JCSHD
COGNITIVE SCIENCES AND HUMAN DEVELOPMENT

Digital Juggling: How Media Multitasking Affects Working Memory Performance Among University Students

Hannah Tan Yit Yung, Mohamad Azhari Abu Bakar*, Kartini Abd Ghani & Ida Juliana Hutasuhut
Faculty of Cognitive Sciences and Human Development, Universiti Malaysia Sarawak, Sarawak, Malaysia

ABSTRACT

The widespread adoption of media multitasking among university students raises concerns about its underexplored effects on working memory. This study investigates the relationship between media multitasking habits and both verbal and visuospatial working memory performance. A correlational research was conducted with 40 undergraduate students from a local university, ensuring equal gender distribution and using convenience sampling. Media multitasking habits were measured with the Short Media Multitasking Measure (MMM-S), while both verbal and visuospatial working memory performances were assessed using the Digit Span Task (DST) and Corsi Block-Tapping Test, respectively. The results revealed a significant positive relationship between media multitasking habits and working memory performance, as indicated by greater recall accuracy but longer task completion times for participants with higher media multitasking scores.

Keywords: media multitasking, verbal working memory, visuospatial working memory, university students

ARTICLE INFO
Email address: Mohamad Azhari Bin Abu Bakar (abmazhari@unimas.my)
*Corresponding author
https://doi.org/10.33736/jcshd.7678.2024
e-ISSN: 2550-1623

Manuscript received: 22 August 2024; Accepted: 20 September 2024; Date of publication: 30 September 2024

1 INTRODUCTION

In today's hyper-connected digital age of continuous information exchange and pervasive digital media use, media multitasking, defined as the simultaneous engagement with multiple media sources, with at least one of them being a media-related task (Beuckels et al., 2021), has become a widely adopted skill and increasingly common, particularly among younger individuals (Matthews et al., 2022). This behaviour typically involves rapid and frequent shifts in attention between various media sources (May & Elder, 2018). While it grants unlimited access to information, knowledge, and entertainment, it raises concerns about its effects on working memory performance.

Working memory is a mental space for temporarily storing and processing information. The most prominent model, proposed by Baddeley and Hitch (1974) and later expanded by Baddeley (2000), identifies three key components of working memory: verbal working memory (phonological loop), visual and spatial working memory (visuospatial sketchpad), and central executive. These components work together to effectively retain and process information over short periods. May and Elder (2018) emphasise the growing significance for university students to adeptly navigate complex tasks, effortlessly switching between emails, social media, streaming content, and academic-related activities on a daily basis.

Research indicates that media multitasking significantly impacts working memory performance, though the effects are complex. For instance, Uncapher et al. (2016) observed reduced working memory performance among heavy media multitaskers, which persisted even in the absence of external distractions, suggesting that the pauls of frequent multitasking may extend beyond the immediate context, potentially leading to a more generalised impairment in working memory performance. Conversely, Murphy and Creux (2021) posited that media multitasking might enhance some aspects of working memory, like capacity and processing speed, while impairing others, such as inhibition performance, implying that media multitasking could foster a trade-off between different cognitive processes, where the gain in one area might come at the expense of deficits in another. Given the growing prevalence of media multitasking, especially in present-day educational environments, it is crucial to understand its broader cognitive implications.

Despite the global prevalence of media multitasking, there needs to be more empirical studies on its precise effects on working memory performance, a key component in learning, problem-solving, and decision-making (Chai et al., 2018; Cowan, 2015). Existing research reveals mixed findings, focusing primarily on either the negative consequences (Moisala et al., 2016; Ralph & Smilek, 2017) or the potential advantages and mitigating factors (Alzahabi et al., 2017), resulting in a lack of holistic perspective in comprehending the research topic. Besides that, the relationship between media multitasking and working memory performance remains under-researched, particularly among university students, a demographic highly engaged with digital media and technology. Most research emphasises Western populations, leaving a gap in comprehending how media multitasking affects working memory in other contexts, such as Malaysia. This study addresses this gap, providing a more comprehensive understanding of the cognitive consequences of media multitasking among university students.

