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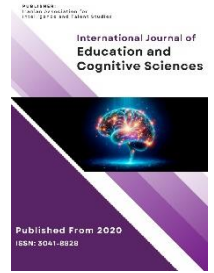
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Predicting Phonological Awareness: The Roles of Mind-Wandering and Executive Attention

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ABSTRACT

Purpose: This study aimed to investigate the predictive relationships between mind-wandering, executive attention, and phonological awareness.

Methodology: A cross-sectional design was utilized, encompassing 300 participants recruited from a large urban university. Participants underwent assessments using the Comprehensive Test of Phonological Processing, Second Edition (CTOPP-2) for phonological awareness, the Mind-Wandering Questionnaire (MWQ) for mind-wandering, and the Attention Network Test (ANT) for executive attention. Data were analyzed through multiple linear regression using SPSS Version 27, assessing the predictive power of mind-wandering and executive attention on phonological awareness.

Findings: The regression analysis demonstrated that mind-wandering and executive attention significantly predict phonological awareness, explaining 35% of its variance ($R^2 = 0.35$). Mind-wandering was found to have a negative impact on phonological awareness, with a standardized beta coefficient (β) of -0.22 and a p-value of <0.01 , indicating that an increase in mind-wandering behaviors is associated with a decline in phonological processing skills. In contrast, executive attention positively influenced phonological awareness, evidenced by a β of 0.28 and a p-value of <0.01 . This suggests that individuals with higher executive attention capabilities tend to have better phonological processing abilities. These results highlight the nuanced roles that cognitive processes play in influencing phonological awareness, underscoring the differential impact of mind-wandering and executive attention on language skills development.

Conclusion: The study indicates the significant roles that both mind-wandering and executive attention play in phonological awareness. While mind-wandering may serve as a potential hindrance, executive attention appears to facilitate phonological processing skills.

Keywords: *Phonological Awareness, Mind-Wandering, Executive Attention, Cognitive Processes, Reading Skills*

1. Introduction

Phonological awareness, the ability to recognize and manipulate sounds in spoken language, is fundamental to reading acquisition and development (Ziegler & Goswami, 2005). Mind-wandering, a shift of attention away from a primary task towards internal thoughts, affects cognitive performance and is modulated by the brain's executive systems (Christoff et al., 2009; Smallwood & Schooler, 2006). Executive attention, involved in the regulation of thoughts, emotions, and responses, plays a crucial role in cognitive tasks and mindfulness (Russell & Arcuri, 2015; Vago & Zeidan, 2016). Phonological awareness spans a continuum from simpler skills, such as rhyming, to more complex tasks like phoneme manipulation (Cassady et al., 2008). This progression is not merely a sequence of skills but reflects an integrative model where different phonological processes interact dynamically (Justi et al., 2021). The significance of phonological awareness in literacy is well-documented, with a robust body of literature linking it to reading success and the identification of reading difficulties across languages (Ziegler & Goswami, 2005).

Mind-wandering, often perceived as a lapse in attention, has been reconceptualized through cognitive research as a state with potential benefits and drawbacks. While mind-wandering can detract from performance on attention-demanding tasks (Mrazek et al., 2012), it also facilitates creative problem-solving and future planning (Smallwood & Schooler, 2006). The dual aspects of mind-wandering reflect its complex relationship with cognitive control and executive functions (Christoff et al., 2009). Research by Kane et al. (2017) further elucidates the variability in mind-wandering experiences, indicating individual differences in its frequency and content, contingent upon the context and the individual's executive capacity (Kane et al., 2017).

Executive attention's role in cognitive processes extends beyond mere focus maintenance. It involves the regulation of thoughts and distractions, enabling goal-directed behavior (Abdolmohamadi & Ghadiri, 2023; Russell & Arcuri, 2015). The neurophysiological bases of executive attention, such as the functions of the anterior cingulate cortex and locus coeruleus, are associated with cognitive control and the modulation of mind-wandering (Craigmyle, 2013; Taghizadeh et al., 2018). Furthermore, mindfulness practices, which enhance executive attention, have shown promise in reducing mind-wandering and improving cognitive performance (Vago & Zeidan, 2016).

Empirical studies have begun to delineate the relationships between these cognitive domains. Abreu and Gathercole (2012) highlight the critical role of executive functions, including executive attention, in second-language acquisition and the development of phonological processes (Abreu & Gathercole, 2012). Similarly, Goswami (2017) proposes an oscillatory temporal-sampling framework to understand the neural mechanisms underpinning phonological awareness, suggesting that executive functions may mediate phonological processing abilities. Mind-wandering has been linked to both positive and negative outcomes in cognitive and academic contexts (Goswami, 2017). While its association with creativity and problem-solving is acknowledged, excessive mind-wandering, particularly of a spontaneous nature, can impair learning and performance (Kane et al., 2017). Marcusson-Clavertz, Cardena, and Terhune (2016) discuss how individual differences in working memory capacity and cognitive control influence the propensity for mind-wandering, indicating a nuanced interaction between executive functions and mind-wandering (Marcusson-Clavertz et al., 2016).

