02455 Experiment in Cognitive Science

The Impact of Exposure to Rapid Video Content on Working Memory

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December 1, 2023

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1 Abstract

This study investigates the impact of short video content exposure on the phonological loop component of working memory in university students. Employing a mixed-design approach, 25 participants were randomly assigned to either a group exposed to a 10-minute compilation of rapid TikTok clips or a control group viewing a nature documentary segment of equal length. The study primarily sought to ascertain whether this type of digital media consumption influences working memory capacity, as measured by the Reliable Digit Span (RDS) test, conducted both before and after the media exposure. Statistical analysis, including a Shapiro-Wilk test for normality, paired samples t-test and Mann-Whitney U tests, was conducted to evaluate the pre-post exposure score differences within and between groups. The findings revealed no significant impact of the type of video content on working memory performance. These results suggest that short-term exposure to TikTok videos does not significantly affect the phonological loop in working memory. This study contributes to the growing body of research on the cognitive effects of digital media, highlighting the need for further investigation with larger sample sizes and varied content types to fully understand the relationship between rapid video content consumption and cognitive processes in university students.

2 Introduction

2.1 Motivation

The past decade has seen the rapid growth of the internet and, with it, the adoption of social media. Today, social media has become an integral part of our daily lives, with billions of users engaging with numerous platforms every day. Especially the demographics of teens and adolescents spend many hours online [1]. This abundance of content and hyperconnectivity has sparked widespread societal debate about its consequences [2]. Studies have found that time spent on social media correlates with self-reported self-esteem, anxiety and depression [3]. Nonetheless, social media's effects on cognitive processes, such as working memory, need to be better understood [4].

Working memory can be defined as the ability to retain a relatively limited amount of knowledge that is readily accessible for performing functions such as problem-solving, reasoning and decision-making [5]. Research has shown that social media can influence memory capacity, recollection and content in multiple ways. For example, studies have found that people are likely to have a stronger memory of personal experiences that they post on social media. However, this can also introduce bias and distortion to that memory [6]. Additionally, persons who interact with multiple forms of media at the same time have been found to perform worse on simple memory tasks [7].

The recent emergence of short video platforms, such as TikTok, YouTube Shorts, and Instagram Reels, poses new challenges and opportunities for studying the impact of social media on working memory. These platforms allow users to create and consume brief videos that are often catchy, entertaining, and viral. They also feature algorithms that tailor the content to the preferences and behaviors of each user, creating a personalized and addictive experience. According to a survey by Statista [8], TikTok was the most downloaded app in 2022, with over 670 million downloads worldwide. Similarly, a survey by Meta in 2022 revealed that 45% of Instagram users watch Reels at least once a week [9]. These statistics indicate that short video platforms have a significant presence and influence in many people's daily lives. Therefore, it is pertinent to investigate how exposure to short video platforms affects working memory and with a focus on a demographic that is a heavy user. This project is motivated by the need to understand the cognitive consequences of social media use.

2.2 Literature review

2.2.1 Theoretical Framework and History

In order to create an experiment to evaluate the working memory performance, we first need to understand the theoretical framework behind it. In this section, we will review the difference between working memory and short-term memory, as well as the working memory model introduced by Baddeley and Hitch [10] and later revised by Baddeley [11][12].
As per the distinction of Cowan, 1995 [13], Engle et al., 1999 [14], short-term memory can be described as a simple storage buffer, whereas working memory involves much more than

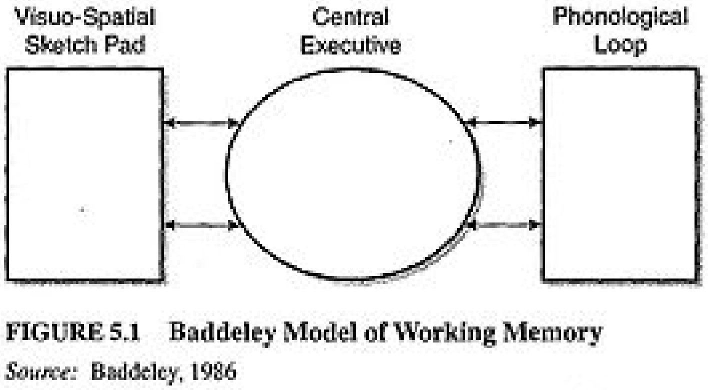

Figure 1: Working Memory model Baddeley and Hitch 1974 [10].

that. More specifically, Baddeley and Hitch (1974) [10] introduced the working memory model, which consists of 3 components: the phonological loop, the visuospatial sketchpad and the central executive.

The phonological loop temporarily holds auditory data, i.e., speech sounds and verbal content. The visuospatial sketchpad is for temporary storage and manipulation of visual and spatial information. Lastly, the central executive is the component responsible for managing information processing within working memory. It is vital for focusing, making choices, and dealing with information from different places.

However, the above model was revised by Alan Baddeley in 2000 [11] when a novel component was incorporated: the episodic buffer. This addition was made to address certain limitations in the original model and to provide a more comprehensive model of working memory processes. The episodic buffer serves as an integrative system within working memory, allowing for the temporary storage and manipulation of information from various sources.

Amongst the aforementioned components, the phonological loop is crucial for our experiment, so we will examine its characteristics in more depth. As defined in the original model, it is responsible for temporarily holding auditory and verbal information. More specifcally, it consists of two subcomponents: a passive storage system for speech sounds (the phonological store) and an active rehearsal system (the articulatory control process) [15]. Furthermore, it plays an important role in determining the overall working memory capacity. This is due to the fact that this subsystem, which is responsible for the temporary storage and manipulation of phonological information, influences how much verbal content can be held and processed in working memory [16]. The capacity of the phonological loop is a predictor of performance in a range of cognitive tasks, including language comprehension and learning [17],[16], making it an interesting component to study in the context of exposure to different types of media.

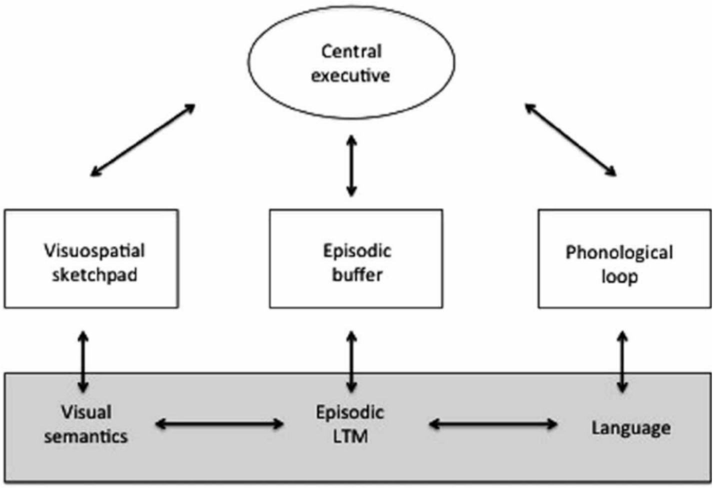

Figure 2: Revised Working Memory model (2000) [11]

Many experiments have been designed in the past to measure the performance of the various components of the working memory. These experiments use various methods and tasks to assess different aspects of it. For instance, some of them include:

- **Digit Span Test**: In this task, participants are presented with a series of digits and are required to repeat them back in the same order (forward digit span) or in reverse order (backward digit span). This assesses the capacity of the phonological loop. We will provide a more extensive description of the test later in the report because we will use it to conduct our experiment.

- **Visual-Spatial Working Memory Task**: Participants may be asked to remember and manipulate visual or spatial information, such as the location of objects on a grid or their orientation. This assesses the visuospatial sketchpad.

- **Dual-Task Paradigm**: This requires participants to perform two concurrent tasks, such as maintaining information in working memory while simultaneously performing a cognitive or perceptual task. This assesses the central executive's ability to manage competing demands on attention and working memory resources.

- **Functional Brain Imaging**: Neuroimaging techniques like functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) are used to study the neural basis of working memory. These methods can reveal brain regions associated with different working memory components.

2.2.2 The Practice effect

Having mentioned several tests that measure the working memory performance and due to the structure of our study, which involves participants taking a test twice; described in detail later in this report, it is key to examine briefly what the *practice effect* is.

Specifically, it is a phenomenon that involves improvement in task performance that happens with repeated exposure to the same task. This effect is particularly relevant in tests like the Digit Span Test, used to assess the capacity of the phonological loop, where as participants become more familiar with the task structure, their performance may improve not solely due to changes in working memory capacity but as a result of repeated practice. This improvement can be attributed to various factors, including enhanced test-taking strategies, or reduced anxiety [18]. Additionally, as per the *Working memory span tasks: A methodological review and user's guide* [19], it can lead to enhanced recall strategies and increased efficiency in memory retrieval. Therefore, it is crucial for cognitive experiments involving working memory tests to consider the practice effect, as it may influence the results and the interpretation of differences in the recorded performance.