The discussion above raised the following research questions:

1. Is there any significant relationship between media multitasking habits and verbal working memory performance based on the total correct recall?
2. Is there any significant relationship between media multitasking habits and verbal working memory performance based on the total time taken?
3. Is there any significant relationship between media multitasking habits and visuospatial working memory performance based on the total correct recall?
4. Is there any significant relationship between media multitasking habits and visuospatial working memory performance based on the total time taken?

The present study examines the relationship between media multitasking habits and verbal and visuospatial working memory performance, measured by total correct recall and time taken. Departing from the conventional categorisation of participants as heavy and light media multitaskers, this research utilises a more nuanced approach. It expands the scope of working memory tests by incorporating multiple tests rather than relying on a single overall performance measure.

2 METHODS

2.1 Participants

Forty undergraduates from Universiti Malaysia Sarawak (UNIMAS), with equal gender distribution, were recruited to participate in this study via convenience sampling. Participants were provided with informed consent detailing the purpose of the study, potential risks, and benefits associated with their involvement in the study, as well as their right to withdraw at any time without penalty. Confidentiality was ensured by restricting access to the research data exclusively to the researcher team and implementing secure data storage protocols. The anonymity of the participants was maintained, with no personally identifiable information linked to the study outcomes.

2.2 Design

The study employed a quantitative, correlational design to examine the relationship between media multitasking habits and working memory performance. The independent variable is the participants' media multitasking habits. The dependent variable is working memory performance, specifically measuring verbal and visuospatial working memory performance based on total correct recall and total time taken.

2.3 Instruments

The instruments used in this study were structured into the following sections: A) Informed Consent Form, B) Demographic Information, C) Short Media Multitasking Measure (MMM-S), D) Digit Span Task (DST), and E) Corsi Block-Tapping Test.

The Short Media Multitasking Measure (MMM-S), developed by Baumgartner et al. (2017), was used to quantify the participant's media multitasking habits using a 4-point Likert scale (1 = Never, 2 = Sometimes, 3 = Often, 4 = Very Often). The individual scores for each item are summed and averaged to obtain an overall score for each participant. The MMM-S has high reliability, with a Cronbach's alpha (a) of 0.90 in a sample of 2278 participants (Baumgartner et al., 2017), indicating strong internal consistency in measuring media multitasking habits.

The Digit Span Task (DST), adapted by Orsini et al. (1987) from Miller's (1956) original design, was adopted in this study to determine the participant's verbal working memory performance. Participants recall a sequence of digits, with the longest correctly recalled sequence representing their digit span. The DST has shown moderate to acceptable internal consistency, with Cronbach's alpha (a) ranging from 0.68 to 0.89 (Gignac et al., 2017; Paula et al., 2016) and a split-half reliability of 0.76, making it a reliable tool for measuring verbal working memory performance in adults, particularly university students.

The Corsi Block-Tapping Test, originally developed by Corsi (1972) and later digitalised by Kessels et al. (2000), was adopted in this study to measure the participant's visuospatial working memory performance. Participants recall a sequence of blocks, with the longest correctly recalled sequence representing their Corsi block span. Paula et al. (2016) demonstrated that the task has a Cronbach's alpha (a) of 0.75, indicating moderate to good reliability in measuring visuospatial working memory performance.

2.4 Procedure

A pilot test involving six participants was conducted prior to the main study. Participants included three from the Faculty of Cognitive Sciences and Human Development, and one each from the Faculty of Economics and Business (FEB), Faculty of Medicine and Health Sciences (FMHS), and Faculty of Engineering (FENG). The aim is to evaluate the suitability of the instruments for Malaysian university students at UNIMAS and to detect any potential concerns related to their comprehension and relevance. Minor adjustments were made based on the participants' feedback to ensure that the DST and Corsi Block-Tapping Test links were clickable and accessible. The findings confirmed that the instruments were suitable and effective for the main study.

