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Article

The study of technology and the use of individual cognitive effort

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SUMMARY

A trial study was performed in 2021 to investigate the link between technology and transactive memory. Transactive memory is shared knowledge in which members share the responsibility to encode, store, and retrieve certain tasks or assignments, leading to a successful and collective performance. In general, the internet has a become a popular database for individuals to use because of its ability to encode, store, and retrieve files of information for our own purposes, so our experiment wanted to test the cognitive ability of retrieving information through our memory without relying on technology. We hypothesize that a participants' expected access to an external source affects the recall rate and retrieval of information. We asked high school students to read 20 trivia statements and observed the difference in recall rate while typing on their computers to see their conditional response by saying either the statements were saved on the computer or deleted. The use of computers is significant in testing participants who were told that the trivia statements would be deleted were more likely to remember the information than participants who were told the statements would be saved, although this result was statistically non-significant.

INTRODUCTION

Transactive memory defines as knowledge about someone, or something's expertise stored to remember the information. Transactive memory works as an external memory, where an individual's metamemory allows them to be aware of the information that someone or something has for them and is available for retrieval. In theory, it helps provide individuals with more knowledge from other resources besides themselves for quicker access. The internet is an example of using transactive memory because it is a resource for individuals to rely on for accessing information. Individuals tend to recall stored information like the internet instead of memorizing the content of the information, demonstrating an example of transactive memory (1).

Technology has granted us the ability to access information but is also heavily

dependent on it. For example, the "Google Effect" explored the tendency to forget information because we can easily access it on our technological devices (2). The "Google Effect" studied whether the internet affects the use of transactive memory (3). Finally, a different example is studying how one person might be good at remembering exam questions but terrible at remembering the exam answers. However, the other person may be good at remembering the exam answers but terrible at remembering exam questions. If each person knows one's areas of expertise and non-expertise, this strategy saves individual cognitive effort. Therefore, these are some examples of examining the use of transactive memory through technology or any daily work.

Experiments by Sparrow et al form the framework for examining transactive memory theory and observing the participant's retrieval process. In the first experiment, participants read and typed out 40 trivia statements (4). Half of the participants pressed the spacebar to save what they typed. The other half of the participants pressed the spacebar to delete what they wrote. The experiment had all participants recall as many facts as possible. The results showed that 31% of individuals recall correctly in the deleted condition on average compared to 22% of individuals in the saved condition who recall correctly (4). The controlled condition stated that researchers asked both groups to remember. We are repeating Sparrow's experiments to find stronger results in our cohort since it is focused on 16–17-year-old students. This prior work sets up the basis of how individuals grew symbiotic with computers. Specifically, it is how our minds have directed themselves to one source of global information to store information an individual wants to remember (4).

Another example conducted about human interaction with technology is Wegner's study (5). Specifically, the study focuses on couples given a memory task that would prompt the use of collective transactive systems. Participants working with their partners were asked to memorize seven everyday categories and given explicit memory instructions under two conditions. For some partners, the category assignment of expertise designated directions, with one partner responsible for remembering items in some categories and the other partner for the remaining items. For other pairs, there was no assignment of expertise and no directions for which categories to remember. Then, everyone was separated to complete a measure of individual recall. The attempt to remember information together identifies the focus of the assignment's effect on its partners, demonstrating an example of transactive memory by relying on which partner should recall which items given in this task.

These prior results pinpoint how explicit memory instructions instill new uncertainty of knowing that each partner could rely on the other in dividing which items to

remember. As such, the idea of assigning expertise results in a positive effect on memory performance. Wegner's study identifies how transactive memory is useful in individual recall through explicit instructions and that technology is an asset to attaining any unknown information.

Our motivation for conducting this study was to examine participants' dependent relationship with technology. We hypothesize that participants would exhibit improved recall by reading trivia statements and typing under the condition of deleted rather than as saved. Therefore, we tested how participants use their memory without relying on the internet. The results of our study include no statistical difference in correctly recalling trivia statements, where more statistical data is required to support the theory of transactive memory. The experiment can help us learn more about the relationship between human memory and technology.

