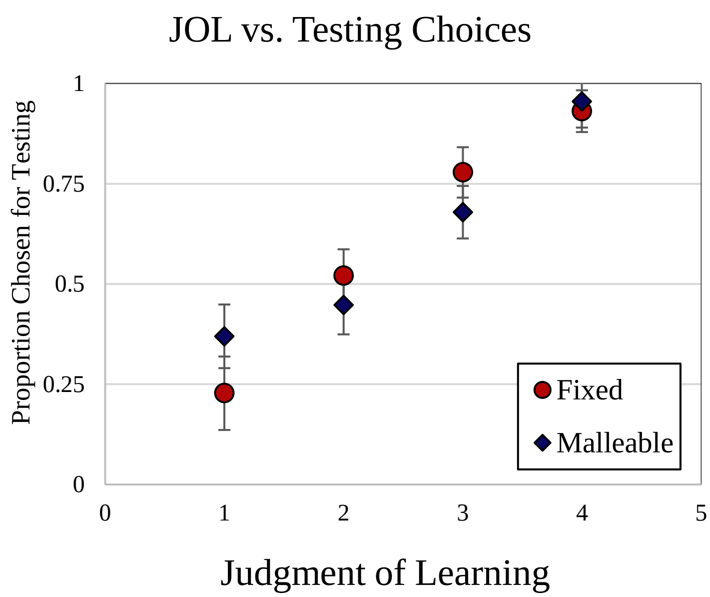
Next, we examined whether TOI condition affected the number of items participants choose to test. As shown in Figure 2, the proportion of items chosen for testing did not significantly differ between the malleable group (M = 0.57, SD =.29) and fixed group (M = 0.61, SD =.31 ; $t(57) = 0.55$, $p = 0.58$, $d = 0.13$).

Figure 2. The average proportion of items participants chose to be tested on, rather than restudy. Higher scores indicate more items that were tested. Error bars indicate one standard error of the mean above and below the sample mean.



We then examined whether TOI condition impacted which items participants chose to test. To do so, we calculated the gamma correlation between a participant's JOL for an item and their choice to be tested on the item. Negative gamma correlations indicate that learners choose to test on well-learned items and restudy poorly-learned items (while positive correlations indicate the opposite pattern). The gamma correlation between JOL and choice did not differ between the malleable intelligence group (M = -.76, SD = .52) and the fixed intelligence group (M= -.83, SD= .25; ($t(43) = 0.55$, $p = 0.58$, $d = 0.17$).

Figure 3. The average proportion of items participants chose to be tested on across JOL scores. Higher JOL scores indicate items participants felt they had learned well. Error bars indicate one standard error of the mean above and below the sample mean.



Finally, we examined whether final test performance varied between the groups. The fixed intelligence group did not show significantly different recall (M = .36, SD = .16) than the malleable intelligence group (M = .31, SD = .13; $t(57) = 1.34$, $p = 0.19$, $d = 0.34$).

Discussion

Experiment 1 successfully changed participants' TOIs. Although the first intervention changed people's beliefs about the nature of intelligence, it did not change their testing choices. This reveals that TOI is likely not the main driving force behind the study strategies that students use. These findings also indicate that interventions based on TOI changes may not be successful in encouraging the use of testing as a strategy.

Although previous research has demonstrated that TOI impacts the interpretation of effort, these interpretations did not translate into choices about whether or not to use testing, which is a more effortful study strategy (Miele & Molden, 2010). The lack of effect on testing choices reveals that the amount of effort involved may not be the reason students choose a study strategy. If this had been the case, we would expect participants in the *malleable intelligence group* to use testing significantly more since they would see the more effortful strategy as a better method to learn the material. Additionally, there were not significant differences between the groups for testing choices across JOLs. While TOI can influence JOL, differences in beliefs about learning did not lead to different study strategy choices between the groups.

In addition to TOI, we also measured memory controllability beliefs through the memory controllability inventory (MCI). The altered TOI did not lead to a change in MCI. Although we did not aim to directly influence MCI, we expected that the two concepts would be related since they both address the fixed or malleable nature of intellect-related concepts. Because there was not a significant difference between the groups' ratings on the MCI, which indicates that people potentially view the nature of memory differently than intelligence.

Memory is required in the Swahili-English word pair task and plays a key role in testing or restudying, so we designed the intervention in Experiment 2 to more specifically target beliefs about memory and therefore the study strategies we aimed to change.

Experiment 2

Introduction

The TOI scale refers to intelligence in a broad sense, but research is now exploring how beliefs about more specific aspects of intelligence impact achievement across the lifespan (Lachman, Bandura, Weaver, & Elliott, 2007). It is possible that people differ in their beliefs about different domains, and this variability may impact different areas of achievement. One domain in particular is memory. Memory is required to learn concepts such as novel words and is the skill hopefully strengthened by restudying and retesting.

Restudying and retesting both rely on and relate to memory, so manipulating someone's beliefs about memory controllability may directly impact their study choices. Much like intelligence, memory can be viewed as fixed or malleable. In the same way the TOI scale identifies these different beliefs, the memory controllability inventory (MCI) can identify those who view memory as fixed or malleable.

Study 2 will compare views of memory controllability and the number of items participants choose to restudy or be tested on. We hypothesize that participants holding a fixed view of memory will be more likely to choose restudying because they will not see the benefit of the extra effort in being tested. On the other hand, participants who hold a malleable nature of memory will be more likely to choose testing because they will be more interested in an effortful strategy due to linking effort and learning. The second study will examine whether manipulating views of memory controllability will impact study strategies.

Method

Participants.

Participants were recruited in the same manner as Experiment 1. Sixty-five participants completed and earned partial course credit for participating.

Instruments.