Participants were recruited through convenience sampling. Data collection was facilitated using Google Forms, with the questionnaire administered individually to 40 participants. The participants were required to be present at the physical testing location to complete the DST and Corsi Block-Tapping Test to record the correct recall and time taken. Each session began with participants completing the MMM-S. The media multitasking score for each participant was calculated by averaging the nine items in the MMM-S. In the DST, participants were presented with a sequence of two digits, which they were required to recall and repeat in the same order. The sequence gradually increased in length, and the longest correctly recalled sequence represents the participant's digit span, with the duration of each trial recorded. In the Corsi Block-Tapping Test, participants were presented with a sequence of two blocks and were required to click the blocks in

the same order, with the sequence length increasing after each correct response. The longest correct sequence and task completion times were recorded for each participant.

Following the data collection process, the gathered data was analysed using statistical methods and SPSS software. Inferential statistics, including Pearson correlation and Spearman Rank-Order correlation, were employed to explore the relationship between media multitasking habits and working memory performance. The findings aim to deepen the understanding of how media multitasking affects working memory performance, addressing conflicting results from previous studies. Moreover, the findings could help university students manage their media multitasking habits for academic purposes and help educators optimise learning environments during lectures.

3 RESULTS

Table 1 presents the demographic information of participants. Most participants were Chinese, aged 19 to 22, enrolled in the Faculty of Cognitive Sciences and Human Development, primarily in Year 3, with CGPAs ranging from 3.50 to 4.00.

Table 1. Demographic information of participants.

Demographic Variables	**Categories**	**Frequency (n)**	**Percentage (%)**
Gender	Female	20	50.0
	Male	20	50.0
Race	Bumiputera Sabah	1	2.5
	Bumiputera Sarawak	10	25.0
	Chinese	20	50.0
	Indian	2	5.0
	Malay	7	17.5
Age	19 – 22 years old	23	57.5
	23 – 26 years old	16	40.0
	27 – 30 years old	1	2.5
Faculty	FACA	2	5.0
	FCSHD	19	47.5
	FCSIT	5	12.5
	FEB	3	7.5
	FENG	5	12.5
	FMHS	3	7.5
	FRST	1	3.5
	FSSH	2	5.0
Year of Study	Year 1	8	20.0
	Year 2	8	20.0
	Year 3	19	47.5
	Year 4	5	12.5

CGPA	2.99 – 2.50	3	7.5
	3.49 – 3.00	15	37.5
	4.00 – 3.50	22	55.0

Given the small sample size, a Shapiro-Wilk test was conducted to determine the appropriate statistical analysis. Table 2 shows the results of the normality tests. The p-values for the Digit span ($p = 0.079$), total time taken to complete the Digit Span Task ($p = 0.069$), and total time taken to complete the Corsi Block-Tapping Test ($p = 0.094$) indicated no significant evidence of non-normality. Thus, Pearson correlation analysis was selected to examine these hypotheses. Conversely, the Spearman Rank-Order correlation was utilised for that hypothesis because the Corsi span showed non-normality ($p < 0.001$).

Table 2. Tests of normality.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Digit span (Total correct recall)	.147	40	.030	.950	40	.079
Total time taken to complete Digit Span Task	.140	40	.046	.949	40	.069
Corsi span (Total correct recall)	.219	40	<.001	.874	40	<.001
Total time taken to complete Corsi Block-Tapping Test	.116	40	.194	.953	40	.094

a. Lilliefors Significance Correction

Pearson correlation was carried out to investigate the relationship between media multitasking habits and verbal working memory performance based on total correct recall. Table 3 depicts the results, revealing a strong positive relationship between media multitasking score and Digit span, with a Pearson correlation coefficient of $r = 0.571$, $p < 0.001$. Since $p < 0.05$, there is a statistically significant relationship between media multitasking habits and verbal working memory performance as measured by total correct recall.