2.2.3 Related work

After having briefly examined the working memory model, the structure and significance of its phonological loop, as well as a few of the tests that researchers use to measure the performance of its components, we will now explore existing research related to the relationship between working memory performance and social media.

A study by Aharony and Zion 2019 [20], examined the impact of WhatsApp usage on teenagers' working memory. Two groups, a control and an experimental group, were surveyed using questionnaires and the Wechsler Intelligence Scale for Children-IV (WISC-IV)[21]. The findings revealed that WhatsApp distractions on smartphones impaired working memory performance. More specifically, significant distinctions emerged in the three subtests: digit recall, letter sequencing, and a mathematics assessment. The digit recall task, in particular, is closely related to the functioning of the phonological loop, as it requires the retention and manipulation of auditory-verbal information. These findings suggest that digital distractions, such as those from social media platforms, might specifically interfere with the efficiency of the phonological loop.

Another noteworthy study is the one by Yildirim and Ogel-Balaban (2021) [22] involving 70 healthy older adults (55-84 years), which examines the relationship between Facebook use and cognitive functions. It was found that Facebook users performed better on the Trail Making Test Part A (TMT-A) compared to non-users. Also, factors such as the duration of use, network size, and frequency of active and passive engagement correlated with cognitive performance. These results imply that older adults who use social media and engage with it may have better cognitive skills, which highlights the potential cognitive benefits of engaging with digital media. The variety of stimuli encountered on platforms such as Facebook may be similar to the diverse audiovisual elements present in popular short social media videos. Therefore, this study raises the question of whether exposure to different types of digital media can influence the efficiency and capacity of specific working memory components, such as the phonological loop, which is the object of our experiment.

Moreover, the experimental study by Almarzouki [23], is worth mentioning because of its experimental design. Specifically, 118 university students were recruited to examine the impact of social media usage on working memory and depression. The study's structure involved participants performing a working memory task under two conditions: after interacting with social media and after a control activity (painting online). This design allowed for a direct comparison of the cognitive effects of social media interaction versus a non-social media activity. The results indicated no significant difference in working memory performance between the social media and control conditions in the general sample. However, in participants with at least moderate depression, social media use predicted significantly more errors compared to the control condition. The focus on working memory performance under different conditions mirrors our interest in understanding how exposure to various types of video content might influence the phonological loop component of working memory.

The studies mentioned above explore the different roles that the components of working memory play in cognition, which is a scientific field with many unexplored aspects. Their findings, in combination with the rapid evolution of social media platforms nowadays, underscore the need for further research in this field. Particularly in understanding how modern digital interactions, like watching different types of video content, impact cognitive processes vital for everyday tasks.

2.3 Research question

Does immediate prior exposure to short video content affect the phonological loop of university students' working memory?

Our research question refers to how university students' working memory is influenced by their immediate prior exposure to short video content on social media. More specifically, the focus of this experiment is on the phonological loop, which is a component of working memory that plays an important role in determining the working memory capacity. The latter has proven to be an indicator of cognitive performance in tasks such as learning and language comprehension [17][16].

Given the extensive presence of platforms like TikTok and Instagram reels in students' lives, we are curious about the potential effects of a quick social media scroll on their cognitive abilities. The phonological loop is crucial for various academic tasks that involve learning. Therefore, by asking, "Does immediate prior exposure to short video content affect the phonological loop of university students' working memory?" we aim to better understand how this digital interaction might impact the mental resources students rely on for their academic pursuits. This investigation not only holds relevance within educational settings but also contributes to our broader knowledge of the intricate relationship between digital engagement and cognitive performance.

2.4 Hypotheses

There is a significant difference in RDS test score after a 10-minute exposure to curated short video clips from TikTok compared to exposure to a single long video clip, reflecting the impact of media format on the working memory's phonological loop.

To explain further, we anticipate that university students who engage with the rapid content typical of TikTok just before undergoing a working memory test will exhibit significantly different performance in the test immediately after, in contrast to those exposed to a continuous, slower and more consistent 10-minute documentary clip. This idea stems from the belief that the phonological loop may behave differently when exposed to fast-paced, varied content in comparison to a slow-paced documentary. The potential disruption or improvement in the phonological loop's functioning can produce insights into how brief social media distractions might temporarily disrupt this particular working memory's component which is responsible for various cognitive tasks, such as language comprehension and learning. We are curious to see if even a short dose of digital distraction is able to affect how effectively students can use their memory and cognitive resources. This research could shed light on the real-world implications of our digital habits on cognitive performance.

3 Methods

This section provides a detailed walk-through of the experimental design, the reasoning behind how the experiment has been setup as well as the theoretical framework behind the statistical analyses. All code used for this project can be found on our GitHub repository [24].

3.1 Participants

For the study, it is the aim to ensure a balanced representation of genders to minimize gender-related biases in our results. In total, 25 test participants are recruited. The participants are university students of all genders in the age group 20-26. Ideally, participants should be in a positive mood and well-rested, without experiencing exhaustion or fatigue, to minimize the potential influence of these factors on cognitive performance. However, as this is beyond our control, we opted instead to mitigate the fatigue factor by scheduling experimental sessions only during active hours, between 9 AM and 7 PM, to align with participants' naturally alert and awake states. This approach is helpful in collecting reliable data to draw conclusions from regarding the impact of immediate social media exposure on working memory.

After the experiment, we collected data on the participants' social media usage habits, which can be seen in the figures below.
As seen in Figures 3, 4 and 5 the recruited participants have used various platforms for social media content while their self-reported daily usage differs. When asked whether they think

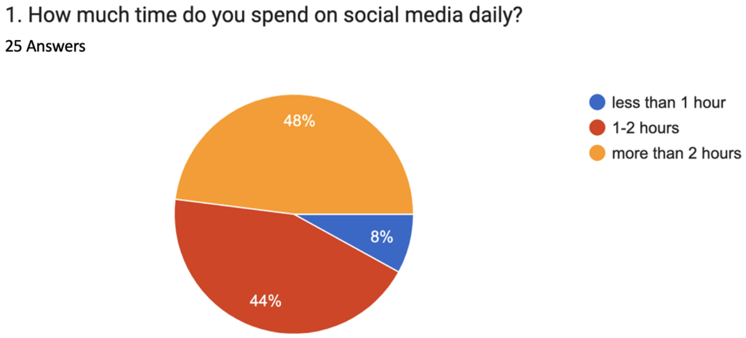

Figure 3: Pie chart of participants' self-reported daily social media usage.

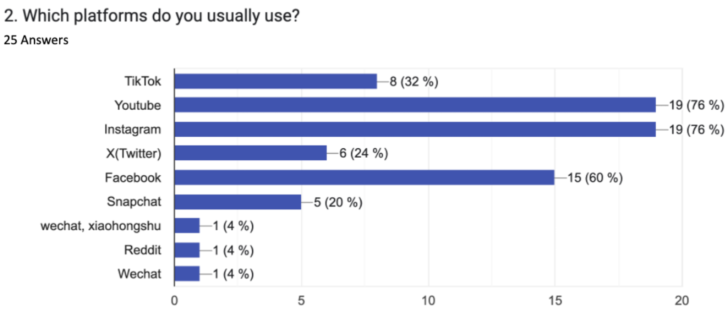

Figure 4: Social media platforms that the participants use (self-reported).

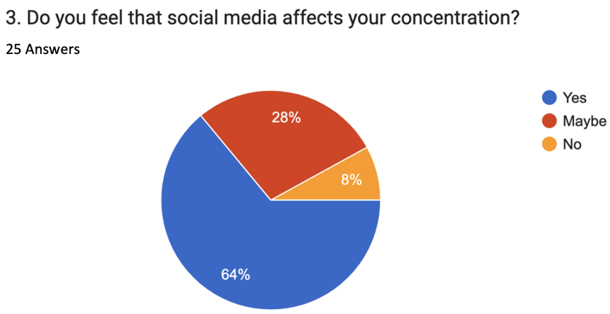

Figure 5: The final question that participants were asked in the post-experiment questionnaire.

social media affects their concentration, the majority replied "yes", hence, in line with the hypothesis presented in this study.