One of two articles modified from Bergen (1992) was presented to students to manipulate their views on memory controllability; one focused on the changeable nature of memory through the use of effortful strategies while the other focused on the fixed, unchangeable nature of memory (see Appendices E and F). The modifications included changing the word "intelligence" to "memory" throughout. Additionally, the modified articles discussed competitors in the World Memory Championship, rather than a child with advanced learning abilities. The malleable memory article discussed the importance of competitors' learning and using good memory strategies; while the fixed memory article stressed the natural abilities of the competitors. The remaining instruments including the word-pairs, JOL scale, and TOI/MCI scales remained the same as Experiment 1.

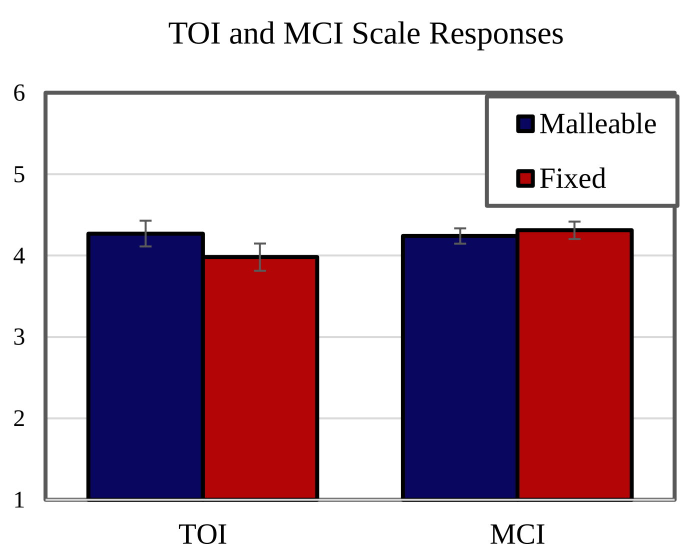
Procedure.

The procedures for Experiment 2 were the same as Experiment 1, with the exception of which articles participants read. The articles in Experiment 2 discussed memory controllability (see Appendices E and F).

Results

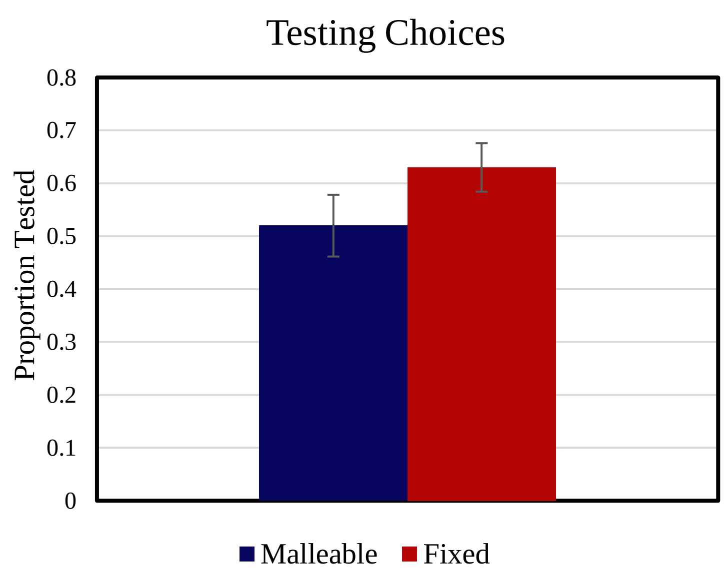
First, we examined survey scores to check if the MCI manipulation affected participants' self-reported beliefs about memory controllability. The *malleable memory group* did not report stronger agreement with malleable views of memory ($M = 4.24$, $SD = .89$) than the *fixed memory group* ($M = 4.31$, $SD = .96$; $t(63) = 1.25$, $p = .22$, $d = -.08$). Similarly, we examined whether the MCI intervention affected participants' beliefs about theory of intelligence. Theory of intelligence beliefs did not differ between the *malleable memory group* ($M = 4.27$, $SD = .53$) and the *fixed memory group* ($M = 3.98$, $SD = .61$; $t(df) = .49$, $p = .62$, $d = .51$).

Figure 4. The average scores on the Theories of Intelligence Scale and the Memory Controllability Inventory as a function of condition. Higher scores indicate greater endorsement of fixed views of intelligence and memory. Error bars indicate one standard error of the mean above and below the sample mean.



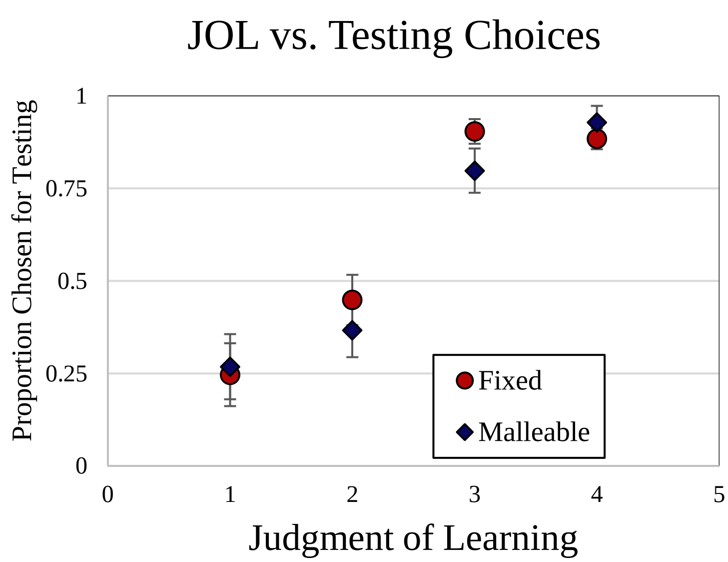
Next, we examined whether the MCI condition affected the number of items participants choose to test. The proportion of items chosen for testing did not significantly differ between the *malleable memory group* (M = 0.53, SD = .33) and *fixed memory group* (M = 0.63, SD = .26; $t(63) = 1.45$, $p = 0.15$, $d = 0.37$).