Table 3. Pearson correlation between media multitasking habits and verbal working memory performance based on total correct recall.

		Media Multitasking Score	Digit span (Total correct recall)
Media Multitasking Score	Pearson Correlation	1	.571**
	Sig. (2-tailed)		<.001
	N	40	40
Digit span (Total correct recall)	Pearson Correlation	.571**	1
	Sig. (2-tailed)	<.001	
	N	40	40

***. Correlation is significant at the 0.01 level (2-tailed).*

Table 4 shows the Pearson correlation analysis between media multitasking habits and verbal working memory performance based on total time taken. The analysis revealed a weak positive relationship between the media multitasking score and the total time taken to complete the Digit Span Task, with a Pearson correlation coefficient of $r = 0.370$ and $p = 0.019$. Since $p < 0.05$, there is a statistically significant relationship between media multitasking habits and verbal working memory performance based on total time taken.

Table 4. Pearson correlation between media multitasking habits and verbal working memory performance based on total time taken.

		Media Multitasking Score	Total time taken to complete Digit Span Task
Media Multitasking Score	Pearson Correlation	1	.370*
	Sig. (2-tailed)		.019
	N	40	40
Total time taken to complete Digit Span Task	Pearson Correlation	.370*	1
	Sig. (2-tailed)	.019	
	N	40	40

**. Correlation is significant at the 0.05 level (2-tailed).*

Table 5 presents the Spearman rank-order correlation analysis results between media multitasking habits and visuospatial working memory performance based on total correct recall. The analysis indicated a moderate positive relationship between media multitasking scores and Corsi span, with a correlation coefficient of $r = 0.518$, $p < 0.001$. Since $p < 0.05$, there is a statistically significant relationship between media multitasking habits and visuospatial working memory performance based on total correct recall.

Table 5. Spearman correlation between media multitasking habits and visuospatial working memory performance based on total correct recall.

			Media Multitasking Score	Corsi span (Total correct recall)
Spearman's rho	Media Multitasking Score	Correlation Coefficient	1.000	.518**
		Sig. (2-tailed)	.	<.001
		N	40	40
	Corsi span (Total correct recall)	Correlation Coefficient	.518**	1.000
		Sig. (2-tailed)	<.001	.
		N	40	40

***. Correlation is significant at the 0.01 level (2-tailed).*

Table 6 depicts the Pearson correlation analysis between media multitasking habits and visuospatial working memory performance based on total time taken. The results demonstrated a weak positive relationship between the media multitasking score and the total time to complete the Corsi Block-Tapping Test, with a Pearson correlation coefficient of $r = 0.318$, $p = 0.046$. Since p

< 0.05, there is a statistically significant relationship between media multitasking habits and visuospatial working memory performance based on total time taken.

Table 6. Pearson correlation between media multitasking habits and visuospatial working memory performance based on total time taken.

		Media Multitasking Score	Total time taken to complete Corsi Block-Tapping Test
Media Multitasking Score	Pearson Correlation	1	.318*
	Sig. (2-tailed)		.046
	N	40	40
Total time taken to complete Corsi Block-Tapping Test	Pearson Correlation	.318*	1
	Sig. (2-tailed)	.046	
	N	40	40

**. Correlation is significant at the 0.05 level (2-tailed).*

4 DISCUSSION

The study is grounded on the notion that the media multitasking habits of participants may influence their working memory performance, specifically in verbal and visuospatial aspects. The main question is whether frequent engagement in media multitasking enhances or impairs working memory performance. Empirical findings indicated a statistically significant relationship between media multitasking habits and both verbal and visuospatial working memory performance, assessed by the total correct recall and total time, among undergraduate students at UNIMAS.