RESULTS

We examined a sample of 20 participants divided into two groups, initially told that they should remember a series of 20 provided trivia statements. One group of participants first read the statements and then typed them as quickly as possible on a computer. Then, they received explicit instructions about the trivia statements possibly saved on the computer, excluding any attempt for clarification. Finally, the second group performed the same steps with the condition as deleted. Participants refrained from using their notes when we asked them to recall as many trivia statements as they could in a separate document.

Mean is the central tendency used in the raw data and models the number of statements correctly recalled. The results show how participants in the group testing the deleted condition had a larger average mean than the saved condition. Participants under the condition that the trivia statements stated as deleted recalled an average of 6.0 +/- 3.1 correctly. Whereas participants told the trivia statements would be saved recalled an average of 4.3 +/- 2.6 correctly.

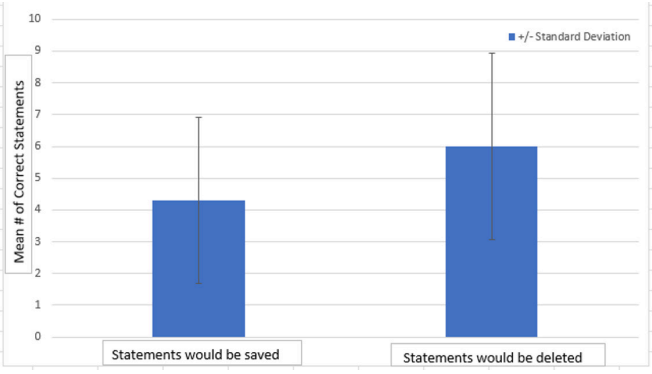

Figure 1: Correct recall of trivia statements when participants were told the statements would be saved or deleted. Bar graph showing standard deviation with error bars presenting the standard deviation. 20 high school participants with 10 participants in both conditions saved or deleted told to memorize 20 trivia statements. T-test, p = 0.15.

(**Figure 1**). These comparisons demonstrate that participants given explicit instructions to remember their statements under the rule of deleted had a higher recall.

Furthermore, a power analysis of the sampling data studies the probability of whether our experiment can correctly reject the null hypothesis is 0.25, which is well below the desired power of 0.7-0.8 (2). Therefore, more samples are needed, and standardized procedures are necessary to avoid variation. In addition, the data also outlines the trends of how there is an important influence on individual recall ability and the different levels of reliance on technology.

The experiment used an Independent Measures design, where our analysis showed no statistical difference between the number of statements correctly recalled by the "saved" and "deleted" groups ($p = 0.15$). The p-value of the correct trivia statements recalled from the controlled condition, given explicit instructions was 0.15, which states there is a 15% chance of the difference as observed. This statistic does not support our initial hypothesis. Therefore, the null hypothesis is accepted. The null states that there is no statistical difference in correctly recalling 20 typed trivia statements between participants told the trivia statements would be deleted and saved.

DISCUSSION

My research question was whether participants would exhibit improved recall by memorizing trivia statements if told it was deleted rather than told these statements would be saved on the computer. The results of the hypothesis stated that there was no statistical difference in correctly recalling trivia statements. The results did not successfully replicate the original study by Sparrow et al. on transactive memory, demonstrating that the null hypothesis is accepted. Therefore, our data do not support the Transactive memory theory, so more sampling is needed since our data does not support or refute the theory. The results also show that the environment created from the experiment didn't model the use of technology that affect our memory. Hence, it is likely that our data collection is not statistically agreeable because it is related to the unusually high standard deviation in the saved condition.

The design of our experiment was independent measures, which used randomized trivia statements to ensure no familiar patterns were present. Limitations were participant variability and the need to get a broader range of sampling size in both tested conditions of saved and deleted. A modification for this design could be randomly assigning participants to both experimental conditions and increasing participation by heavily advertising the study's purpose.

Opportunity sampling helped collect samples of participants within a short time. However, the participants we have used are already familiar to the researchers. From here, it introduces selection bias, where participants choose to join the experiment, ultimately not reaching proper randomization. Furthermore, participants were students affiliated with similar

classes, so the sample was not a good demographical representation of a 17–18-year-old population. The sampling could be modified to reach a diverse sampling size through a web-hosted form and to track students from each age category.