Figure 5. The average proportion of items participants chose to be tested on, rather than restudy. Higher scores indicate more items that were tested. Error bars indicate one standard error of the mean above and below the sample mean.



We then examined whether TOI condition impacted which items participants chose to test. To do so, we calculated the gamma correlation between a participant's JOL for an item and their choice to be tested on the item. Negative gamma correlations indicate that learners choose to test on well-learned items and restudy poorly-learned items (while positive correlations indicate the opposite pattern). The gamma correlation between JOL and choice did not differ between the *malleable memory group* (M = -.91, SD = .18) and the *fixed memory group* (M = -.78 , SD = .45; t(48) = 1.40, p = .17, d = -.38).

Figure 6. The average proportion of items participants chose to be tested on across JOL scores. Higher JOL scores indicate items participants felt they had learned well. Error bars indicate one standard error of the mean above and below the sample mean.



Finally, we examined whether final test performance varied between the groups. The *fixed memory group* did not show significantly different recall (M = .37, SD = .20) than the *malleable memory group* (M = .34 , SD = .19; t(63) = .62, p = .56 , d = .157).

Discussion

Experiment 2 did not successfully alter participants' beliefs about the controllability of memory. Additionally, there were no significant differences in TOI between the groups. Furthermore, the intervention did not lead to a difference in the testing choices across JOL.

Although the articles used were altered from articles that did lead to a difference in TOI, the articles aimed at influencing beliefs about memory controllability were ineffective at altering TOI or MCI beliefs. The modifications potentially did not present a compelling case for the fixed or malleable nature of memory. Including additional pieces of evidence for either side may have been more effective. Potentially an intervention that successfully altered MCI beliefs would also be effective at altering testing choices.

Neither the Theory of Intelligence or the Memory Controllability manipulations were effective at changing testing choices, so we decided to target beliefs about testing more specifically.

Experiment 3

Introduction

The TOI and MCI interventions were unsuccessful at changing participants' study strategy choices. One of the hypothesis we had about why testing is not fully utilized as a study strategy is that people do not know it is a beneficial study strategy. To address this possibility, we designed an intervention that explicitly told people about the benefit of testing. The other intervention was the same malleable intelligence intervention used in Experiment 1. Like the testing intervention, we believed the malleable intelligence intervention may lead to increased use of testing, so this comparison would allow us to see which intervention more effectively promotes the use of testing. Experiment 3 examined whether teaching participants about the testing effect and describing the benefits would impact the use of testing as a study strategy.

Method

Participants.

Forty-two participants were recruited from the Psychology subject pool and the Educational Psychology department online subject pool. Participants from both pools received class credit for participating. We did not expect there to be any differences between the two groups.

Instruments.

Participants were presented with one of two articles; one is the same the article from Experiment 1 explaining the changeable nature of intelligence and the other explains the effectiveness of using testing as a study strategy (see Appendices B and H). The remaining instruments including the word-pairs, JOL scale, and TOI/MCI scales remained the same as Experiment 1 and 2.

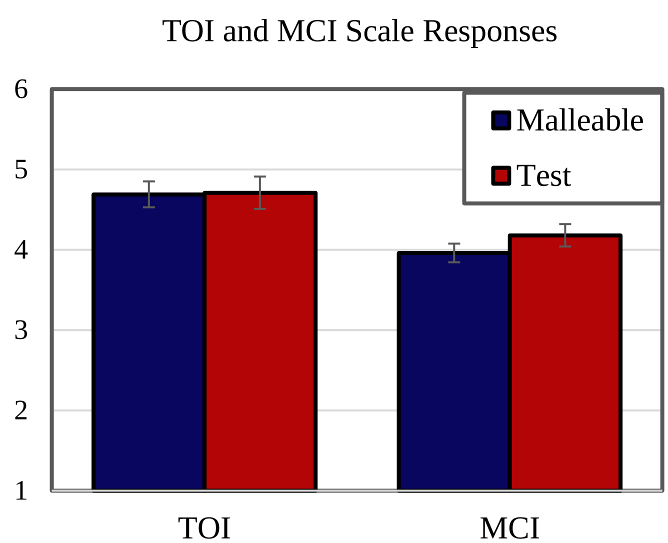
Procedure.

The procedure for Experiment 3 was the same as Experiment 1 and 2, with the exception of which articles participants read. Participants began by reading either the paper about the changeable nature of intelligence or explaining testing effect (see Appendices B and H).

Results

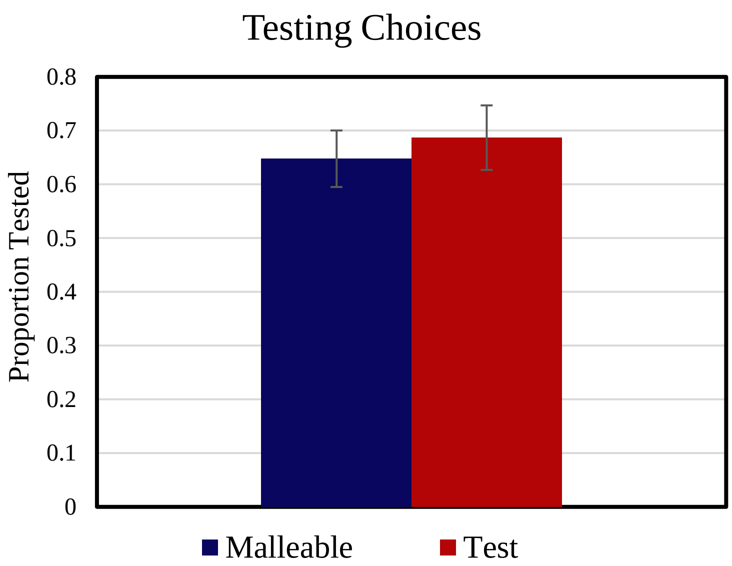
First, we examined survey scores to check if the testing manipulation affected participants' self-reported beliefs. Theory of intelligence beliefs did not differ between the *malleable intelligence group* ($M = 4.69$, $SD =.74$) and the *testing group* ($M = 4.71$, $SD = .92$; $t(40) = .07$, $p = .95$, $d = .02$). Similarly, we examined whether the testing intervention affected participants' beliefs about memory controllability. Memory controllability beliefs did not differ between the *malleable intelligence group* (M = 3.96, SD = .53) and the *testing group* (M = 4.18, SD = .64; t(40) = 1.18, p = .25, d = -.37).