Power Analysis

A test population of 25 is not of great size. A power analysis can help shed light on which effect size can be expected from this specific sample size. The analysis will be based on results from another study investigating the effects of social media with a similar setup [20]. Despite having differences, namely, in the type of social media, WhatsApp, we opt to use numbers from this study since it is the most similar, we could find among related literature also using digit span tests. Cohen's d is obtained by:

$$d = \frac{M_1 - M_2}{SD_{\text{pooled}}}$$

Plugging in the mean and standard deviations of the result of the study [20], a Cohen's d of 0.77 is obtained. This means that the referenced study has a moderate-high effect. For our experiment, a Cohen's d of 0.40 was found, indicating a small effect size. Sample size calculation for testing differences between 2 groups is obtained by:

$$n \geq \frac{2 \cdot (Z_{\alpha/2} + Z_\beta)^2}{d^2}$$

where $Z_{\alpha/2}$ are the points on a normal distribution to give desired significance $\alpha/2$ and Z_β are the points on a normal distribution to give desired power $1 - \beta$.

Using $\alpha = 0.05$ and $1 - \beta = 0.8$, to obtain the same effect size as the study, ideally, our experiment would need more test participants; 28 in each group, to be exact, yielding a total of 56 participants. Accordingly, we go into the experimental phase knowing that the findings will have little effect size given the constraint in a limited test sample population size.

3.2 Ethical Considerations

Informed Consent

The participants of this study are fully informed of the study before consenting to the participation. They can withdraw consent at any given time- and without repercussions.

Confidentiality

All the data collected are anonymized and kept in accordance with GDPR. No personally sensitive data are collected.

Potential for harm

Throughout the duration of the study, participants are not subject to any harm as a result of the activities related to the experiment. The video content being shown to the participant does not include any form of violence or gore. We minimize potential risks and discomforts and provide appropriate care and support when needed. The participants are monitored closely throughout the study, and we intervene if needed.

Communication of result

Participants have the option to be kept informed of the study results. Furthermore, at any point, they can ask questions and raise concerns. We report the results with transparency and honesty, without any form of falsification, fabrication, or misrepresentation.

3.3 The Experiment

- **Experimental design:**

  Mixed design
  Two separate groups; One exposed to curated 10-minute video consisting of TikTok videos no more than 10 seconds long (video: [25]) and a control group shown a 10-minute full-length segment from a nature documentary (video: [26]). Within these two groups, each participant serves as their control by taking the test both prior and after content exposure.

- **RDS Test**
  The Reliable Digit Span test has been a component of the widely used Wechsler memory scales (WMS) [27]. It is one of the oldest, most commonly used, and well-validated embedded PVTs [28]. It was originally developed using the Digit Span subtest of the Wechsler Adult Intelligence Scale-Third Edition [29]. During the test, digit sequences are presented, beginning with a length of two digits and increasing by 1 every two trials. The participant's goal is to repeat the sequences correctly. If they do not correctly repeat the sequence of a specific length in both trials, the test stops. The total number of sequences reported correctly is combined across forward span (sequences repeated in order) and backward span (sequences repeated in reverse order) to produce the final score. In our experiment, we plan to visually present the sequences to subjects, with an interval of 1 second per digit. Their answers will be recorded and transcribed.

  For this experiment, the participants take the RDS test through a keyboard-operated laptop interface implemented from scratch using the TKInter [30] library in Python [31]. The user flow of the interface can be seen in screenshots from Figure 14 and up in Appendix.

- **Variables:**

Independent Variable (IV)
Exposure to video content, either curated TikTok clips or single nature documentary clip.

Dependent Variable (DV)
Memory Performance (measured by participants' RDS test score)

- **Controlled Variables:**

Time of Exposure
Participants are exposed to social media for a fixed duration of 10 minutes.

Type of Content
The video content test participants are exposed to is carefully vetted for harmful, offensive language and does not contain violence of any kind. The curated TikTok clips are of no longer than 10 seconds length and the nature documentary control video was cut to match the exact length. The content is all in English.

Physical Test Environment
Under ideal circumstances, the physical test environment would be kept constant to the highest degree possible. However, since our experiment was conducted under time and resource constraints, this was not done to the fullest. Although not all participants were tested in the exact same physical location, 2 locations were mainly used: DTU SkyLab [32] and DTU Smart Library [33]. However, the general type of environment is controlled for, with all tests being conducted in a quiet room with a table and a chair. During the RDS tests and content exposure, the participants are left alone in front of a laptop (for the test) and a mobile device (for the video content).

By employing a mixed design based on a between-subjects setup with a separate control group, the duration of the experiment can be reduced, mitigating the effects of fatigue and learning. However, the between-subjects design requires higher sample size for high power, which, as shown in the power analysis, we do not possess. Within the respective groups, participants undergo both pre- and post-exposure tests. This is the within-subjects element in the design. We aim to directly address the potential impact of the 'practice' effect of participants undergoing the same type of test twice by using the difference between the post- and pre-exposure RDS test scores for both groups instead of only considering the post-exposure scores.

3.4 Experimental Procedure

The experimental design involves two separate groups of university students, which are created randomly. However, in practice, 14 are exposed to social media (TikTok) content and 11 in the control group, being exposed to nature documentary. This suggests that the randomization process is better suited for large sample sizes. The full experiment takes about 30 minutes to conduct.

- **Introduction and Explanation:**
  Participants are briefed on the purpose and procedure of the experiment. For this purpose, we are careful not to reveal too much detail and instead opt to describe the overall goal on a higher level, and not that we are testing two groups with two different types of exposure. This will reduce potential bias and assumptions that participants would go into the experiments with. They are informed of the step-by-step procedure and that we aim to measure their memory performance before and after exposure to social media, again, without revealing our specific hypotheses to avoid bias. The participants are asked to read the information consent sheet, if they have not done so already, and sign on the last page.

- **Exposure Group Assignment**
  Having given their consent, participants are expected to draw a test ID (number) from a pile of paper slips. This number assigns them to either the TikTok or control nature documentary video group. An uneven number means TikTok while even number means control video.

- **RDS Test - Practice:**
  Participants are sat on a chair in a quiet room in front of a desk with a laptop. They are asked to type in their test ID number into the RDS interface (for us to distinguish between data in the two groups). They are asked to read the on-screen instructions in the RDS test interface carefully. At this point, they have the opportunity to ask us any questions should the instructions need to be clarified. They then proceed to take a practice RDS-test with a sequence length capped to 3 (both forwards and backward).

- **RDS Test - Pre-Exposure:**
  Participants are asked to take the RDS test and their test score is automatically recorded upon completion and saved for analysis at a later stage in the process.

- **Social Media Exposure:**
  Participants will then be exposed to 10 minutes of video content through a mobile device, either TikTok or the control video. As mentioned above, the content will be controlled in regards to the length of the videos as well as the sequence being predetermined by us.

- **RDS Test - Post-Exposure:**
  Immediately after the video exposure, participants are asked to take another RDS test. The results are saved automatically upon completion.

- **Questionnaire on Social Media Usage Habits**
  Finally, participants are asked to answer a brief questionnaire on which social media platforms they use, how long they spend daily on social media, and whether they think

it has an impact on their concentration. For this final question, we opt for the wording "concentration" instead of "working memory", since the latter, despite being more accurate, can be hard to understand for participants without background in science.

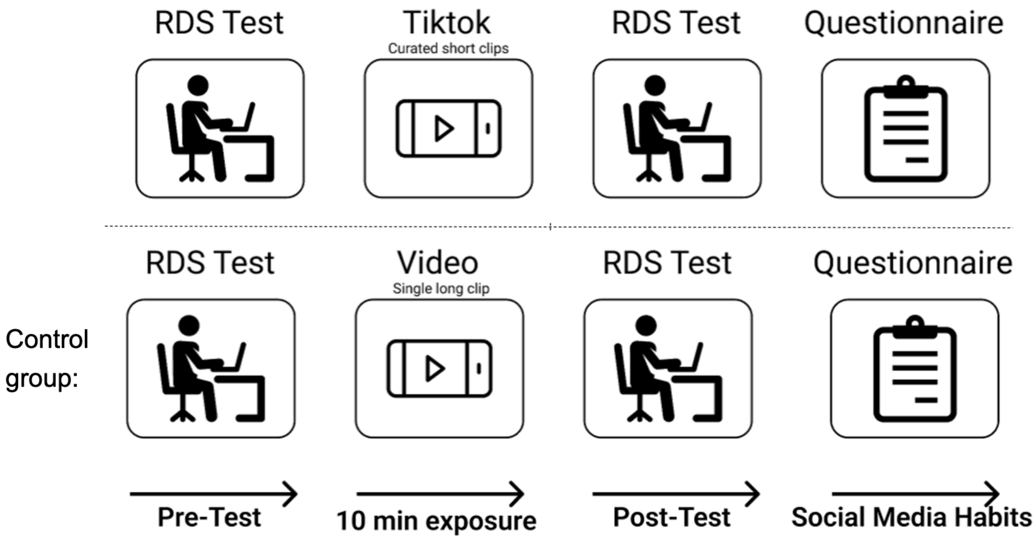

Figure 6: Experimental design.

