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Assessing Cognitive Control in EFL Development: Online vs. In-Person Classes

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Abstract

In recent years, there has been increasing interest in understanding how cognitive skills influence second language acquisition. Cognitive control, a set of mental processes that include attention, inhibition, and working memory, has been shown to play a significant role in language learning. This study examines the impact of cognitive control skills on language development among adult Iranian English learners, comparing it both in online and in person settings. Forty adult EFL learners were divided into two groups and underwent a 9-week instructional period, with cognitive control skills assessed using the Attention Network Task (ANT), and two controlling measures of working memory tasks, and a Raven's IQ test. Data were analyzed using Pearson correlation, regression, and ANCOVA to determine relationships between variables. The results of the study revealed that while aspects of cognitive control like orienting and alerting do not have a significant impact on language development, the more complex, controlling aspect exhibits a positive relationship (F=4.937, p=0.033). This relationship was contingent upon controlling for differences between post-examination and primary examination of ANT results, indicating that controlling attention is a stronger predictor of language outcomes. Furthermore, the study demonstrated that the mode of instruction—online or in-person—has no significant impact on this relationship (F=0.009, p=0.925), suggesting that cognitive control operates independently of teaching mode. The study's findings suggest that educators and curriculum developers should emphasize activities targeting the controlling component of cognitive control in language learning, as this is linked to better language development. Additionally, since the mode of instruction does not significantly impact this relationship, effective language instruction can be delivered in both online and in-person settings, providing flexibility in course design.

Key Terms: Attention Network Task (ANT), Cognitive Control, EFL Learners, In-Person Instruction, Language Development, Online Instruction, Working Memory

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1. Introduction

Language learners generally exhibit different levels of performance and understanding under the same educational context, which has long triggered debates and been the focus of numerous studies (Skehan, 1989; Gardner, 1985; Dörnyei & Skehan, 2003; Robinson, 2001). Language development is a cognitive ability unique to human beings that does not exist in isolation from other cognitive and neural machinery skills (Christiansen & Chater, 2008). Studies have shown that learning languages can influence one's cognitive control skills (Sullivan et al., 2014), a phenomenon often referred to as the "bilingual advantage" in the literature (Bialystok et al., 2003). It refers to the belief that bilinguals' use of two (or more) languages, i.e., selecting one while inhibiting the other(s), promotes their executive control skills (Bialystok et al., 2004). Some behavioral evidence (Roelofs & Piai, 2011; Strijkers et al., 2011), brain imaging studies (Delnooz et al., 2013; Heim et al., 2012), and investigations of patients with brain damage (Coelho et al., 2012; Endo et al., 2013) have shown that cognitive control (CC) plays an important role in language production.

Despite these findings, there is still a need to address how cognitive control affects language learners in non-bilingual contexts, specifically among English as a Foreign Language (EFL) learners. Cognitive control has only recently started to be empirically examined in adult second language (L2) learners (Luque & Morgan-Short, 2021). The bulk of research on bilingualism and cognitive control has focused on how bilinguals manage language competition, supporting theoretical accounts that attribute a crucial role to cognitive control mechanisms in bilingualism (Luque & Morgan-Short, 2021). This study, however, aims to investigate how cognitive control skills influence language development in EFL learners, who are not fully proficient in their second language and can be considered emerging bilinguals (Luque & Morgan-Short, 2021).

The interaction between cognitive control and language learning is also evident in studies examining bilingual language processing. Research has shown that bilinguals adept at managing multiple languages exhibit modulated cognitive control in different language interactional contexts, affecting both their language comprehension and production (Smalle & Möttönen, 2023). Such findings highlight the adaptive nature of cognitive control mechanisms in response to varying linguistic demands.