Figure 7. The average scores on the Theories of Intelligence Scale and the Memory Controllability Inventory as a function of condition. Higher scores indicate greater endorsement of fixed views of intelligence and memory. Error bars indicate one standard error of the mean above and below the sample mean.



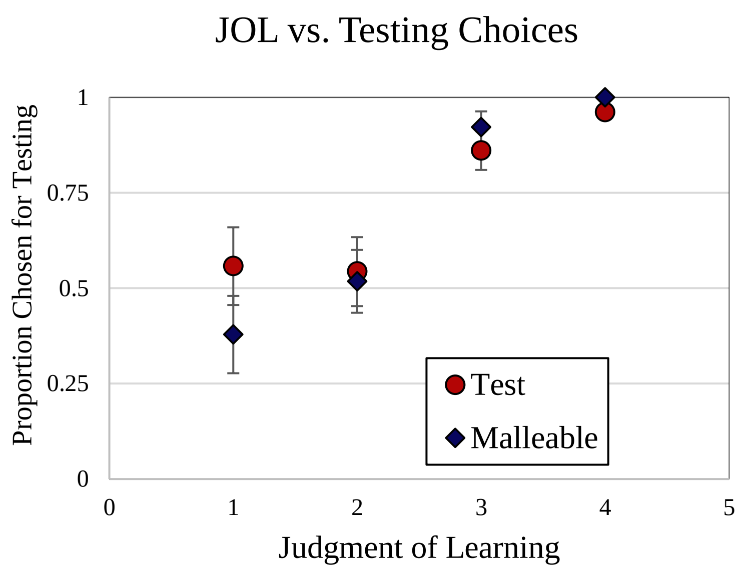
Next, we examined whether TOI condition affected the number of items participants choose to test. The proportion of items chosen for testing did not significantly differ between the *malleable intelligence group* (M = .65, SD = .24) and *testing group* (M = .69, SD = .28; *t*(40)= .48, *p* = .63, *d* = -.15).

Figure 8. The average proportion of items participants chose to be tested on, rather than restudy. Higher scores indicate more items that were tested. Error bars indicate one standard error of the mean above and below the sample mean.



We then examined whether TOI condition impacted which items participants chose to test. To do so, we calculated the gamma correlation between a participant's JOL for an item and their choice to be tested on the item. Negative gamma correlations indicate that learners choose to test on well-learned items and restudy poorly-learned items (while positive correlations indicate the opposite pattern). The gamma correlation between JOL and choice did not differ between the *malleable intelligence group* (M = -.96, SD = .07) and the *testing group* (M = -.85, SD = .21 ; t(29) = 1.99 , p = .06 , d =-.70).

Figure 9. The average proportion of items participants chose to be tested on across JOL scores. Higher JOL scores indicate items participants felt they had learned well. Error bars indicate one standard error of the mean above and below the sample mean.



Finally, we examined whether final test performance varied between the groups. The *malleable intelligence group* did not show significantly different recall (M = .43, SD = .20) than the *testing group* (M = .42, SD = .19; t(40) = .21, p = .83, d = .05).

Discussion

In Experiment 3, there were no significant differences in TOI or MCI scores for the two groups. The proportion of items participants chose to be tested on was also not significantly different. Furthermore, the testing group intervention did not lead to a difference in the testing choices across JOL. Much like Experiment 2, the testing group article was created for this experiment and has not been used previously. Potentially a different article or intervention explaining the testing effect might lead people to use testing as a study strategy more. The method used in Experiment 3 though would not be an effective intervention to increase the use of testing.

General Discussion

The three interventions were unsuccessful in altering the proportion of items people chose to be tested on. Despite the first experiment manipulating TOI, the proportion of items participants chose to restudy versus be tested on was not impacted. These results show the stubbornness of testing choices and perhaps indicate that study strategy choices have multi-faceted influences that are possibly set early and resistant to short-term change. Prior usage and habits or what has been modeled for the learner may have been influencing the learner since very early in life and undoing these influences may take more than an article. An activity such as studying that most of our student participants likely do frequently may be especially resistant to short-term changes. One additional area that could be examined as an influence of testing choices is views of self-efficacy. This is similar to TOI because it influences how people approach challenges.

Although the interventions were unsuccessful, we did replicate previous findings that participants test items they feel they have learned well and restudy those that they feel they've learned poorly. This may be counterproductive since testing promotes greater recall. Perhaps testing as a study strategy is uniquely resistant to change due to its intuitive use as assessment rather than a study strategy. The frequent use of testing in stressful situations may lead to negative connotations that prompt resistance to use it.

Further research should identify why people choose the study strategies they do and what interventions might successfully change their study strategy choices.

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Appendix A

THE BRAIN

The Origins of Intelligence:

Is the Nature-Nurture Controversy Resolved?

BY JEROME BERGLUND

Adam Steagal is gifted. Although he is just eighteen months old, he can understand over 2000 words, has a speaking vocabulary of 500 words, and is even able to identify five different species of birds. Early in his life, Adam's parents had a hunch that he was unusual.