3.4.1 Research Limitations and Mitigation

Since the experimental design requires participants to take the RDS test twice (3 times incl. practice), one could question whether this introduces an element of fatigue as a potential confounding factor. We aim to mitigate this factor through the mixed design, where participants for both TikTok and control group undergo a practice and pre-test. Although the design doesn't eliminate the effect altogether, it ensures that both groups would experience the same levels of fatigue and practice, making comparing the exposures more valid. Additionally, we plan on using the differences in the pre-post exposure scores.

3.5 Data Collection and Pre-processing

All data collection and preprocessing steps are performed in Python [31]. The participants' RDS test scores are automatically recorded upon completion of the test through the TKInter [30] interface. The scores are saved in .txt-files with the content format: "forward score, backward score, combined score" -where the scores are in numbers.

Information regarding exposure type and pre/post is encoded into the naming of the file, e.g., "1_post_test.txt" -where the number indicates the test-ID (uneven TikTok, even control video) and post/pre meaning pre/post-exposure.

The data is loaded into a single data frame with as shown in Figure 7.

$$\text{25 test subjects}\left\{\overbrace{\begin{bmatrix} \boldsymbol{Fwd}_{pre\_1} & \boldsymbol{Back}_{pre\_1} & \boldsymbol{Comb}_{pre\_1} & \boldsymbol{Fwd}_{post\_1} & \boldsymbol{Back}_{post\_1} & \boldsymbol{Comb}_{post\_1} & \boldsymbol{Fwd}_{diff\_1} & \boldsymbol{Back}_{diff\_1} & \boldsymbol{Comb}_{diff\_1} & \boldsymbol{Exposure}_{1} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \boldsymbol{Fwd}_{pre\_25} & \boldsymbol{Back}_{pre\_25} & \boldsymbol{Comb}_{pre\_25} & \boldsymbol{Fwd}_{post\_25} & \boldsymbol{Back}_{post\_25} & \boldsymbol{Comb}_{post\_25} & \boldsymbol{Fwd}_{diff\_25} & \boldsymbol{Back}_{diff\_25} & \boldsymbol{Comb}_{diff\_25} & \boldsymbol{Exposure}_{25} \end{bmatrix}}^{\text{10 cols}}\right.$$

Figure 7: The RDS test score data from the participants are loaded into a single data frame with 10 columns and 25 rows containing the forward, backward, and combined scores for pre- and post-exposure. Moreover, we compute the differences for these scores post-pre. The last column denotes the type of exposure, e.g., TikTok or control.

Due to the limited amount of participants, according to the prior conducted power analysis, it was decided not to categorize individuals with either exceptionally poor or outstanding performance as outliers. Outliers were defined as cases in which individuals were unable to complete the test in accordance with the experimental design due to factors such as compromised attention span (failure to engage with the presented video), interruptions leading to multiple breaks that disrupted the experimental procedure, instances of test cheating, or program failures during the test session. However, no instances fitting these criteria were observed, leading to the absence of outliers based on the above-defined parameters.

3.6 Data Analysis

To determine which statistical tests are valid to perform on the result data, a Shapiro-Wilk test is done to determine whether the RDS-test scores are normally distributed. Specifically, we aim to test the following distributions statistically:

- *TikTok: pre-post scores subtraction outcome* against *Control Video: pre-post scores subtraction outcome*. (This serves to determine if the 2 distributions differ. A significant difference in the distributions could indicate that one type of exposure influenced more working memory performance. No significant difference could indicate that both exposures influenced the test score similarly or not at all).
- *All participants: pre-exposure* against *All participants: post-exposure*. (This serves to determine if the 2 distributions differ without taking into account the type of exposure. Significant differences could indicate the influence of a practice effect rather than the exposure to video).

For the Shapiro-Wilk test, being a hypothesis test, we set up the following null hypothesis and test against a significance level of 0.05:

H0: The sample population of the RDS test scores is normally distributed.

The following are the resulting Shapiro-Wilk normality tests on the RDS test scores. We have rounded to 3 decimal places (4 decimal places for the p-value):

RDS test score	**M (SD)**	**Test statistic - W**	**p-value**
Tiktok: pre-post subtraction outcome	0.500 (3.290)	0.708	0.0004
Control video: pre-post subtraction outcome	1.636 (1.920)	0.947	0.6014
All participants: pre-exposure	11.560 (2.434)	0.941	0.1591
All participants: post-exposure	12.560 (2.927)	0.963	0.4735

Table 1: Result from Shapiro-Wilk test on RDS test score results.

As seen in Table 3.6, although 3 of the 4 p-values exceed 0.05, the p-value for *Tiktok: pre-post subtraction outcome* is below 0.05. Accordingly, for the *Tiktok: pre-post subtraction outcome*, the null hypothesis shall be rejected, meaning that it that this particular sample does not fit a normal distribution.

3.7 Statistics

For the scores that do not pass the normality check (p-values larger than 0.05), this study applies Mann-Whitney U non-parametric statistical tests for analysis. For the scores that are normally distributed, the paired samples t-test is performed.

3.7.1 Mann-Whitney U test

In the context of experiments with one factor, two levels, and a between-subjects design, the Mann-Whitney U test is recommended as a non-parametric alternative. The Mann-Whitney U test is utilized for comparing differences between two independent groups, testing the hypothesis that the two groups either originate from the same population or have identical medians. This test does not presuppose a specific distribution (such as a normal distribution of samples) for computing test statistics and p-values. The Mann-Whitney U test can be applied to both small samples (5-20) and large samples (n>20), with the power of the test increasing with sample size.[34]

For the Mann-Whitney U test, the test statistic is calculated using the formula:

$$U = \min(U_x, U_y) = m \cdot n + \frac{m \cdot (m+1)}{2} - R_x$$

using

$$U_x = m \cdot n + \frac{m \cdot (m+1)}{2} - R_x$$

and

$$U_y) = m \cdot n + \frac{n \cdot (n+1)}{2} - R_y$$

where U_x and U_y are the sums of the ranks for the two groups, m and n are the sample sizes, and R_x is the sum of the ranks for the first group.

3.7.2 Paired Samples t-test

A paired samples t-test is applied to compare the Reliable Digit Span test scores of the participants pre and post-exposure to video content. The t-test determines if there is a statistically significant difference between the means of the two populations. Paired samples t-test can be expressed as:

$$t = \frac{\bar{d}}{s_d/\sqrt{n}}$$

where $\bar{d}$ denotes the mean difference in test score, and s_d being the standard deviation of the difference between the scores, where n is the sample size. The null hypothesis (H_0) here is that there is no difference between the population means ($\mu_d = 0$), while the alternative hypothesis (H_a) is that there is a difference between the population means ($\mu_d \neq 0$). We will use a significance level of 0.05 and the t-statistic and the p-value will be reported as the test result.

4 Results

4.1 Data Visualization

Before conducting any analysis on the data, the RDS test scores for pre and post-exposure to TikTok and the Control video, is visualized(Figure 8).

For visualizations of the forward and backward scores separately, refer to Figures 10 and 11 in Appendix, respectively.

It is important to note here that in the following sections, we will be referring to the RDS scores as *combined scores*. This is because they are a combination of the forward and backward scores. Also, we will be referring to the forwards and backward part of the RDS scores, as *forward score* and *backward score*.

4.2 TikTok Vs. Control Video

In this section we test if the type of exposure has an effect on RDS-test combined score difference (subtraction outcome) between pre and post-exposure by applying a non-parametric Mann-Whitney U test with the following null hypothesis:

H0: The distributions of RDS test score differences belonging to TikTok and control video are identical.