One of the major challenges faced by both teachers and students in instructional settings is that, even with the same context and teaching methods, students show different degrees of language development, which might be attributed to their varied cognitive skills. While a small number of studies have examined the role of cognitive control skills in adult L2 outcomes, the findings remain inconclusive. Some research has indicated a positive relationship (Bartolotti, Marian, Schroeder, & Shook, 2011; Darcy, Mora, & Daidone, 2016; Grant, Fang, & Li, 2015; Kapa & Colombo, 2014; Linck, Kroll, & Sunderman, 2009), whereas others have not observed such associations (Linck & Weiss, 2015; Stone & Pili-Moss, 2016). Behavioral and neurocognitive studies have highlighted the role of cognitive control in different aspects of adult L2 learning, such as the lexical (Linck et al., 2009; Bartolotti et al., 2011; Grant et al., 2015), phonological (Levy et al., 2007; Darcy et al., 2016), grammatical (Kapa & Colombo, 2014), and through cognitive control training (Chen, Ma, Wu, Zhang, Fu, Lu, & Guo, 2020). However, contradictory results have emerged regarding its association with grammar acquisition (Linck & Weiss, 2015; Stone & Pili-Moss, 2016). This variation in findings might be due to the influence of different learning contexts and teaching modes on cognitive control mechanisms.

Since the outbreak of COVID-19, the prevalence of online teaching has surged, highlighting the need to study cognitive control skills in the context of online classes and compare them with in-person classes to determine through which medium of teaching cognitive control plays a more significant role in language development. Previous research, such as Ni (2013), has suggested that cognitive control skills do not significantly impact language development, but these studies have not investigated cognitive control in online learning environments. There is currently limited research on how these skills affect EFL learners' language development in varied learning environments, creating a critical gap that this study aimed to address.

Thus, this research sought to provide a model that illustrates the impact of class mode (online vs. in-person) on the relationship between cognitive control skills and language development. The results of this study can offer valuable insights into how cognitive control skills can be leveraged to enhance EFL learners' language development and inform instructional practices across both online and in-person learning environments. This study explored the extent to which cognitive control skills predict language learning success and whether different instructional modes modulate this relationship.

Concerning the above-mentioned problems, the current study aimed to fulfill the following objectives: First, to examine the impact of individuals' cognitive control skills on language development and its contributions to variance in L2 development. In other words, this study investigated cognitive control skills in the context of L2 development as a foreign language, where language learners still need to converse in their mother tongue outside the classroom context. In this study, students' cognitive control skills were assessed through attention, utilizing the Attention Network Test (ANT) (Fan, McCandliss, Sommer, Raz, & Posner, 2002), which allows for a more in-depth examination of cognitive control skills in language learners.

Second, as most studies have focused on bilingual advantage among proficient language learners who use both languages professionally, this research was conducted on learners of English who are not proficient, that is, elementary-level language learners. Thus, this study aimed to determine whether learners who have already developed cognitive control skills in their first language can transfer these skills to enhance their second language performance.

The significance of this study lies in its potential to provide valuable insights into the role of cognitive control skills in EFL learners' language development. By comparing online and in-person classes, the study identified effective instructional practices for developing these skills in different learning environments. The results could inform the design of instructional materials and teaching strategies tailored to the specific needs of EFL learners, leading to improved language proficiency and academic achievement. Additionally, the study could contribute to our understanding of the cognitive processes underlying language development and provide a foundation for future research.

2. Literature Review

2.1. Cognitive Control Skills in Language Learning

Cognitive control refers to a set of cognitive processes that include inhibition, attention, conflict monitoring, selection, updating, and task-switching (Sabourin & Vinerte, 2018). It enables individuals to regulate goal-directed behaviors and manage competing tasks, making it integral to effective language learning. Executive functioning (EF), a closely related concept, encompasses similar processes that assist in the regulation and monitoring of goal-directed behavior, particularly self-control and self-regulation (Braver, 2012; Miyake & Friedman, 2012). Motivational scaffolds have been shown to significantly enhance the use of metacognitive strategies, fostering both individual and socially-shared metacognition among EFL learners, making them critical tools in promoting cognitive engagement across varied learning contexts (Jafarigohar & Mortazavi, 2016).