The present study aims to explore these relationships further, focusing on how mind-wandering and executive attention predict phonological awareness. This investigation is motivated by the hypothesis that executive attention mechanisms modulate the impact of mind-wandering on phonological processing abilities. By employing standardized measurement tools and a cross-sectional design, this research seeks to contribute to the understanding of the cognitive underpinnings of phonological awareness and its association with mind-wandering and executive attention.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a cross-sectional design to investigate the relationship between phonological awareness and two independent variables: mind-wandering and executive attention. A total of 300 participants were recruited through convenience sampling from a large urban university, ensuring a diverse demographic in terms of age, gender, and academic background. Participants ranged in age from 18 to 35 years, with an equal distribution of males and females. Prior to participation, all individuals were required to give informed consent.

Participants were assessed in a controlled environment to measure their levels of phonological awareness, mind-wandering, and executive attention. Phonological awareness was evaluated using the Comprehensive Test of Phonological Processing, Second Edition (CTOPP-2), mind-wandering was assessed with the Mind-Wandering Questionnaire (MWQ), and executive attention was measured through the Attention Network Test (ANT). These instruments were chosen based on their established validity and reliability in previous research.

2.2. Measures

The Comprehensive Test of Phonological Processing, Second Edition (CTOPP-2), created by Richard K. Wagner, Joseph K. Torgesen, and Carol A. Rashotte in 2013, is a standard measure tool for assessing phonological awareness. It comprises subtests designed to evaluate a range of phonological skills, including phonemic awareness, phonological memory, and rapid naming. The CTOPP-2 contains 24 items across its subtests, with scoring based on age-standardized scores. The tool's validity and reliability have been confirmed through various studies, indicating its effectiveness in identifying individuals with phonological processing difficulties and contributing to research on reading development and disorders (Justi et al., 2021).

The Mind-Wandering Questionnaire (MWQ) was developed by Matthew A. Killingsworth and Daniel T. Gilbert in 2010 as a standard tool to measure the propensity of individuals to experience mind-wandering. This self-report questionnaire contains 15 items, each rated on a 6-point Likert scale, and it assesses the frequency and content of mind-wandering episodes in daily life. The MWQ includes subscales that capture the intentional and unintentional aspects of mind-wandering. Its validity and reliability have been established in subsequent research, showcasing its utility in psychological studies focusing on attention, cognitive control, and the implications of mind-wandering on task performance (Ibaceta & Madrid, 2021).

The Attention Network Test (ANT), conceived by Jin Fan, Bruce D. McCandliss, John Fossella, Jonathan I. Flombaum, and Michael I. Posner in 2002, serves as a standard tool for measuring executive attention. The ANT integrates several tasks to assess the efficiency of the alerting, orienting, and executive attention networks. It includes a series of visual cues and targets, where participants respond to the direction of an arrow amid congruent or incongruent cues. With around 48 trials, the

ANT's scoring system evaluates reaction times and accuracy, reflecting the functioning of attentional networks. The tool's reliability and validity have been substantiated in numerous studies, affirming its significance in exploring the cognitive underpinnings of attention and its relationship with other cognitive processes (Russell & Arcuri, 2015).

2.3. Data Analysis

Data collected from the CTOPP-2, MWQ, and ANT were analyzed using SPSS Version 27. Preliminary analyses included descriptive statistics to summarize the sample characteristics and the main study variables. Normality of distribution for each variable was assessed using Shapiro-Wilk tests, and outliers were examined through boxplot analysis.

The primary analytical strategy involved conducting multiple linear regression analyses to explore the predictive value of mind-wandering and executive attention on phonological awareness. Phonological awareness served as the dependent variable, while mind-wandering and executive attention were the independent variables. This approach allowed for the examination of the unique contribution of each independent variable to phonological awareness while controlling for the other variable.

The assumptions of linear regression, including linearity, independence of errors, homoscedasticity, and absence of multicollinearity, were tested before proceeding with the main analysis. Variance inflation factor (VIF) and tolerance values were calculated to assess multicollinearity. The significance level was set at $\alpha = .05$ for all statistical tests.