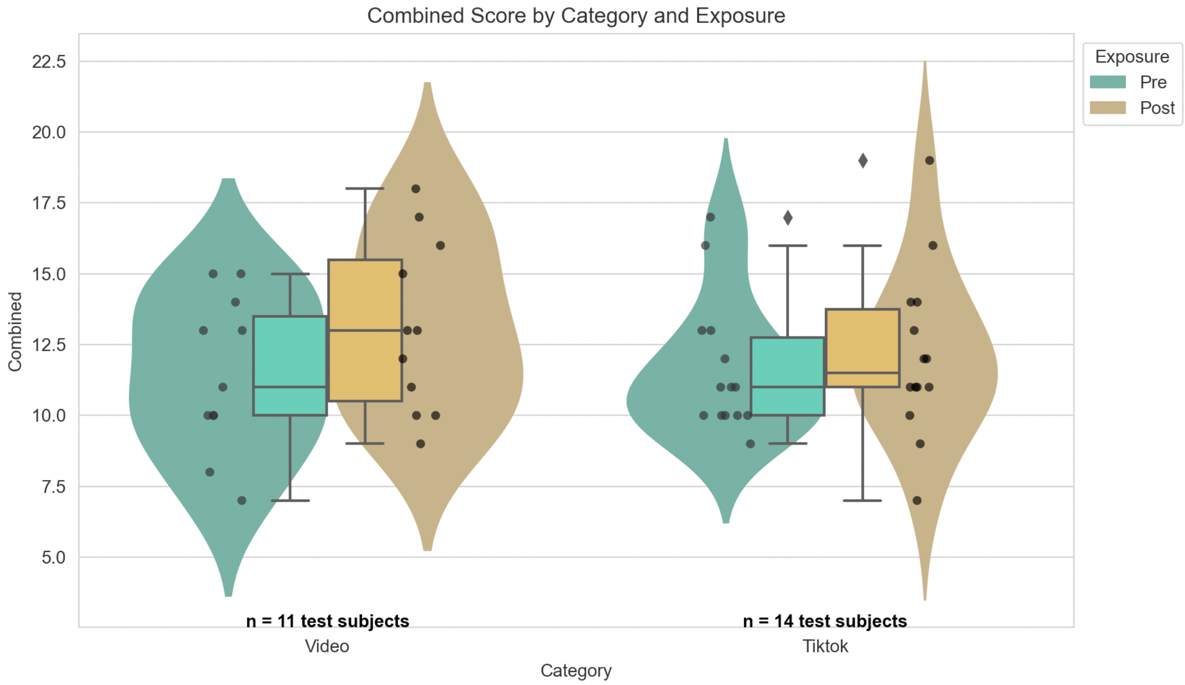

Figure 8: **Data Visualization -** Distribution of pre and post-exposure RDS test scores for both TikTok and the control video group.

For the difference between the *Tiktok: pre-post scores subtraction outcome* and the *Control Video: pre-post scores subtraction outcome* the following is obtained:

Tiktok Mean (SD)	Control Mean (SD)	Test statistic - U	*p*-value
0.500 (3.290)	1.636 (1.920)	66.0	0.5598

4.3 Practice Effect

At present it is important to determine if there is a statistically significant difference between the distributions of the pre and post test scores of all the participants. Since they are normally distributed according to Table 3.6, we will proceed to apply the paired samples t-test. This is necessary to check for a potential 'practice effect' between all pre and post-exposure RDS test scores with the following null hypothesis:

H0: The distributions of pre and post-exposure RDS test scores are identical.

The results are as follows:

Pre-test Mean (SD)	Post-test Mean (SD)	T statistic	*p*-value
11.560 (2.434)	12.560 (2.927)	-1.73	0.0960

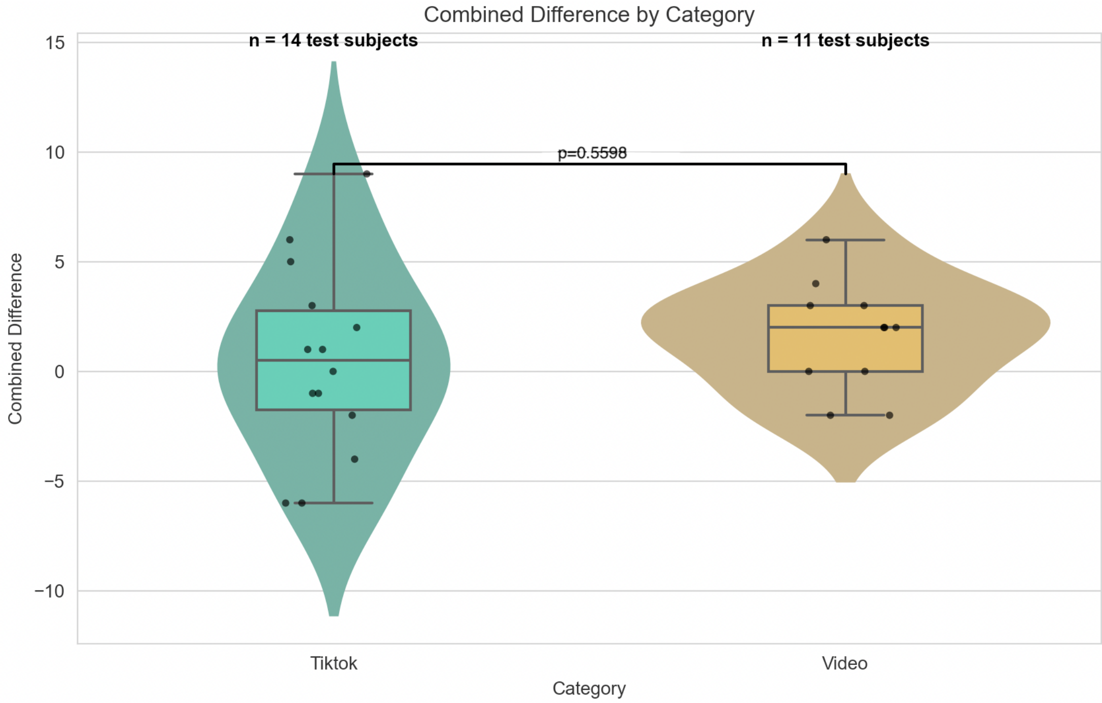

Figure 9: **TikTok Vs. Control -** Distribution of difference (subtraction outcome) in combined RDS test (post-pre) scores for both TikTok and the control video group. Mann-Whitney U test yields p-value of 0.5598.

5 Discussion and Conclusion

5.1 Discussion

The result for the statistical testing of *Tiktok: pre-post scores subtraction outcome* distribution and the *Control Video: pre-post scores subtraction outcome* distribution yielded a p-value of 0.785. Since it is much higher than the significance level decided (0.05), we can conclude that there is insufficient evidence against the null hypothesis, indicating a non-significant result. More specifically, this means that the type of exposure (Tiktok compilation or Control video) did not influence the difference in the pre and post-test scores of the participants.

This poses a subsequent question: Is the difference in the pre and post-test results statistically significant? This could indicate the existence of a potential *practice effect*. To examine that, we performed the paired samples t-test for the scores of all the participants pre and post-exposure. The results yielded a p-value of 0.0960, which once again means insufficient evidence against the null hypothesis, i.e., the difference between the pre and post-test scores is not statistically significant. Therefore, there is not enough evidence to support the existence of the practice effect.

Furthermore, the above two tests for the forward and backward test scores were performed separately to examine whether they showcased any significant differences in their distributions. The results did not yield any significant results and can be found in the appendix and the Jupiter notebook.

From the study that we conducted and based on the results gathered, it is clear that we cannot conclude to approve our initial hypothesis. However, rejecting it completely is questionable due to the power analysis. More specifically, the power analysis demonstrates that we have a low effect size, and we would have needed 56 participants in total in order to achieve a moderate-high effect. It is also notable that we have an imbalance in the group sizes, with 14 TikTok and 11 control, a number that would ideally be the same.

Moreover, the fact that our initial hypothesis was rejected is not sufficient to answer the research question of this study: *Does immediate prior exposure to short video content affect the phonological loop of university students' working memory?*. This is because the outcome might have been different if we made changes to the independent variable. In detail, had the *time of exposure* been 30 minutes or more, the participants might have scored entirely differently in the post-test. In addition, the *type of content* we chose to expose the participants to plays a vital role in this experiment. If both the short video compilation and the control video displayed slightly different content, we cannot be sure that the results could have been the same. This is because the participant's engagement could differ, which may or may not have influenced their test scores afterward. Additionally, the experiment could have been conducted under even tighter control, including having participants be in the same physical space, using the same laptop and mobile device. Moreover, extra control could have been obtained by ensuring that participants had similar hours of sleep and ideally conducted the experiment in an even more limited time slot in order to reduce the fatigue factor. The above limitations emerged due to time and resource constraints.

5.2 Future Work

In the field of cognitive science, our study has explored the link between the phonological loop and exposure to short, rapid video content. This area has yet to be widely studied, making our research a small step in understanding this cognitive connection. Despite the absence of significant results in our current findings, exploring how modern media influences cognitive processes holds ongoing value. Considerations for further research could include the investigation of other facets of working memory, such as visual components, or exploring the impact on the phonological loop through alternative experimental approaches. While our current findings did not yield significant results, exploring how modern media influences cognitive processes remains valuable.