Materials such as our trivia statements have allowed us to test our manipulated conditions of being told the trivia statements were saved or deleted. However, a limitation was that the trivia statements lacked no variations or levels of difficulty considered. Based on our results, we concluded that the presence of technology does not influence the use of transactive memory to recall short-term statements.

MATERIALS AND METHODS

Design

The experiment used an independent sampling design with two groups. The first 10 participants had to read and memorize 20 trivia statements under the condition that the statements on the computer were saved. The other 10 participants had to read and memorize 20 trivia statements under the condition that the statements on the computer were deleted. Then, statistical analysis had to be conducted to study the results. Specifically, a t-test compares the means of both groups, categorized into the condition given by the researcher. The t-test incorporated Microsoft to conduct the analysis, with an alpha of 0.05 as the statistical significance cut-off. An independent sampling design has participants experiencing only one condition: whether they were told their typed statements would be saved or deleted. In general, we've used the design because it creates an unbiased sample, as it attempts to allow for more groups to be tested and increases validity. The design also reduces demand characteristics, making it less likely for participants to guess the purpose of this experiment and avoid strict memorization of remembering the statements.

Type of Sampling

We've used opportunity sampling in our experiment, urging the student population to respond if interested. From the sample, our participants were 20 high school students fluent in English to ensure verbal instructions were comprehended. We chose to study students over 16 years old to reduce participant variability and study the effects of the Transactive Memory Theory on an adolescent's memory when using technology daily. An introduction to the study was first made with flyers and a social platform, where students contacted the researchers. Interested students then contacted the researchers to provide their email addresses to receive an email about the experiment's purpose and a consent form (**Appendix 1**).

Control Variables

The control variables we used in our experiment were our Standardized Verbal Instructions and Trivia Statements (**See Appendices 2 and 4**). The subjects were presented with the standard trivia statement list and read the standard verbal instructions. In our trivia statements, we've used the same trivia statements for both conditions of saved or deleted to measure the different difficulties of the statements' information and the length of the sentences. The Standardized Verbal Instructions were important to control to avoid introducing undesirable errors in the experiment if different participants received different instructions.

Use of Computers and Trivia Statements Explained

The materials presented to the participants in the experiment were computers and trivia statements. Specifically, the computers were used to ensure the participant's ability to type the trivia statements in the limited time they feel they are done recalling as many statements as they could. (**Appendix 1**). The order of the trivia statements was randomized for each participant to avoid bias. Finally, the trivia statements typed by the participants were scored based on matching the original trivia statements established by the researchers.

Procedure

Researchers first chose an area for participants to experiment. Then, they were given explicit directions to remember these statements and limited to anything else to keep the process discrete. Participants then recieved a list of trivia statements on paper for 5 minutes to read. Afterward, the researcher issued a laptop stating that the computer would save your statements or erase them. Next, the researchers gave participants another 5 minutes to type their trivia statements from paper onto a computer. After the participant is finished, the researcher either erases their trivia statements with a blank document if the condition tested was deleted or opens a new document if the condition tested was saved. Finally, the researcher then has the participant recall the trivia statements they've previously typed and retype them on a separate document in 3 minutes.

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Appendix 1

Sample Consent Form (Signed by Participants)

Consent to Participate:

We ask for you to participate in a research study and remember that your participation in this study is entirely voluntary, and it is important that you read the entirety of the information below and reach out to us with any questions you may have before deciding to participate.

Purpose of the study:
The results of this study will assist the researchers in the investigation of how the presence of technology affects the ability to recall short-term memories.

Procedures:
If you agree to participate, you will meet one of the researchers at a scheduled time and location that suits your availability. The experiment will take no longer than 20 minutes.

As participants, you will be asked to read a series of trivia statements in 5 minutes. After that, they will have a laptop to type out the written statements for the next 5 minutes. The participant will then be required to remember as many statements as they can within 5 minutes.