Several cognitive tasks have been used to measure cognitive control, such as the Flanker Task (Eriksen & Eriksen, 1974), the Automated Continuous Performance Task (Morales et al., 2013), the Simon Task (Simon & Rudell, 1967), and the Attention Network Task (ANT) (Fan et al., 2002). The **Attention Network Task (ANT)**, in particular, investigates three distinct attention networks: alerting, orienting, and executive control (Posner & Peterson, 1990). This tool is widely used due to its ability to simultaneously assess multiple facets of attention and its proven reliability across different age groups and research contexts (Fan et al., 2002). However, one of its limitations is its complexity for individuals with attention disorders, which is less of a concern for this study since it involves healthy language learners without such disorders.

Empirical studies on cognitive control and language learning suggest mixed results. For instance, Nour, Struys, and Stengers (2019) explored how interpreting experience influences attention dynamics, finding that high proficiency in bilinguals does not necessarily correlate with improved cognitive control. Their findings highlight the role of daily language use and proficiency levels as significant factors that influence cognitive outcomes. Similarly, Boumeester et al. (2019) found that only high proficiency in more than one language significantly impacted cognitive abilities like inhibition and attention-switching, indicating a proficiency-based advantage.

Despite these findings, other research presents contradictory evidence. Studies such as Ouzia et al. (2019) suggest that emotional factors, like anxiety, may differentially affect inhibitory control in monolinguals and bilinguals, complicating the relationship between bilingualism and cognitive advantages. Luque and Morgan-Short (2021) examined the role of reactive control in L2 learners and found it to be a significant predictor of general L2 proficiency. However, the literature remains inconsistent regarding the extent to which cognitive control influences specific aspects of language development, such as grammar acquisition (Stone & Pili-Moss, 2016; Linck & Weiss, 2015).

2.2. Role of Working Memory and General Intelligence in Language Development

A considerable body of research has explored the role of working memory (WM) and general intelligence in language learning. General intelligence is most closely associated with complex reasoning and problem-solving tasks (Carroll, 1993) and is often linked to executive functions such as inhibition and cognitive flexibility (Duncan et al., 1996; Salthouse et al., 2003). Studies have shown that participants with stronger WM tend to exhibit better L2 processing by managing interference from their native language more effectively (Kroll et al., 2002). However, the exact contributions of WM to different aspects of L2 learning, such as vocabulary and phonological processing, remain a point of contention (Dempster, 1991).

2.3. Online Versus In-Person Language Instruction and Cognitive Control

The rise of online learning since the COVID-19 pandemic has led to an increased focus on how instructional mode influences cognitive and language development. While some studies suggest that online settings offer comparable or even superior outcomes to face-to-face instruction (Bourelle et al., 2016; Blake et al., 2008), others argue that the differences in engagement and interaction significantly impact language proficiency (Ni, 2013). Linck, Schwieter, and Sunderman (2020) investigated how EFs influence language control in online speech production, finding that better WM and inhibitory control predicted reduced language switch costs, a finding consistent with cognitive control theories. Despite the availability of structured pedagogical guidelines, many Iranian EFL teachers tend to deviate from the recommended practices, which highlights the gap between instructional design and its practical application, thereby influencing cognitive outcomes in different learning settings (Ganji & Khoobkhahi, 2021).

2.4. Theoretical Framework of the Study: Adaptive Control Hypothesis and Internet's Cognitive Impact

The study is grounded in the Adaptive Control Hypothesis (ACH) (Green & Abutalebi, 2013), which posits that bilinguals adapt their cognitive control processes based on the interactional context they engage in. This model emphasizes the role of language-switching behaviors in shaping cognitive control adaptations, making it relevant for studying L2 learners as emerging bilinguals. The second theoretical underpinning this study is based on the cognitive impact of internet use, which involves a complex interplay of simultaneous and successive processing skills (Vygotsky, 1978; Quigley & Blashki, 2003). Online activities such as gaming and synchronous communication have been found to alter cognitive processing speed and attention allocation, making them particularly pertinent for understanding cognitive control in language development (Johnson, 2006, Figure 1).