5.3 Conclusion

This project sets out to investigate the impact of rapid video content from social media on working memory through a mixed-design experiment. Our findings are inconclusive due to

the limited effect size, thus the hypothesis cannot be rejected completely. Moreover, there is limited prior research in this specific area, creating opportunities for future investigations between cognitive processes and rapidly evolving digital media. Relevant scientific studies within the field of cognitive science have examined the impact of messaging apps usage, such as WhatsApp, on the working memory performance of young individuals[20]. Similar existing studies have examined potential connections between social media usage and how they may contribute to mental health outcomes in the student population[23].
However, a notable gap in the literature persists regarding the precise influence of short videos on distinct components of working memory. Specifically, insufficient attention has been dedicated to understanding how the utilization of short videos may selectively affect the phonological loop -a crucial part of working memory responsible for auditory-verbal information processing. Consequently, a thorough exploration into detailed interactions between short-form video consumption and the complexity of working memory, particularly the phonological loop, remains an unexplored domain within current cognitive science research.

6 Participant Consent Form with Information Sheet

Study Title: The Impact of Social Media on Working Memory

6.1 Introduction

You are invited to participate in a research study conducted by Marina Epitropaki, Styliani Kalyva and Huayuan Song at DTU. Before you decide whether or not to participate, it is important for you to understand why this research is being conducted and what your participation will involve. Please take the time to read this form carefully and ask any questions you may have before making your decision. Your participation is entirely voluntary.

6.2 Purpose of the Study

The purpose of this study is to investigate the impact of exposure to social media on working memory. We will assess your working memory before and after exposure to a controlled video.

6.3 Experimental Procedure

6.3.1 Introduction and Explanation

The process consists of 3 steps:

- Memory test - Pre-Exposure
- Video Content Exposure
- Memory test - Post - Exposure

6.3.2 Memory Test - Pre-Exposure:

You will take the Reliable Digit Span (RDS) test before any exposure to social media. Your responses will be recorded for later analysis. During this test, you will be presented with digit sequences and asked to repeat them correctly. The goal is to repeat the sequences accurately. Then, you will repeat the same test, but you will have to repeat the sequences backwards.

6.3.3 Social Media Exposure

You will be exposed to 10 minutes of video content from a social media platform through a mobile device. We will predetermine the content.

6.3.4 Memory Test - Post-Exposure:

Immediately after the social media exposure, you will undertake the same memory test as before.

6.3.5 Post-Experiment Questionnaire:

You will complete a questionnaire about your demographic information and your social media usage and habits. This will help us identify patterns amongst people with similar social media habits.

6.3.6 Data Collection:

Data will be collected on your performance in both pre and post-exposure memory tests. We will not collect any personal data, and we will not be able to trace back to specific participants' behaviors.

6.4 Risks and Benefits

There is a low risk that you will experience fatigue over this study. However, you may benefit from gaining insight into your working memory performance.

6.5 Confidentiality

Your responses to the questionnaire and your test results will be kept confidential. We will use numerical codes to identify your data; nothing will tie the data back to you; thus, the collection will be anonymous.

6.6 Voluntary Participation

Participation in this study is entirely voluntary. You may choose to withdraw from the study at any time without penalty.

6.7 Contact Information

If you have any questions about this study, please contact:

Marina Epitropaki at s222727@student.dtu.dk
Styliani Kalyva at s222752@student.dtu.dk
Huayuan Song at s183897@student.dtu.dk

6.8 Agreement to Participate

By signing below, you indicate that you have read and understood the information provided in this consent form and agree to participate in the study. You may request a copy of this form for your records. As a research participant, you can leave a research study at any time without repercussions. When withdrawing from a study, let the research team know that you want to withdraw.

Name of participant: ______________________________

Signature of participant and date: ______________________________

List of Figures

7 Appendix

By applying the statistical procedure mentioned above, the folowing Mann-Whitney U Statistic values and corresponding p-values are obtained:

Type of Difference	Mann-Whitney U Statistic	p-value
Forward Difference	67.0	0.5922
Backward Difference	66.0	0.5543
Combined Difference	66.0	0.5598

Table 1: Mann-Whitney U Test Results for Different Types of Differences

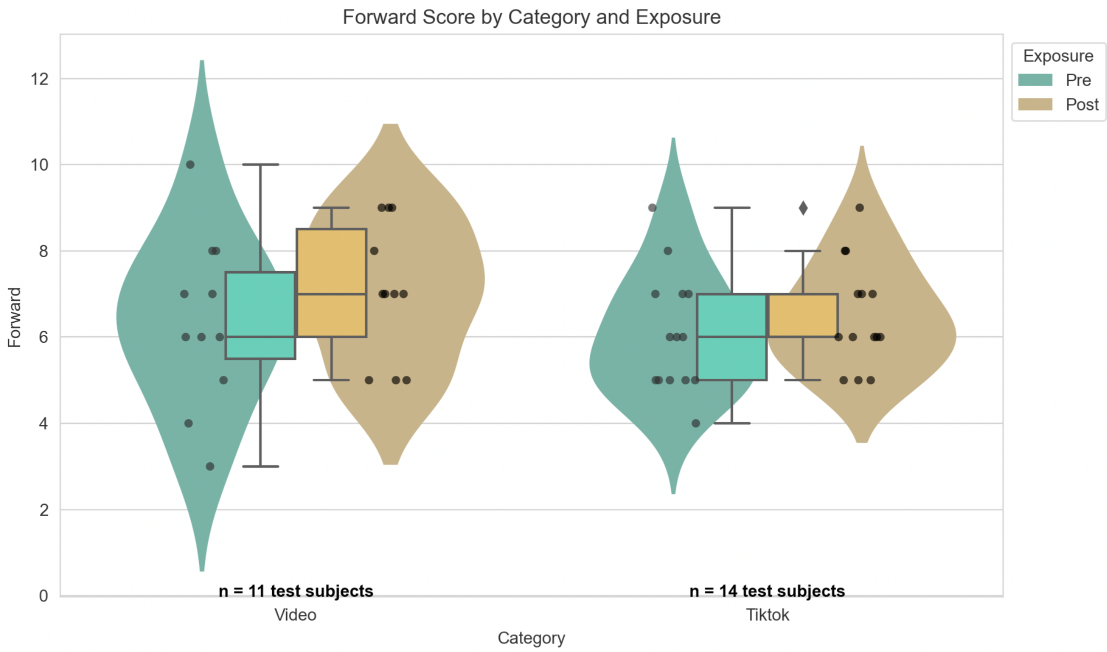

Figure 10: Distribution of pre- and post-exposure RDS forward test scores for both TikTok and the control video group.

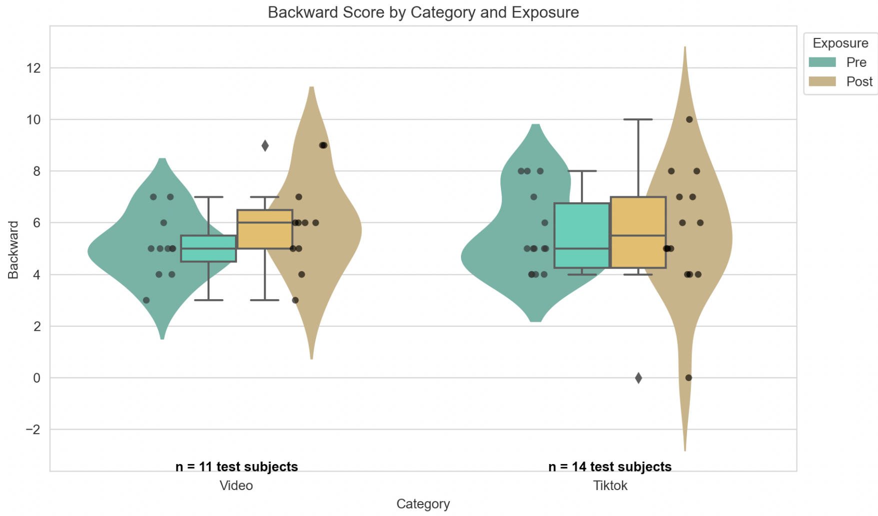

Figure 11: Distribution of pre- and post-exposure RDS backward test scores for both TikTok and the control video group.