At the age of 8 months he was crawling and investigating everything in the Steagal household. All babies are curious, but Adam's curiosity led him to heights of baby creativity. He was not simply banging on pots and pans; Adam had learned to dismantle a toy camera and put it back together again. He had the coordination to handle small objects, the ability to remember how parts fit together, and could concentrate on the camera for almost an hour. Most children can't do what Adam was doing until they are at least three or four.

When he was ten months old, Adam's parents brought him to University of Michigan's Unit for Intelligence Research (UIR). Paula Rescorla, the director of UIR, found that Adam had an IQ of 185. Experts consider an IQ of 130 "very superior." Adam's IQ is so extreme that only one person in a million has an IQ that even comes close. Researchers like Rescorla are keenly interested in what made Adam so smart.

The traditional "is it heredity or is it environment?" question is battered around the halls of UIR daily. But, people who take the side that intelligence is genetically determined are going to be believed less and less. Current research shows that intelligence can be increased substantially by environmental factors.

In the past decade, a number of comprehensive studies have been published in the United States and in Europe. These studies provide the clearest answers so far in the ongoing debate. The most significant of these studies will be published this fall in Psychological Review, a prestigious psychological journal published in the United States.

John Knowles, the author of the article and a professor at Harvard, concludes that, "intelligence seems to have a very strong genetic component. In addition, the environment seems to play a somewhat important role during the first three years of life. After the age of three, though, environmental factors (barring brain damage) seem to have almost no influence on intelligence."

"The brilliance of Mozart and Einstein was mostly built into them at birth. Their genius was probably the result of their DNA."

Knowles spent the last decade tracing identical twins who were raised apart. In a relentless search throughLatin America, Africa, and North America, he was able to locate 83 pairs of twins who were raised separately. These twins ranged in age from 7 to 51 and came from all economic levels.

Knowles had an ideal sample to study the nature-nurture question. The twins in his study were often reared in different cities by parents of different social classes. The various pairs of twins came from different countries, spoke different languages, were different ages, and he followed them for ten years. Knowles tested the subjects individually with the best "culture-fair" intelligence tests available.

Culture-fair tests measure intelligence by having people identify relationships between shapes and objects. Because the tests use only shapes and objects — not words — to measure intelligence, cultural factors don't influence people's scores. Consequently, they provide a much more accurate measure of intelligence than most other intelligence tests. In addition, culture-fair tests don't discriminate against any ethnic groups. Because Knowles used these sophisticated measures of intelligence, he was able to make stronger conclusions than have been possible in the Past.

He found that twins raised apart had very similar levels of intelligence. Twins separated at birth on the average had almost very similar levels of intelligence. But, they sometimes had differences in their IQs as great as ten to fifteen points. Almost all of the twins in his study that were separated after the age of three had nearly identical IQs. If one twin was bright, the other was almost always equally bright. If one twin was not-so-bright, the other twin was probably not-so-bright.

According to Knowles' results, up to eighty-eight percent of a person's intelligence is due to genetic factors. About ten percent of intelligence seems to be determined during the first three years of life. This means that intelligence may be increased or decreased by only about two percent during most of a person's life. To support this claim, Knowles can show that people's intelligence did not change much in ten years. Many things in their environment shifted in that time, but their intelligence stayed constant.

According to Knowles, his results suggest that "the brilliance of Mozart and Einstein was mostly built into them at birth. Their genius was probably the result of their DNA, not their schooling, not the amount of attention their parents gave them, not their own efforts to advance themselves. These great men were probably born, not made."

Knowles' research also showed that intelligence plays a major role in many important areas of people's lives. His results show that very bright people were happier than less bright people. Intelligent people made more money than less intelligent people. In fact, he found that intelligent people don't get divorced as often as unintelligent people and often have spouses that are rated as more attractive. Based on these results, Knowles said, "we tend to make a big deal out of intelligence in our society, and my research suggests it's justified. In Western cultures especially, people are admired and tend to succeed because they are smarter than the average person."

Other researchers are finding similar results. Hans Eysenck recently published an article supporting Knowles' research. Eysenck's studies show that a person's environment does not alter his or her intelligence. He found that bright children placed in "dull" environments did not become less intelligent. Instead, they tended to take advantage of the less-gifted people around them. Relatively dull children placed in stimulating environments did not seem to get any smarter.

Eysenck also found that intelligence was related to important "real-world" variables. He found a strong relationship between IQ scores and people's salaries. He again found a positive relationship between happiness and intelligence. Eysenck said, "I set out to show that intelligence was not genetically determined. Now my research suggests that some people do have superior genes. In addition, we are finding that many important things in people's lives arc determined at least partly by how smart they are."

"We tend, to make a big deal out of intelligence in our society, and my research suggests it's justified. In Western cultures especially, people are admired and tend to succeed because they are smarter than the average person."

Needless to say, Knowles' and Eysenck's research is drawing much attention from other psychologists. Their findings are a blow to researchers who have spent years arguing that intelligence is due to environmental factors.

Leo Kamin of Princeton University is one such researcher. In the 1960s and '70s, he argued strongly that there was no good evidence to show the link between intelligence and genetics. He helped to prove that Sir Cyril Burt, a now infamous intelligence researcher, faked his data to show that intelligence was inherited. When Burt was alive, he was knighted in England for his research. When Kamin examined Burt's results, he discovered serious flaws that could only have resulted by faking the data.

This experience has made him highly skeptical of any research that establishes a relationship between intelligence and a person's genes. Because of this, he carefully examined Knowles study. He says he found "no flaws in [Knowles'] methods or his analysis. For me, these results are a little like finding out that the earth is round when you've spent 25 years trying to show it's flat. But I am a scientist first and foremost. If the best research shows that intelligence is mostly genetically determined, I will accept that fact. Knowles' research is simply the best."