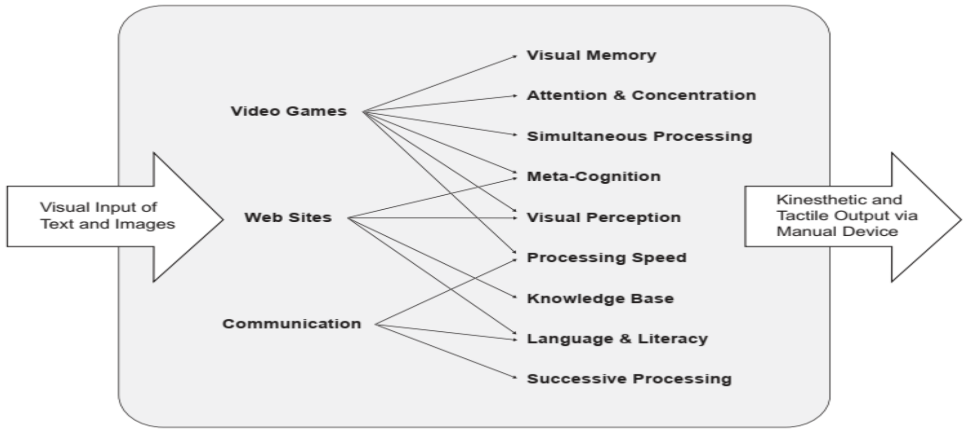


Fig.1. *A theoretical framework for organizing the effects of Internet use on cognitive processes (Adopted from Johnson, 2006)*

These frameworks guide the exploration of how distinct learning environments (online versus in-person) influence the cognitive mechanisms underpinning language development. By integrating these perspectives, the current study seeks to propose a model that accounts for both the cognitive and environmental factors affecting EFL learners.

Based on the gaps identified, the study addresses the following research questions:

1. What is the relationship between cognitive control skills and language development?
2. Do online classes have any impact on the relationship between cognitive control skills and language development?
3. Do in-person classes have any impact on the relationship between cognitive control skills and language development?
4. Is there any significant difference between the online and in-person classes regarding the relationship between cognitive control and language development?
5. What is a model for the relationship between language development and cognitive control?

2.5. Hypothetical Model of the Study

The proposed model integrates cognitive control mechanisms, class modes (online vs. in-person), and their effects on different aspects of language development. Figure 2 illustrates how the interaction between these variables influences learning outcomes.

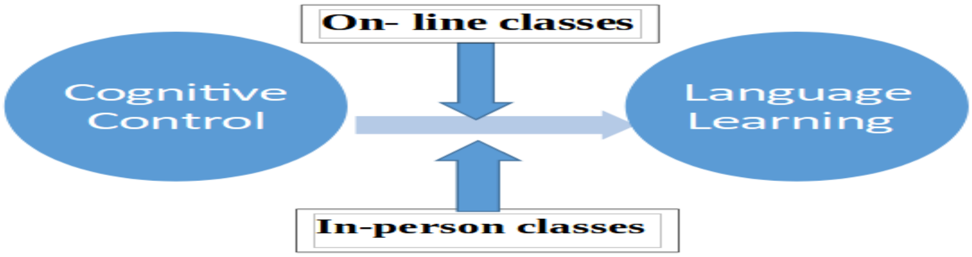


Fig.2. *Hypothetical Model of the Study*

3. Method

3.1. Study Design

The study employed a quasi-experimental design with a placement test and achievement test with two control groups setup to examine the impact of cognitive control skills on language development in EFL learners. The main reason to choose this design was to understand the causal relationship between cognitive control skill and language development. A quasi-experimental design was selected because it allows for the study of naturally occurring groups (online and in-person classes), ensuring ecological validity while maintaining a level of control over the intervention. This design is ideal for real-world educational settings where complete randomization is often not feasible due to logistical constraints. (Rogers & Revesz, 2020).