The study found a statistically significant and strong positive relationship between media multitasking habits and verbal working memory performance based on total correct recall. Participants with higher media multitasking scores, reflecting frequent media multitasking, showed heightened proficiency in verbal working memory tasks, such as the DST. This aligns with Seddon et al. (2021), who suggested that the ability to manage multiple media streams concurrently may confer cognitive benefits. The enhanced DST performance among participants with high media multitasking scores may reflect increased adaptability in processing verbal information amidst simultaneous media exposure (Matthews et al., 2022; Seddon et al., 2021), suggesting that frequent media multitasking may develop cognitive strategies that augment their verbal working memory performance.

A statistically significant but weak positive relationship was found between media multitasking habits and verbal working memory performance based on total time taken, indicating that frequent media multitaskers may take longer to complete the DST. This implies a potential link between enhanced media multitasking and reduced processing speed. These findings contrast with prior studies by Murphy and Creux (2021) and Murphy et al. (2024), which reported superior processing speeds among high-media multitaskers. This discrepancy suggests that the impact of media multitasking on verbal working memory performance, as assessed by task completion time, may vary across cognitive tasks and individual characteristics. In addition, the weak correlation

suggests that media multitasking accounts for only a small portion of the variability in task completion time, indicating a relatively modest influence on this aspect of working memory.

Spearman rank-order correlation analysis revealed a significant moderate positive relationship between media multitasking habits and visuospatial working memory performance based on total correct recall in the Corsi Block-Tapping Test. Participants with higher media multitasking scores tend to exhibit higher Corsi span, specifically in accurately recalling the sequence of spatial locations presented in the task. This suggests that frequent media multitaskers may develop cognitive skills that enhance their ability to effectively process and retain spatial information. This aligns with Wannagat et al. (2024), who found that superior cognitive skills corresponded with better task performance during media multitasking among both younger and older adults. Nevertheless, contrasting studies, such as Uncapher et al. (2016) and Uncapher and Wagner (2018), reported diminished visuospatial working memory performance among heavy media multitaskers, highlighting the complexity of this correlation.

A statistically significant but weak positive relationship was observed between media multitasking scores and the total time taken to complete the Corsi Block-Tapping Test, indicating that as media multitasking scores increase, so does the total time taken to complete the visuospatial working memory task administered. However, given the weak correlation, it can be noted that while the findings suggest an association, causality may not be inferred. This suggests that other factors, which were not accounted for in this study, may have influenced task completion times beyond the media multitasking habits of the participants recruited in this study.

The study highlights potential cognitive costs associated with media multitasking habits, particularly its adverse effects on working memory performance. Participants with higher media multitasking scores demonstrated better Digit span and Corsi span scores but also took increased completion times for both the DST and Corsi Block-Tapping Test. This suggests a possible trade-off mechanism, where higher media multitaskers achieve improved accuracy but at the expense of longer completion times, indicating that these individuals may be allocating more cognitive resources and time to ensure precise information processing during these tasks, possibly as a compensatory strategy to manage the cognitive demands of media multitasking.

Despite extensive research on media multitasking and working memory performance (e.g., Alzahabi et al., 2017; Lui & Wong, 2012; Minear et al., 2013; Moisala et al., 2016; Ophir et al., 2009; Ralph & Smilek, 2017; Yap & Lim, 2013), significant gaps remain, particularly due to mixed findings, the need for targeted research on Malaysian university students, and the call for methodological advancements beyond mere categorisation of participants into heavy media multitaskers (HMMs) and light media multitaskers (LMMs). The results align with Cognitive Control Theory and Baddeley's Model of Working Memory, suggesting that media multitasking negatively impacts both types of working memory. Higher media multitasking scores are associated with increased recall and longer completion times, indicating a trade-off between accuracy and processing speed. This signifies poorer working memory performance, as an efficient working memory system ideally balances speed and accuracy (Baddeley, 2000; Cain & Mitroff,

2011; Uncapher et al., 2016). These findings underscore the need for educational strategies to mitigate the negative effects of media multitasking.