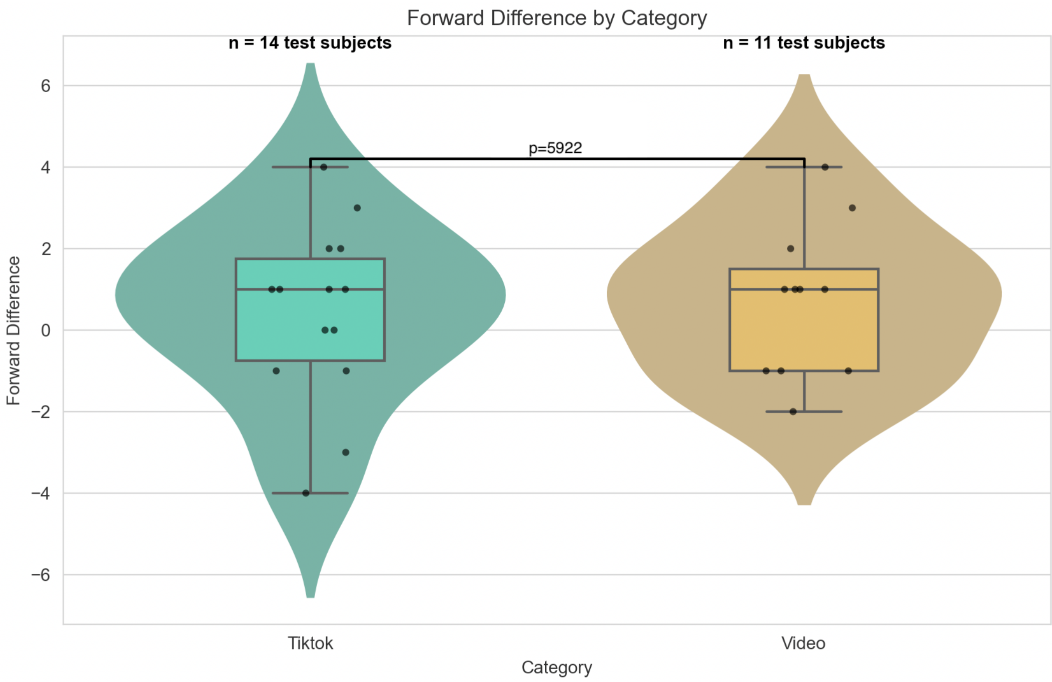

Figure 12: Distribution of difference in forward RDS test (post-pre) scores for both TikTok and the control video group. Mann-Whitney U test yields p-value of 0.5922.

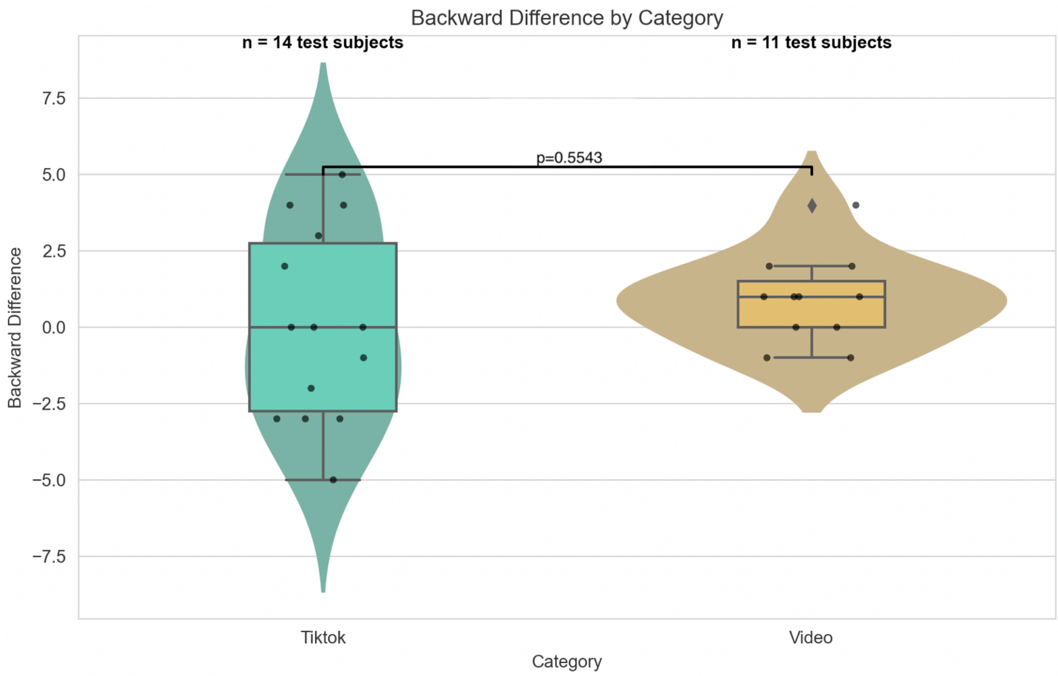

Figure 13: Distribution of difference in backward RDS test (post-pre) scores for both TikTok and the control video group. Mann-Whitney U test yields p-value of 0.5543.

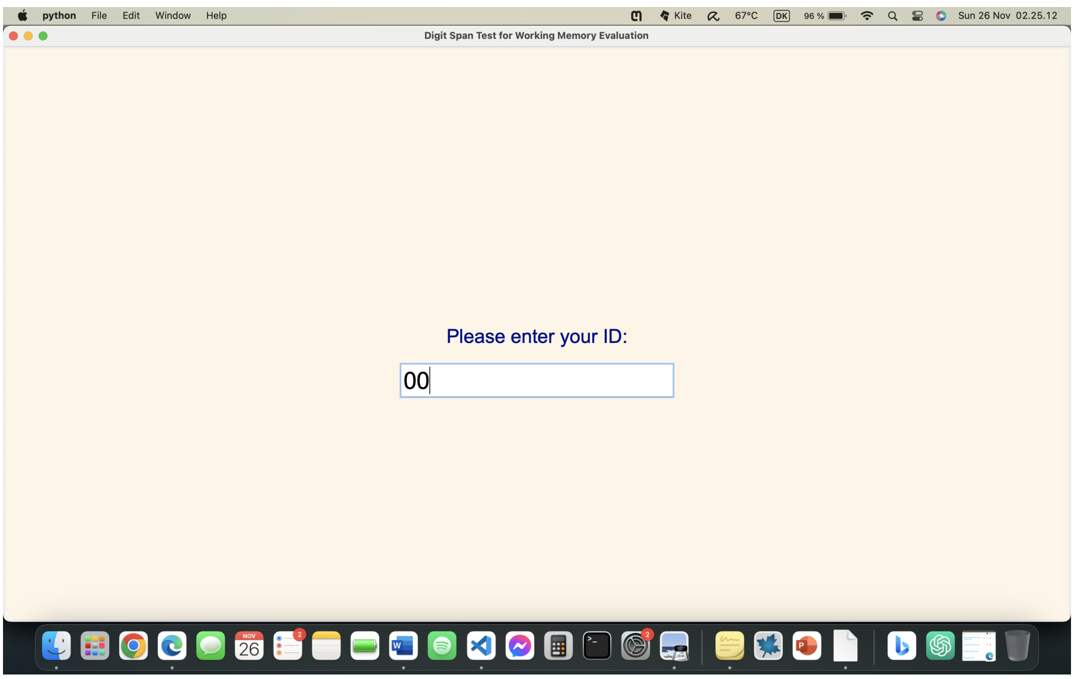

Figure 14: RDS test interface: First screen test participants are presented with; they need to type in their test ID.

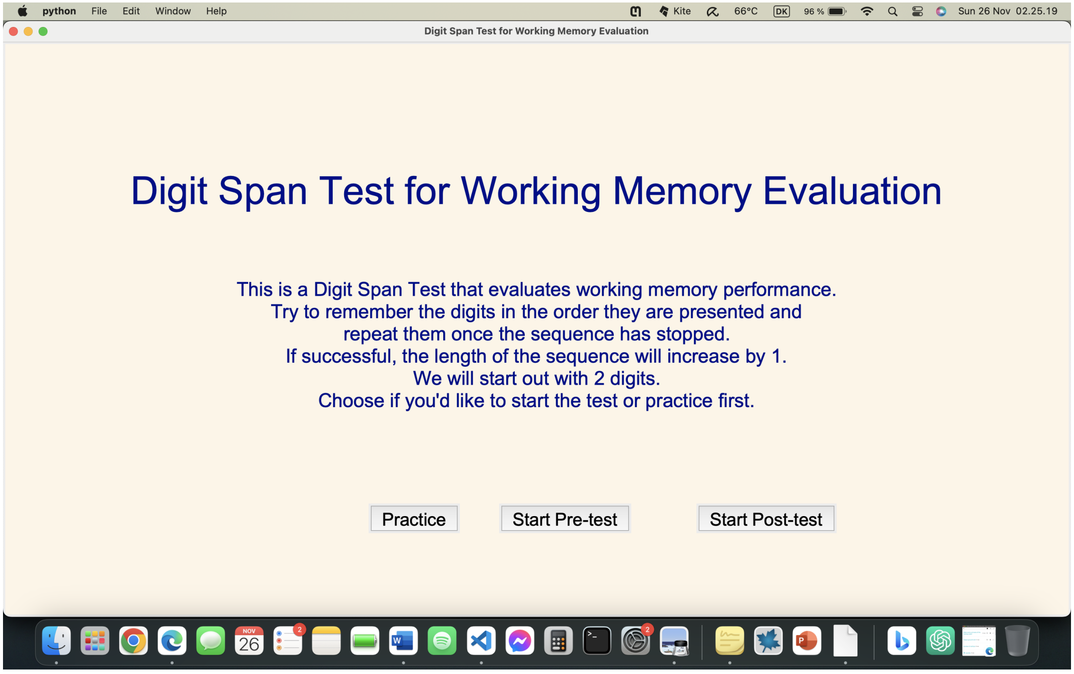

Figure 15: RDS test interface: Instructions screen follows ID entry.