The independent variables were the instructional mode (online versus in-person) and the cognitive control skill levels (assessed through a series of tasks such as the Attention Network Test (ANT). The dependent variable was language development**,** measured using a standardized language proficiency test administered before and after the intervention.

3.2. Participants

The study involved 40 adult EFL learners, aged 18 to 30, who were beginner English learners, with comparable levels of language proficiency, randomly assigned to either the in-person or online group. Inclusion criteria required participants to be native speakers of the same language, free from any diagnosed attention disorders, and enrolled in a structured English language course. They were from similar middle-class backgrounds and had no or minimal prior English knowledge. The study employed convenience sampling, and gender was not considered a variable due to ease of participant recruitment. This approach is particularly suitable for classroom-based studies, where students are grouped based on pre-existing class assignments (online versus in-person) and random assignment is not feasible (Dörnyei, 2007). Measures were taken to ensure that differences between the groups were solely attributed to the mode of instruction.

3.2.1. Demographic Information of Participants

Group	Number of Participants	Age Range (Years)	Gender (All Female)	Proficiency Level	Average Years of Education
Online Class	20	18-30	10/10	Elementary	14
In-Person Class	20	18-30	10/10	Elementary	14

3.3. Research Instruments

Four instruments were used for the data collection: Cambridge placement test, working memory test (OSpan, RSpan, and SymSpan) (Oswald, McAbee, Redick, & Hambrick, 2015), Raven's general intelligence (IQ) test (Arthur & Day, 1994), and Attention Network Task (ANT) all with Persian instructions. With regard to ANT's construct validity, Ishigami et al. (2016) after performing ANOVA, proved that each network score was significant and independent. In terms of its criterion validity, they ran hierarchical linear regressions which revealed that both controlling scores and demographic information are strong predictors of performance of conflict resolution, verbal memory, and retrieval ($p<0.05$) (Ishigami et al., 2016). Finally, they reported that split-half correlation analyses showed that alerting, orienting, and controlling are statistically reliable in the ANT (Ishigami et al., 2016). Its internal consistency, as measured by Cronbach's alpha, typically ranges from 0.80 to 0.85, ensuring that the instrument consistently measures alerting, orienting, and executive control components.

The reliability of these tasks is supported by the high internal consistency and stability of the composite scores derived from each task. The latent variable modeling used in these studies indicates that the verbal and spatial working memory tasks are highly interrelated, sharing between 70% and 85% of their variance. (Kane et al., 2004).

The tasks have been validated using large, diverse samples, further supporting their generalizability and robustness across different populations. For example, the studies on these tasks have included over 4,885 participants, allowing for reliable model testing and validation across various demographic groups (Oswald et al., 2015).

Raven's Progressive Matrices, a widely used non-verbal measure of general intelligence, has shown excellent internal consistency, with reliability coefficients (e.g., Cronbach's alpha) ranging from 0.90 to 0.94 in adult populations (Raven et al., 2000). Its strong reliability ensures that individual differences in cognitive control and intelligence are accurately captured. The test has strong construct and criterion validity, supported by extensive empirical evidence linking performance on the matrices to general cognitive abilities, including problem-solving and abstract reasoning (Carroll, 1993). This makes it an ideal control variable to account for individual differences in cognitive abilities.

The language proficiency test used in this study was standardized, with reported reliability coefficients of 0.85 to 0.90 in prior validation studies, ensuring consistent measurement of language skills across different levels. The test has been validated through factor analysis, which confirmed its structure and the distinct dimensions of language proficiency it measures (grammar, vocabulary, and comprehension). Additionally, it shows high convergent validity, correlating strongly with other standardized language assessments (Bachman & Palmer, 1996).