The study acknowledges several limitations that should be considered in future research. Firstly, the relatively small and homogenous sample size of 40 participants may limit the statistical power and generalisability of the findings (Marszalek et al., 2011; Nayak, 2010). However, recruiting participants from eight out of ten faculties within UNIMAS enhances the sample's diversity and representativeness across different academic disciplines with varying media multitasking habits. Additionally, uncontrolled confounding variables, such as individual differences in cognitive abilities, remain a limitation that could bias the results (Sponheim, 2023). To mitigate this, the study recruited participants pursuing a bachelor's degree at UNIMAS and ensured equal gender representation, thus controlling for educational level and gender-related differences. At the same time, the use of randomised questions in the DST and Corsi Block-Tapping Test further minimised this limitation. Although the reliance on self-reported data to assess the participants' media multitasking habits may introduce potential bias or inaccuracies (Brenner & DeLamater, 2016), the use of validated MMM-S (a = 0.90) (Baumgartner et al., 2017) enhances the credibility of the findings. Moreover, the sole reliance on the DST and Corsi Block-Tapping Test may only partially capture the dynamic nature of working memory in real-world scenarios, which presents a minor yet relevant limitation. However, the use of DST (a = 0.68 – 0.89) (Gignac et al., 2017; Paula et al., 2016) and Corsi Block-Tapping Test (a = 0.75) (Paula et al., 2016) supports the reliability of the measurements.

Based on the research findings and limitations, several recommendations can be proposed for future research endeavours. Future research should explore other variables like individual cognitive abilities and the timing of working memory tasks to better understand the relationship between media multitasking and working memory performance. Standardised cognitive assessments, like the Wechsler Adult Intelligence Scale (WAIS-IV), could help account for cognitive differences. Replicating the study with larger, more diverse samples from multiple universities and using longitudinal designs would enhance generalisability. To reduce biases from self-reported data, future studies should incorporate objective measures like smartphone usage tracking and use ecologically valid tasks that mimic real-world media multitasking. Expanding the focus to include executive functions, attentional control, and neuroimaging techniques could offer deeper insights into the neural mechanisms underlying the relationship between media multitasking habits and working memory performance.

The present study has successfully identified significant positive relationships between media multitasking habits and both verbal and visuospatial working memory performance based on total correct recall and total time taken among UNIMAS undergraduates. Participants with greater media multitasking scores demonstrated improved recall accuracy, although this was accompanied by increased task completion times, highlighting the potential cognitive trade-offs associated with media multitasking habits among the participants. These findings suggest that while media multitasking may enhance recall accuracy, it also imposes cognitive costs, particularly affecting working memory performance. Efficient working memory performance, as supported by Poll et al. (2013), involves a balance between processing speed and recall accuracy. This study advances

current theories and contributes to academic literature, offering practical implications and guidance for university policymakers. A key takeaway is that media multitasking among university students may adversely impact working memory performance, which could, in turn, influence academic performance. Hence, understanding and managing media multitasking habits is crucial for optimising cognitive performance and academic success among university students.

ACKNOWLEDGEMENTS

We would like to acknowledge all participants who voluntarily participated in this study. Thank you for your contributions. This research received no specific grant from public, commercial, or not-for-profit funding agencies.

REFERENCES

Alzahabi, R., Becker, M. W., & Hambrick, D. Z. (2017). Investigating the relationship between media multitasking and processes involved in task-switching. *Journal of Experimental Psychology: Human Perception and Performance, 43*(11), 1872–1894. https://doi.org/10.1037/xhp0000412

Baddeley, A. (2000). The episodic buffer: a new component of working memory? *Trends in Cognitive Sciences, 4*(11), 417-423. https://doi.org/10.1016/S1364-6613(00)01538-2