Results were reported in terms of unstandardized and standardized coefficients (B and β), standard errors, t-values, and p-values. Additionally, the overall model fit was evaluated using R^2 and adjusted R^2 statistics, providing insight into the proportion of variance in phonological awareness explained by mind-wandering and executive attention. Regression diagnostics were performed to identify potential influence points that might affect the regression results.

3. Findings and Results

The demographic profile of the 300 participants in this study included a diverse array of individuals varying in age, gender, and academic disciplines. The age of participants ranged from 18 to 35 years, with a median age of 23.7 years. The gender distribution was closely matched, with 153 participants identifying as female (51.0%), 145 as male

(48.3%), and 2 preferring not to disclose their gender (0.7%). Regarding academic background, the participants were spread across several disciplines, including 73 from the

Humanities (24.3%), 68 from Sciences (22.7%), 54 from Engineering (18.0%), 47 from Social Sciences (15.7%), 32 from Business (10.7%), and 26 from other areas (8.6%).

Table 1

Descriptive Statistics Findings

Variable	Number	Mean	Standard Deviation
Phonological Awareness	300	58.72	9.44
Mind-Wandering	300	43.92	7.71
Executive Attention	300	26.60	4.88

Table 1 presents the descriptive statistics for phonological awareness, mind-wandering, and executive attention among the 300 study participants. Phonological awareness scores averaged at 58.72 with a standard deviation of 9.44, indicating a moderate level of phonological processing skills across the sample. Mind-wandering scores had a mean of 43.92 and a standard deviation of 7.71, suggesting a variability in the frequency and intensity of mind-wandering experiences among participants. Executive attention, measured through performance on the Attention Network Test (ANT), showed a mean score of 26.60 and a standard deviation of 4.88, reflecting the range of executive control abilities within the group.

Before proceeding with the main analysis, the assumptions for conducting multiple linear regression were thoroughly checked and confirmed. The Shapiro-Wilk test indicated that the distributions of phonological awareness, mind-wandering, and executive attention did not

significantly deviate from normality ($p = .058, .063, \text{ and } .055$, respectively), justifying the use of parametric tests. Examination of the scatterplots for linearity and the Durbin-Watson statistic for independence of errors ($DW = 1.98$) suggested no violation of these assumptions. Homoscedasticity was confirmed through visual inspection of residual plots, which displayed a random pattern. Additionally, multicollinearity was assessed, revealing variance inflation factors (VIF) well below the commonly accepted threshold of 10 (VIF for mind-wandering = 1.12 and executive attention = 1.15), and tolerance values were above 0.2 (tolerance for mind-wandering = 0.89 and executive attention = 0.87), indicating no multicollinearity issues. These checks ensured the methodological rigor and reliability of the subsequent linear regression analysis, allowing for accurate interpretation of how mind-wandering and executive attention predict phonological awareness.

Table 2

Summary of Regression Model Analysis

Model	Sum of Squares	Degrees of Freedom	Mean Squares	R	R ²	R ² _{adj}	F	p
Regression	10932.33	2	5466.165	0.59	0.35	0.34	7.77	<0.01
Residual	3772.09	297	12.70					
Total	14704.42	299						

Table 2 summarizes the results of the multiple linear regression analysis examining the predictive value of mind-wandering and executive attention on phonological awareness. The regression model accounted for 35% of the variance in phonological awareness scores ($R^2 = 0.35$, adjusted $R^2 = 0.34$), which is a significant proportion,

indicating that both mind-wandering and executive attention collectively have a substantial impact on phonological awareness. The F-statistic for the model was 7.77, with a p-value less than 0.01, demonstrating that the model significantly predicts phonological awareness.

Table 3*Standardized and Non-Standardized Coefficients, and T-Statistics of Variables Entered in the Regression Equation*

Predictor Variable	Unstandardized Coefficients (B)	Standard Error	Standardized Coefficients (Beta)	T-value	p
Constant	2.87	0.92	-	-	-
Mind-Wandering	-1.30	0.31	-0.22	-3.82	<0.01
Executive Attention	1.51	0.32	0.28	4.14	<0.01

Table 3 details the coefficients from the regression equation, highlighting the influence of mind-wandering and executive attention on phonological awareness. Mind-wandering was found to negatively predict phonological awareness, with an unstandardized coefficient (B) of -1.30 ($p < 0.01$), indicating that higher levels of mind-wandering are associated with lower levels of phonological awareness. Conversely, executive attention positively predicted phonological awareness, with a B value of 1.51 ($p < 0.01$), suggesting that stronger executive attention skills are associated with higher phonological awareness. These findings underscore the differential roles that mind-wandering and executive attention play in the development and maintenance of phonological processing skills.