3.4. Data Collection Procedure

Step 1: Obtaining Ethical Clearance and Permissions

a. Ethical clearance and permission were obtained from Fakher Language Institute to conduct the study.

Step 2: Recruitment and Participant Selection

a. A cohort of 50 newly registered female students, aged between 18 to 30 years, was initially recruited.
b. All participants provided informed consent before participating in the study.
c. From the initial cohort, 40 students with similar English proficiency levels were selected and divided into two groups (20 students each).

Step 3: Pre-Course Assessment (Day 1 and Day 2)

a. Prior to the first class session, participants underwent tests assessing working memory and general intelligence (IQ) over two consecutive days.
b. Each test lasted approximately 10-15 minutes with a five-minute break between sessions.
c. The tests were conducted in participants' native language (Farsi) to ensure accurate comprehension and performance.

Step 4: Cognitive Control Skills Assessment (Using ANT)

a. Participants' cognitive control skills were evaluated using the Attention Network Test (ANT) developed by Fan et al. (2002).
b. The ANT was administered via Inquisit 6 software, with instructions translated into Farsi for clarity.
c. Participants responded to visual stimuli presented on computers, and response times were digitally recorded.

Step 5: Course Attendance and Instructional Sessions

a. Participants attended a 20-session language course, covering various language skills over several weeks.
b. Each group (online and in-person) received the same instructional content to maintain consistency across both modes of instruction.

Step 6: Mid-Course and Post-Course Assessments

a. The ANT was administered before and after the course to assess the effects of the instructional mode on cognitive control skills.
b. Response times were analyzed, excluding any inaccurate or extreme responses to maintain data integrity.

Step 7: Monitoring Language Development

a. Throughout the course, participants completed weekly quizzes to track their progress.
b. A post-course language proficiency test was administered to measure overall development in language skills after completing the 20 sessions.

Step 8: Data Analysis and Interpretation

a. The data collected from ANT and language proficiency tests were analyzed to evaluate the impact of instructional mode on cognitive control skills and language development.

3.5. Data Analysis

First, to estimate the impact of IQ and WM on cognitive development, analysis of covariance (ANCOVA) was applied to ensure that the statistical data that came from ANT accounts only for learner's cognitive development. This is a general linear model that blends ANOVA and regression. ANCOVA evaluates whether the means of a dependent variable (DV) are equal across levels of a categorical independent variable (IV) often called a treatment, while statistically controlling for the effects of other continuous variables that are not of primary interest, known as covariates (CV) or nuisance variables. Then, in order to analyze the data obtained from the proficiency test and ANT and determine the relationship between the L2 development scores and the cognitive control measures (i.e., ANT) Pearson's correlation coefficient (linear correlation coefficient) was calculated. Next, to further examine the relationship between cognitive control and L2 development, regression analyses were applied to probe how each of the measures of cognitive control accounted for L2 development. For these regression analyses, a stepwise variable selection was applied. For each measure of cognitive control, a sequential linear regression was conducted with the L2 development composite score as the outcome variable (taken from Luque & Morgan-Short, 2021). Finally, to be able to find whether any of the two modes of teaching can have a different impact on the relationship between cognitive control and language development, a coefficient of determination known as “R2 squared” was utilized.

4. Results of the Study

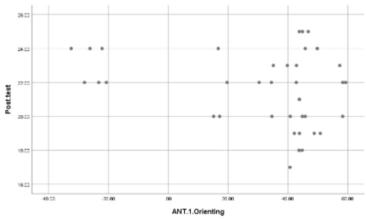
Based on the above-mentioned data analysis procedure, an analysis of between-subjects effects using a regression model was conducted to answer the posed research questions. The dependent variable in this analysis is achievement test, which is a measurement of language learners’ language development. The effects of several independent variables on this outcome were examined. The following tables show the results of the analysis, including the Type III Sum of Squares, degrees of freedom (df), mean square, F-value, and p-value (Sig.) for each variable.