Paula Rescorla at University of Michigan's UIR is excited about Eysenck's and Knowles' results. "It is about lime we realize that intelligence is a genetically-determined ability. Knowing that intelligence is genetically controlled is something that can help society. We can learn to identify quickly those who can really benefit from specialized training. By having young geniuses get the kind of training that challenges them, we will be helping them live up to their abilities. Then they can help society. In addition, we can help less bright people find environments that won't frustrate them. We can pul them into non-threatening environments that match their skills."

The eighteen month-old genius Adam Steagal seems to be in the ideal environment Rescorla described. His young brilliance is being challenged by fascinating toys and games. He is in the company of other intellectual babies. If what the researchers say is true, there is a good chance that Steagal is destined to be a leader in about the year 2020. We can only hope that he will use his brilliance not to control us lesser mortals, but to help us find the ideal environments Rescorla described.

Jerome Berglund is a free-lance writer from Ann Arbor, Michigan. He is a frequent contributor to Psychology Today.

Appendix B

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Origin of intelligence: Nature or nurture?

By: Ray Levich

May 7, 2017

Adam Steagal is gifted. Although he is just eighteen months old, he can understand over 2000 words, has a speaking vocabulary of 500 words, and is even able to identify five different species of birds. Early in his life, Adam's parents had a hunch that he was unusual.

When he was ten months old, Adam's parents brought him to University of Michigan's Unit for Intelligence Research (UIR). Paula Rescorla, the director of UIR, found that Adam had an IQ of 185. Adam's IQ is so extreme that only one person in a million has an IQ that even comes close. Researchers like Rescorla are keenly interested in what made Adam so smart.

The traditional "is it hereditary or is it environment?" question is battered around the halls of UIR daily. But, people who take the side that intelligence is genetically determined are believed less and less. Current research shows that intelligence can be increased substantially by environmental factors.

John Knowles, a prof at Harvard, just published an influential paper that concludes, "intelligence seems to have a minimal genetic component. People may be born with a given level of intelligence, but we see IQs increase by up to 50 points when people enter stimulating environments."

Knowles spent the last decade tracing identical twins who were raised apart. Knowles had an ideal sample to study the nature-nurture question. The twins in his study were often reared in different cities by parents of different social classes. The various pairs of twins came from different countries, spoke different languages, were different ages, and he followed them for ten years. Knowles tested the subjects individually with the best "culture-fair" intelligence tests available. Culture-fair tests measure intelligence by having people identify relationships between shapes and objects. Because Knowles used these sophisticated measures of intelligence, he was able to make stronger conclusions than have been possible in the past.

He found that twins raised in different environments had very different levels of intelligence. According to his results, up to 88 percent of a person's intelligence is due to environmental factors. In his study, if twins were raised in stimulating environments with motivated parents, they tended to have high IQs. Twins raised in unstimulating environments tended to have lower IQs. In an extreme case, a young girl adopted by a college professor and his wife had an IQ of 138. The genetically identical twin was raised by the real mother who was a prostitute. This girl had an IQ of only 85.

Although this evidence is very strong, Knowles has even more evidence which may convince skeptics. He found that people in challenging environments showed substantial increases in their intelligence during the ten year study. Children and adults who were in stimulating environments had increases in IQ ranging from 15 to 48 points. People who were in unstimulating environments showed slight drops in their IQ.

According to Knowles, his results suggest that "the brilliance of Leonardo da Vinci and Albert Einstein was probably due to a challenging environment. Their genius had little to do with their genetic structure. These men are truly admirable because they were challenged and worked to overcome obstacles.

Other researchers are finding similar results. Hans Eysenck recently published an article supporting Knowles' research. Eysenck's studies show that a person's level of motivation can have a profound effect on intelligence. He found that bright children placed in dull environments tended to become less intelligent unless they were motivated to learn. Relatively dull children placed in stimulating environments seemed to get much smarter, especially if they were rewarded for learning new things.

Eysenck said, "I spent much of my life believing that intelligence was genetically determined. Now my research suggests that people do not have superior genes." Needless to say, Knowles' and Eysenck's research are widely praised by researchers who have been trying for years to prove that intelligence is not genetically determined.

Paula Rescorla at University of Michigan's UIR is also excited about Eysenck's and Knowles' results. "I think an absolutely critical thing has come out of these studies. Intelligence is something that motivated people can acquire. We can help motivated children find environments that will help them increase their abilities. And, when someone really doesn't care about intellectual things, we can help them find environments that stimulate them in other ways."

The eighteen-month-old genius Adam Steagal seems to be in an ideal environment right now. His young brilliance is being challenged by fascinating toys and games. But apparently, whether he will be brilliant when he grows up is largely his choice.

Appendix C

Table A1

Swahili-English Word Pairs from Nelson and Dunlosky (1994)

Indonesian	**English**
Telur	Egg
Baru	New
Jelek	Bad
Basah	Wet
Bagasi	Luggage
Baik	Good
Kebudayaan	Culture
Handuk	Towel
Obat	Medicine
Tas	Bag
Debu	Dust
Dimana	Where
Mungil	Cute
Rendah	Short
Panas	Hot
Dompet	Wallet
Restoran	Restaurant
Sekolah	School
Besar	Big
Susu	Milk

Indonesian	**English**
Coro	Cockroach
Ini	This
Bau	Stink
Sakit	Sick
Satu	One
Kiri	Left
Bukit	Hill
Seni	Art
Pesta	Party
Sapi	Cow
Turis	Tourist
Buka	Open
Botol	Bottle
Ban	Tire
Kue	Pastry
Babi	Pig
Roti	Bread
Bistik	Steak
Cinta	Love
Asli	Authentic

Appendix D

Table A2

Theory of Intelligence Scale from Dweck (2000)

Your intelligence is something about you that you cannot change very much.
No matter who you are, you can significantly change your intelligence level.
To be honest, you cannot really change how intelligent you are.
You can learn new things, but you cannot really change your basic intelligence.
You have a certain amount of intelligence, and you cannot really do much to change it.
No matter how much intelligence you have you can always change it quite a bit.
You can change even your basic intelligence level considerably.
You can always substantially change how intelligent you are.