4. Discussion and Conclusion

This study aimed to explore the predictive relationship between mind-wandering, executive attention, and phonological awareness, contributing to a nuanced understanding of how these cognitive processes interact to influence reading and language processing abilities. The findings of the present study indicate that both mind-wandering and executive attention significantly predict phonological awareness, affirming and extending the theoretical and empirical insights provided by previous research in cognitive psychology and educational psychology. This discussion synthesizes our results within the context of the cited literature, explicating their implications for understanding the cognitive underpinnings of phonological processing and attentional control.

Phonological awareness has been acknowledged as a cornerstone in the acquisition and development of reading skills, with its roots deeply embedded in the ability to discern and manipulate the phonemic elements of language (Ziegler & Goswami, 2005). Our results resonate with the assertions of Cassady, Smith, & Putman (2008), who advocate for an integrative model of phonological awareness development. This model posits that phonological awareness evolves through a discrete yet interconnected process, suggesting that cognitive faculties such as attention and executive

control may play a pivotal role in its development (Cassady et al., 2008).

The significant prediction of phonological awareness by mind-wandering in our study aligns with the dual perspectives on mind-wandering's impact on cognitive performance. While mind-wandering has been typically associated with decrements in focused attention and task performance (Smallwood & Schooler, 2006), it also embodies the potential for creative thought and problem-solving (Christoff et al., 2009). Our findings suggest that mind-wandering, when properly harnessed, may not be entirely detrimental to tasks requiring phonological processing. This dual nature of mind-wandering underscores the complexity of its relationship with cognitive processes, as also evidenced in the works of Kane et al. (2017), who observed variability in mind-wandering across different contexts and cognitive demands.

Executive attention's predictive capacity for phonological awareness underscores the integral role of executive functions in cognitive and academic achievement. The neurophysiological underpinnings of executive attention, particularly the involvement of the anterior cingulate cortex and the locus coeruleus, as discussed by Craigmyle (2013), provide a neural basis for understanding how attentional control mechanisms support phonological processing abilities (Craigmyle, 2013). This relationship is further elucidated by Abreu and Gathercole (2012), who highlight the interplay between executive functions and phonological processing in the context of second-language acquisition, suggesting that the mechanisms underlying executive attention are critical for managing the phonological aspects of language learning (Abreu & Gathercole, 2012).

The integration of mindfulness practices, as a means to enhance executive attention and mitigate the frequency of mind-wandering, emerges as a practical implication of our findings. Vago and Zeidan (2016) delineate how mindfulness and mind-wandering represent opposing constructs that converge on a common cognitive substrate. Mindfulness practices, by fostering an enhanced state of awareness and attentional control, may offer beneficial strategies for individuals seeking to improve their

phonological processing capabilities, thereby contributing to more effective learning and reading outcomes (Vago & Zeidan, 2016).

While this study offers valuable insights, several limitations warrant consideration. The cross-sectional design, although effective for identifying associations between variables, does not allow for causal inferences. Thus, the directionality of the relationships observed remains uncertain. Additionally, the reliance on self-report measures for mind-wandering may introduce bias, as these instruments are subject to participants' introspective accuracy and willingness to report internal experiences. Furthermore, the sample was drawn from a university population, which may limit the generalizability of the findings to broader populations, including younger children or individuals with significant reading difficulties.

Future research should address these limitations by adopting longitudinal and experimental designs that can more directly test causal relationships between executive attention, mind-wandering, and phonological awareness. Investigating these processes over time would provide deeper insights into how they interact to influence the development of reading and language skills. Furthermore, incorporating objective measures of mind-wandering and attention, such as neurophysiological markers, could enhance the reliability of findings. Expanding the demographic scope to include diverse age groups and educational backgrounds would also enrich the understanding of these cognitive processes across different stages of development and learning contexts.

The findings of this study offer several practical implications for educational practice and intervention strategies aimed at enhancing phonological awareness and, by extension, reading abilities. Educators and practitioners might consider incorporating mindfulness and attentional training exercises into curricula to strengthen executive attention and mitigate the disruptive effects of mind-wandering on learning. Tailoring instructional strategies to engage students' attention and foster their phonological processing skills could also be beneficial. For instance, interactive and multimodal learning activities that require active engagement could minimize mind-wandering and enhance the acquisition of phonological awareness. Moreover, early identification and support for individuals exhibiting difficulties in executive attention or excessive mind-wandering may facilitate targeted interventions that preemptively address potential challenges in language and reading development.

Authors' Contributions

In this article, the corresponding author was responsible for the intervention implementation, data analysis, and manuscript writing, while the other authors supervised the data analysis and manuscript writing.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the interview and participated in the research with informed consent.

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