After the experiment, data from participants' performance will be recorded for evidence compilation and analysis after our study is concluded.

Time will be allotted after the experiment for a debrief of the experiment

Potential Risks and Discomforts:
There is a possibility that the participant will experience minimal mental stress that could cause discomfort. In the event that the participant experiences any physical or mental discomfort, the researchers will take appropriate action to remedy this discomfort.

Although, neither Skyline High School nor the researchers are responsible to provide medical treatment or compensation for any form of injury sustained as a result of participation in the experiment, except if required by law.

Confidentiality:
Any information or data obtained from the participant or during the experiment will remain confidential and will only be disclosed with participant permission. Identifying information will be stored in an excel sheet that will be promptly deleted after the conclusion of the experiment. Names will not be recorded during the collection of data, but rather as a subject number.

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Withdrawal:
Participation in this study is completely voluntary. The participant is free to withdraw at any time during the process without penalty or consequence. If the participant is uncomfortable with the mental stress the participant may experience within the experiment, you are free to withdraw.

If the researchers notice that a participant is responding to the procedure in a deceitful or ingenuine way, they will be removed from the experiment and their data will not be recorded.

Communication with researchers:
Please feel free to contact us if you have any questions or concerns via email.

By signing below, you are confirming you have read and fully understand the contents of this consent form and are agreeing to participate in this study.

_____ (Printed First and Last Name)
Signature of the Participant:
_____ _____ (Date)

Signature of the Researcher:
_____

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Appendix 2

Standardized Verbal Instructions, Saved Group:

Hello!

Thank you so much for coming and as a participant who has read the consent form, your responsibility is to read the 20 trivia statements for 5 minutes and remember them. These statements that you have typed will be saved. In the rest of the 5 minutes, you will write down as many statements as you can and when time's up, you will place your pencil down and you're all done. We will have a debrief after this experiment.

Standardized Verbal Instructions, Deleted Group:

Hello!

Thank you so much for coming and as a participant who has read the consent form, your responsibility is to read the 20 trivia statements for 5 minutes and remember them. These statements that you have typed will be deleted. In the rest of 5 minutes, you will write down as many statements as you can and when time's up, you will place your pencil down and you're all done. We will have a debrief after this experiment.

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Appendix 3

Debriefing Notes

Hi [Name]!

Thank you so much for participating in my psychology study. As a quick debrief, the purpose of this experiment was to test how well people remembered information they believed they would have access to later. Half the participants were told that the statements they typed out would be erased and the other half were told it would be saved. Both groups were then required to type out as many statements as they remembered. Our experiment was a take on the 2011 Sparrow experiment conducted with high school students. In the original experiment, people that were told the answers would be erased recalled the trivia statements better than the ones that got their document would be saved. The Sparrow experiment concluded that people expect information to remain continuously available, taking access to technology as a constant, they are more likely to remember where to find the information than to remember the details of the item.

Please do not hesitate to reach out if you have any remaining questions or concerns.

Thanks,
[Researcher Name]

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Appendix 4
Trivia Statements:

1. The hashtag symbol is actually a shape called an octothorpe
2. A chef's hat has 100 folds for the 100 ways to cook an egg
3. The most streamed Spotify single is Harry Styles' "Girl Crush"
4. The longest wedding veil was longer than 60 football fields long
5. Some cats can be allergic to people
6. The unicorn is the national animal of Scotland
7. The voices of Mickey and Minnie Mouse are married in real life
8. M&M stands for Mars and Murrie
9. You can hear a blue whale's heart beat from 2 miles away
10. A baby puffin is called a "puffling"
11. The lyrebird can mimic almost any sounds it hears—including chainsaws
12. Elvis only won 3 Grammys
13. The speed of a computer mouse is measured in "Mickeys"
14. You can major in wine at Cornell University
15. The Northern Cardinal is the most popular state bird
16. About 700 grapes go into one bottle of wine
17. Baby sea otters can't swim immediately
18. There's a world record for the most world record titles
19. Moon flowers actually bloom in response to the moon
20. There are over 10 holidays that celebrate chocolate