Baddeley, A. D., & Hitch, G. (1974). Working memory. *Psychology of Learning and Motivation, 8*, 47-89. https://doi.org/10.1016/S0079-7421(08)60452-1

Baumgartner, S. E., Lemmens, J. S., Weeda, W. D., & Huizinga, M. (2017). Measuring media multitasking: Development of a short measure of media multitasking for adolescents. *Journal of Media Psychology, 29*(4), 188-197. https://doi.org/10.1027/1864-1105/a000167

Beuckels, E., Ye, G., Hudders, L., & Cauberghe, V. (2021). Media multitasking: A bibliometric approach and literature review. *Frontiers in Psychology, 12*(623643), 1-18. https://doi.org/10.3389/fpsyg.2021.623643

Brenner, P. S., & DeLamater, J. (2016). Lies, damned lies, and survey self-reports? Identity as a cause of measurement bias. *Social Psychology Quarterly, 79*(4), 333-354. https://doi.org/10.1177%2F0190272516628298

Cain, M. S., & Mitroff, S. R. (2011). Distractor filtering in media multitaskers. *Perception, 40*(10), 1183-1192. http://dx.doi.org/10.1167/10.7.260

Chai, W. J., Hamid, A.I., & Malin, J. (2018). Working memory from the psychological and neurosciences perspectives: A review. *Frontiers in Psychology, 9*. https://doi.org/10.3389/fpsyg.2018.00401

Corsi, P. M. (1972). *Human memory and the medial temporal region of the brain.* [Doctoral dissertation, McGill University]. eScholarship@McGill. https://escholarship.mcgill.ca/concern/theses/05741s554

Cowan, N. (2015). Working memory underpins cognitive development, learning, and education. *Educational Psychology Review, 26*(2), 197-223. https://doi.org/10.1007%2Fs10648-013-9246-y

Gignac, G. E., Reynolds, M. R., & Kovacs, K. (2017). Digit span subscale scores may be insufficiently reliable for clinical interpretation: Distinguishing between stratified coefficient alpha and omega hierarchical. *Assessment,* 1-10. https://doi.org/10.1177/1073191117748396

Kessels, R. P. C., van Zandvoort, M. J. E., Postman, A., Kapelle, L. J., & de Hand, E. H. F. (2000). The Corsi Block-Tapping Task: Standardization and normative data. *Applied Neuropsychology, 7*(4), 252-258. https://doi.org/10.1207/s15324826an0704_8

Lui, K. F., & Wong, A. C. N. (2012). Does media multitasking always hurt? A positive correlation between multitasking and multisensory integration. *Psychonomic Bulletin and Review, 19,* 647-653. https://doi.org/10.3758/s13423-012-0245-7

Marszalek, J. M., Barber, C., Holmes, C. B., & Kohlhart, J. (2011). Sample size in psychological research over the past 30 years. *Perceptual and Motor Skills, 112*(2), 331-348. http://dx.doi.org/10.2466/03.11.PMS.112.2.331-348

Matthews, N., Mattingley J. B., & Dux, P. E. (2022). Media-multitasking and cognitive control across the lifespan. *Scientific Reports, 12*(4349), 1-10. https://doi.org/10.1038/s41598-022-07777-1

May, K. E., & Elder, A. D. (2018). Efficient, helpful, or distracting? A literature review of media multitasking in relation to academic performance. *International Journal of Educational Technology in Higher Education, 15*(13), 1-17. https://doi.org/10.1186/s41239-018-0096-z

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*(2), 81-97. https://psycnet.apa.org/doi/10.1037/h0043158

Minear, M., Brasher, F., McCurdy, M., Lewis, J., & Younggren, A. (2013). Working memory, fluid intelligence, and impulsiveness in heavy media multitaskers. *Psychonomic Bulletin and Review, 20,* 1274-1281. https://doi.org/10.3758/s13423-013-0456-6