Figure 16: RDS test interface: Upon start of test, the number sequence is presented one digit at a time.

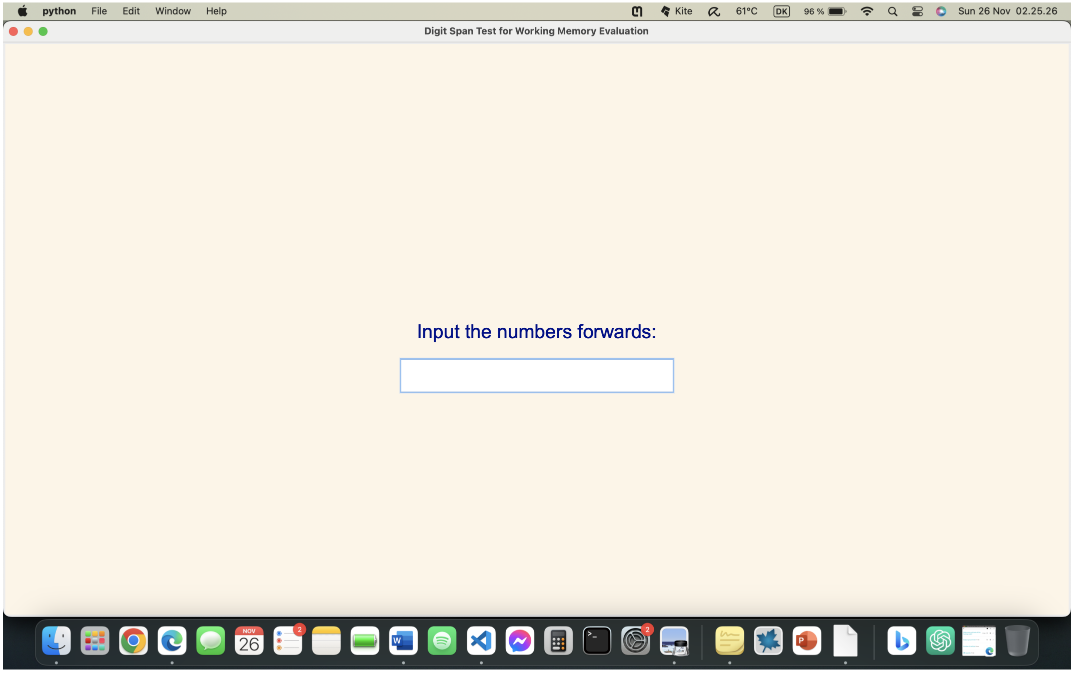

Figure 17: RDS test interface: Participants have to type in the number sequence and hit 'enter'.

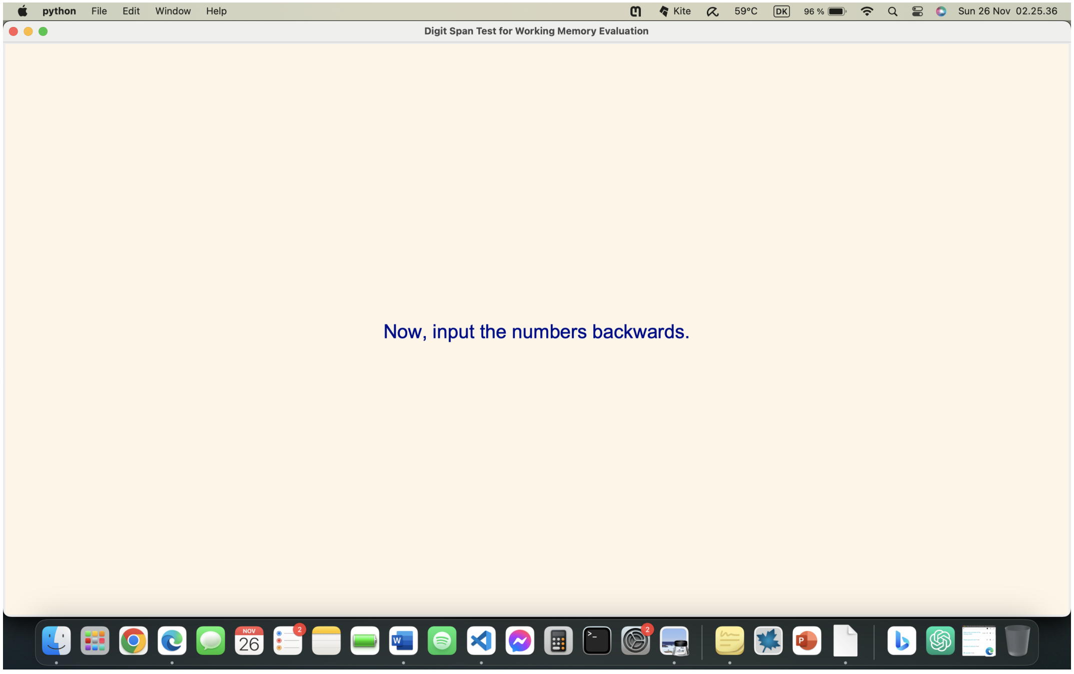

Figure 18: RDS test interface: After completing the forward span, they are prompted to complete backward span test.

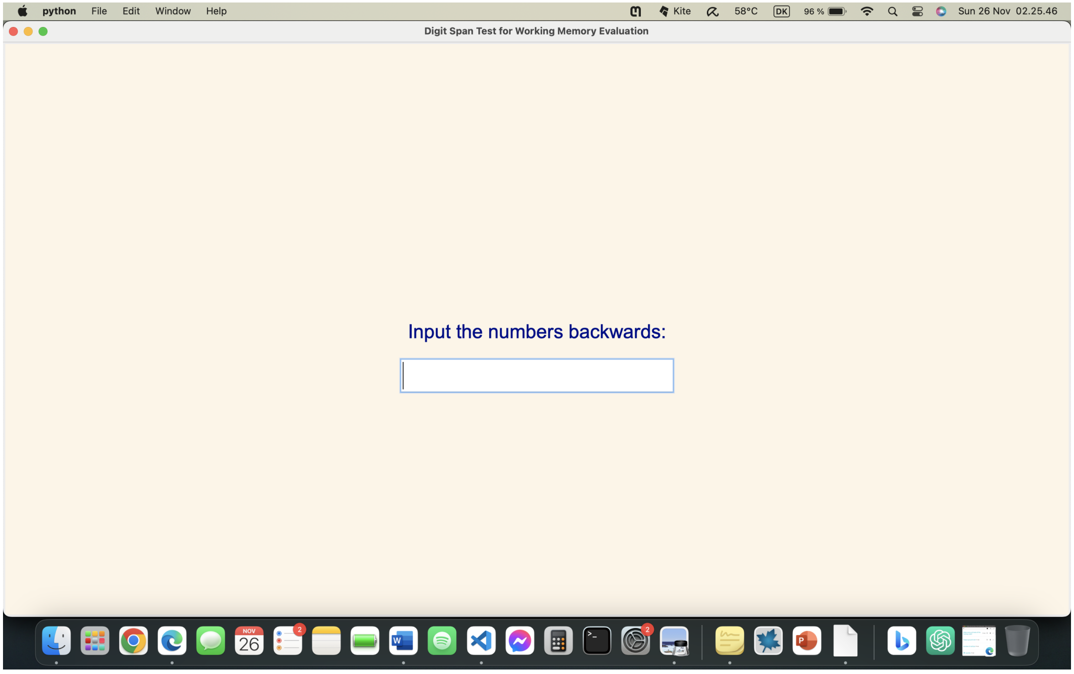

Figure 19: RDS test interface: Number entry works the same for backward span.

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