Appendix E

Table A3

Memory Controllability Inventory Scale from Lachman, Bandura, Weaver, and Elliott (2007)

I can remember the things I need to.
I am not good at remembering things.
I cannot remember things, even if I want to.
If I really want to remember something, I can.
I cannot seem to figure out what to do to help me remember things.
I can find ways to improve my memory.
I can think of strategies to help me keep up my memory.
If I work at it, I can improve my memory.
If I use my memory a lot, it will stay in shape, just like my muscles do if I exercise.
If I use my memory often, I will not lose it.

Appendix F

The Origins of Memory: Is the nature-nurture debate resolved?

By: Ray Levich

May 7, 2016

Nowhere are the incredible memories of some people on better display than the World Memory Championship. At this annual competition, competitors from over 30 countries put their memory skills to the test to compete for a $100,000 grand prize. That large amount of prize money attracted the attention of Dominic O'Brien. Dominic always knew he had a better memory than his family and friends, and after he's won the World Memory Champion eight times, he has proven it. If you talk to the competitors, many will tell you about how they've always just been able to remember things like phone numbers or addresses.

This competition involves remembering much more than a phone number though, and it has revealed many of their true memory abilities to be much greater. Tasks given to the competitors include memorizing the sequence of playing cards in a 52 card deck in 5 minutes and remembering up to 520 digits. People who enter the competition have memory abilities far beyond most.

The traditional "is it hereditary or is it environment?" question is battered around the halls of Harvard's Memory Research Lab daily. But, people who take the side that memory is genetically determined are gaining credibility. Current research shows that memory has a substantial genetic component.

John Knowles, a professor at Harvard and head researcher at the Memory Research Lab, concludes that, "memory capability seems to have a very strong genetic component. In addition, the environment seems to play a somewhat important role during the first three years of life. After the age of three, though, environmental factors (barring brain damage) seem to have almost no influence on memory."

Knowles spent the last decade tracing identical twins who were raised apart. In a relentless search through Latin America, Africa, and North America, he was able to locate 83 pairs of twins who were raised separately. These twins range in age from 7 to 51 and came from all economic levels.

Knowles had an ideal sample to study the nature-nurture question. The twins in his study were often reared in different cities by parents of different social classes. The various pairs of twins came from different countries, spoke different languages, were different ages, and he followed them for ten years. Knowles tested the subjects individually with the best working memory tests available. He found that twins raised apart had very similar levels of working memory. Almost all of the twins in his study that were separated after the age of three had nearly identical memory abilities. In an extreme case, a young girl adopted by a college professor and her husband could recall a series of thirteen items. The genetically identical twin was raised by the real mother who was addicted to heroin. Despite differences in their upbringings, this girl could recall thirteen items too.

According to Knowles' results, up to eighty-eight percent of a person's working memory ability is due to genetic factors. About ten percent seems to be determined during the first three years of life. This means that we cannot really change how big our working memory capacity is. To support his claim, Knowles tracked how much people's ability to remember a sequence of words changed in ten years. He showed that everyone's memory abilities declined with age, but people's relative abilities did not change. In other words, if you're better at remembering things than your peers when you're young, you'll be better at remembering things than your peers when you're old.

Other researchers are finding similar results. William Kremen and his colleagues studied middle-aged twins' short-term memory using a reading span task. Reading span tasks test participants' ability to read sentences while remembering the last word of the sentences. They found the heritability of this skill to be .51, which means the majority of memory abilities were based on genetic factors.

Paula Rescorla at University of Michigan's Unit of Memory Research is excited about Knowles' and Kremens' results. "It turns out that the proverb ***the leopard can't change his spots*** is especially true in terms of memory. Knowing that memory largely determined by genetics is something that can help society. We can learn to identify quickly those who have really strong memory abilities and guide them to jobs that require such skills."

It's clear genetics plays big role in a person's memory. So next time you forget where you put your keys or can't remember someone's name, you can blame your parents for your genetics.

Appendix G

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The Origins of Memory: Is the nature-nurture debate resolved?

By: Ray Levich

May 7, 2016

Nowhere are the incredible memories of some people on better display better than at the World Memory Championships. At this annual competition, competitors from over 30 countries put their memory skills to the test to compete for a $100,000 grand prize. With that much on the line, competitors certainly use the best strategies available. Dominic O'Brien, an eight-time World Memory Champion, did not become interested in memory competitions until the age of 30. He first became interested after watching someone memorize the order of an entire deck of playing cards. He describes the technique of using loci to remember a deck of playing cards as "using journeys to preserve the order of information, so if you want to memorize fifty-two playing cards, you have to memorize fifty-two places in the world to journey." His technique demonstrates the importance of identifying an effective and effortful strategy.

The traditional "is it hereditary or is it environment?" question is battered around the halls of Harvard's Memory Research Lab daily. But, people who take the side that memory is genetically determined are losing credibility. Current research shows that memory can be increased substantially through effortful and effective strategies.

John Knowles, a professor at Harvard and the head researcher at the Memory Research Lab, concludes that, "memory seems to have a minimal genetic component. People may be born with a given level of memory, but we see the number of items people can recall increase by twenty or thirty when people are given good strategies."