Moisala, M., Salmela, V., Hietajarvi, L., Salo, E., Carlson, S., Salonen, O., Lonka, K., Hakkarainen, K., Salmela-Aro, K., & Alho, K. (2016). Media multitasking is associated with distractibility and increased prefrontal activity in adolescents and young adults. *NeuroImage, 134*, 113-121. https://doi.org/10.1016/j.neuroimage.2016.04.011

Murphy, K., & Creux, O. (2021). Examining the association between media multitasking, and performance on working memory and inhibition tasks. *Computers in Human Behavior, 114*(106532). https://doi.org/10.1016/j.chb.2020.106532

Murphy, K., Shin, M., & Stainer, M. (2024). Media multitasking scores and media use hours: A comparison across the standard Stroop task and an emotional Stroop task. *Media Psychology*, 1-21. https://doi.org/10.1080/15213269.2024.2338115

Nayak, B. K. (2010). Understanding the relevance of sample size calculation. *Indian Journal of Ophthalmology, 58*(6), 469-470. https://doi.org/10.4103%2F0301-4738.71673

Ophir, E., Nass, C., & Wagner, A. D. (2009). Cognitive control in media multitaskers. *Psychological and Cognitive Sciences, 106*(37), 15583-15587. https://doi.org/10.1073/pnas.0903620106

Orsini, A., Grossi, D., Capitani, E., Laiacona, M., Papgno, C., & Vallar, G. (1987). Verbal and spatial immediate memory span: normative data from 1355 adults and 1112 children. *Italian Journal of Neurological Sciences, 8*(6), 539-548. https://doi.org/10.1007/bf02333660

Paula, J. J., Malloy-Diniz, L. F., & Romano-Silva, M. A. (2016). Reliability of working memory assessment in neurocognitive disorders: A study of the Digit Span and Corsi Block-Tapping tasks. *Revista Brasileira de Psiquiatria, 38*(3), 262-263. http://dx.doi.org/10.1590/1516-4446-2015-1879

Poll, G. H., Miller, C. A., Mainela-Arnold, E., Adams, K. D., Misa, M., & Park, J. S. (2013). Effects of children's working memory capacity and processing speed on their sentence initiation performance. *International Journal of Language and Communication Disorders, 48*(3), 329-342. https://doi.org/10.1111/1460-6984.12014

Ralph, B. C. W., & Smilek, D. (2017). Individual differences in media multitasking and performance on the n-back. *Attention, Perception, & Psychophysics, 79*, 582-592. https://doi.org/10.3758/s13414-016-1260-y

Seddon, A.L., Law, A. S., Adams, A., & Simmons, F. R. (2021). Individual differences in media multitasking ability: The importance of cognitive flexibility. *Computers in Human Behavior Reports, 3*(100068). https://doi.org/10.1016/j.chbr.2021.100068

Sponheim, C. (2023). *Confounding variables in quantitative studies.* https://www.nngroup.com/articles/confounding-variables-quantitative-ux/

Uncapher, M. R., & Wagner, A. D. (2018). Minds and brains of media multitaskers: Current findings and future directions. *Proceedings of the National Academy of Sciences, 115*(40), 9889-9896. https://doi.org/10.1073/pnas.1611612115

Uncapher, M. R., Thieu, M. K., & Wagner, A. D. (2016). Media multitasking and memory: Differences in working memory and long-term memory. *Psychonomic Bulletin and Review, 23*(2), 483-490. https://doi.org/10.3758%2Fs13423-015-0907-3

Wannagat, W., Martin, T., Nieding, G., Rohleder, N., & Becker, L. (2024). Media multitasking in younger and older adults: Associations with cognitive abilities and biological stress responses. *Media Psychology*, 1-41. https://doi.org/10.1080/15213269.2023.2298686

Yap, J. Y., & Lim, S. W. H. (2013). Media multitasking predicts unitary versus splitting visual focal attention. *Journal of Cognitive Psychology, 25*, 889-902. https://doi.org/10.1080/20445911.2013.835315