Knowles spent the last decade tracing identical twins who were raised apart. In a relentless search through Latin America, Africa, and North America, he was able to locate 83 pairs of twins who were raised separately. These twins range in age from 7 to 51 and came from all economic levels.

Knowles had an ideal sample to study the nature-nurture question. The twins in his study were often reared in different cities by parents of different social classes. The various pairs of twins came from different countries, spoke different languages, were different ages, and he followed them for ten years. Knowles tested the subjects individually with the best memory tests available.

He found that twins raised in different environments had very different levels of working memory. According to his results, up to 88 percent of a person's memory is due to strategies they use to help them remember information. In his study, if twins were raised in environments where they had been taught effective memory strategies, they tended to have strong memories. In an extreme case, a young girl adopted by a college professor and her husband could recall a series of thirteen items. The genetically identical twin was raised by the real mother who was addicted to heroin. This girl could only recall six items.

Knowles has found that people who use effortful, effective memory strategies showed substantial increases in their memory during a ten-year study. People who did not engage in these strategies showed slight drops in their memory abilities over the same period.

Other researchers are finding similar results. Hans Eysenck recently published an article supporting Knowles' research. Eysenck's studies show that a person's use of memory strategies can have a profound effect on memory. He found that children taught a memory strategy involving word association can drastically improve their recall of the order of shapes presented to them. This strategy means the children had to complete an extra step, but this extra effort paid off in their retention rates. Eysenck concludes that "The type of strategies matter. Strategies that feel easy feel that way for a reason; whereas more challenging strategies that require an optimal level of effort can truly lead to drastically increased retention. It turns out the proverb ***no pain, no gain*** is especially true for memory."

Paula Rescorla at University of Michigan's Unit of Memory Research is also excited about Eysenck's and Knowles' results. "I think two absolutely critical things have come out of these studies. The first is that your memory ability is something that can be improved. The second is that this improvement comes from the use of strategies we can identify and teach. We know that when people engage in effortful strategies, they are able to recall significantly more items."

It's clear the strategies a person uses plays a big role in their memory. So next time you forget where you put your keys, try to use some more effortful (and more effective) memory strategies to keep track of them.

Appendix H

Making it stick:
The benefits of testing

By: Ray Levich

May 7, 2017

Adam Steagal is an exceptional student. Since high school, he's been consistently scoring in the top of his class. Researchers at University of Michigan's Unit for Intelligence Research (UIR) are interested in exactly what makes students like Adam so successful. They have been recording his study and testing habits for several months. They hope to use this research to help everyone become more successful students and learners.

At first glance, what separates Adam from his peers seems counterintuitive. After one particularly difficult Anatomy test, some of his classmates were surprised to learn that Adam had only read the book twice. A fellow student, who had read the book six separate times, remarked that Adam had outscored him by nearly twenty percent!

Researcher Paula Rescorla explained that she sees this surprising outcome quite frequently. "When you reread a textbook, you re-expose yourself to the material, but you don't actively retrieve the information. Students often mistake the familiarity that comes from rereading with an actual understanding and memory of the material." It's important to ask yourself whether you remember the material or if reading it just feels easy. So if Adam's exceptional scores don't come from rereading, what is she doing differently?

The cliché "work smarter, not harder" might offer some insight into his success. Many people work extremely hard at studying, reading textbooks for hours, only to find their efforts minimally rewarded. In order to work smarter, understanding how memory works is crucial. A memory is strengthened each time the neural pathways fire. These pathways fire each time the information is accessed or retrieved. Reading does not ask you to retrieve the information; it is simply presenting it to you. Being presented with the material is an important and necessary first step, but it does not lead to the same neural firing that taking a practice test does. Memory researchers have recently shown that answering questions from memory produces the strongest benefits to memory that have been identified – much bigger benefits than just rereading. In fact, rereading does very little to help memory.

Being tested on material promotes greater retention and is more helpful for memory than restudying. The UIR researchers have read and published countless laboratory studies demonstrating this phenomenon, known as the testing effect. Now, they are seeing it play out in real-life learning scenarios with students like Adam. When they asked Adam what study strategies she uses, taking practice tests was his top answer.

Taking practice tests is a way to "work smarter," but also feels harder. Dr. Rescorla explained that this is an important part of what makes it a more effective study strategy. "Testing yourself feels more difficult and often feels less productive when we get things wrong. But it's important to remember that every time you access the information by actively recalling it, you are strengthening the pathways." She also explained that this is true even when you get the answer wrong, especially when you receive feedback. "Answering incorrectly actually helps the brain remember the right answer the next time you are asked to recall the information." Perhaps this is why we so often remember that question we missed on a test. Receiving feedback allows the brain to correct the mistake and strengthen the pathway.

It makes sense that improving memory still requires effort. Unfortunately, the UIR researchers haven't discovered any magic study strategies, but they point out that the effort and sometimes frustration you feel means you are on the track to remembering. We're easily tricked into believing that learning is better when it's easier, but the research shows the opposite: when the mind has to work, learning sticks. Many good students report using practice tests as a primary means of studying, while many poor students report just rereading notes or the book.

There is another explanation for better performance after being tested. Not only does testing help you learn the material better, but it also helps you learn the material in the way you will be asked to use it. You don't learn to drive a car by reading about how to drive. If the goal is to do well in a testing setting, you need to test yourself.

Dr. Rescorla wants to give people the tools to succeed in learning. She describes the frustration she experiences seeing hard-working students not live up to their potential because they are using ineffective strategies. "There seems to be a common misconception that restudying is better, but testing is almost always better for learning. The research and people like Adam's test scores seem to demonstrate this." Dr. Rescorla hopes the research and people's experiences merge and more people will consider using testing as a primary study method. "Hopefully, people will see that the initial increased effort of testing pays off in the end. Students should be testing themselves much more frequently to ensure they will remember what they're studying and pass their tests!"