One of the main questions of this study was the relation between cognitive skills and language development. As cognitive skills in this study were examined through ANT and its measures, the data analysis is also reported on the basis of these three measures of orienting, altering and controlling. Based on Table 1, there was not a statistically significant correlation between ANT.1.orienting and achievement test, score (F=1.197, p=0.282). This suggests that the level of orienting attention did not significantly impact the participants' performance on the posttest. Similarly, there was not a statistically significant correlation between ANT1.alerting and posttest score (F=0.132, p=0.719). This also indicates that the ability to alter attention did not have a significant influence on the participants' performance on the achievement test. In contrast, there was a statistically significant positive correlation between ANT1.controlling and achievement test score (F=4.937, p=0.033), which suggests that individuals with better controlling abilities had higher scores on the achievement test, indicating a positive relationship between controlling attention (the ability to inhibit distractions and manage cognitive resources) and language development. The scatter plots (Figure 3) show this relationship.

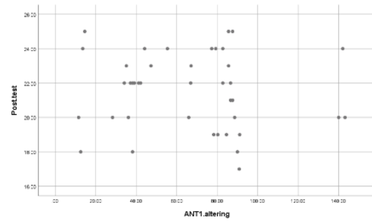
TABLE 1

Relationship Between Cognitive Control Skills and Language Development

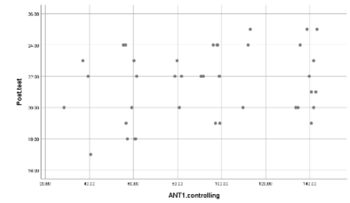
Source	***Type III sum of squares***	***Df***	***Mean Square***	***F***	***Sig.***
Corrected model	59.490[a]	7	8.5	2.09	0.07
Intercept	17.47	1	17.47	4.29	0.05
WM.reading.span	8.84	1	8.84	2.17	0.15
WM.o.span	6.78	1	6.78	1.66	0.21
WM.Sym.span	0.7	1	0.78	0.17	0.68
IQ.n	15.74	1	15.74	3.86	0.058
ANT.1.orienting	4.88	1	4.88	1.197	0.28
ANT1.alerting	0.54	1	0.54	0.132	0.719
ANT1.controlling	20.12	1	20.12	4.937	0.03
Error	130.41	32	4.75		
Total	18766	40			
Corrected Total	189.9	39			
R Squared	*0.131 (Adjusted R Squared= 0.163)*				



Pearson correlation coefficient=-0.253



Pearson correlation coefficient=-0.085



Pearson correlation coefficient=0.238

Fig 3. *Correlation scatter plots illustrating the relationship between language development and cognitive control skills*

Pearson correlation coefficients:

ANT1. Orienting: -0.253

ANT1. Alerting: -0.085

ANT1.Controlling: 0.238

These coefficients reinforce the notion that controlling attention is more relevant to language development than the other two components.

Table 2 indicates that there was a statistically significant difference in ANT2.orienting between the online and in-person classes (F=13.876, p=0.001). However, after adjusting for ANT.1.orienting, the difference was not statistically significant (F=3.556, p=0.068). This implies that the class mode may not have a significant direct impact on orienting attention after accounting for the initial level of orienting attention. It also shows that there was not a statistically significant difference in ANT2.alerting between the online and in-person classes, both before and after adjusting for ANT.1.alerting (F=0.666, p=0.420 and F=3.441, p=0.073, respectively). This indicates that the class mode did not have a significant influence on alerting attention, irrespective of its initial level. The inferential statistics for ANT2.controlling and class mode show that there was not a statistically significant difference in ANT2.controlling between the online and in-person classes, both before and after adjusting for

ANT.1.controlling (F=0.009, p=0.925 and F=0.009, p=0.925, respectively). This suggests that the class mode did not have a significant direct impact on controlling attention, regardless of the initial level of controlling attention.

TABLE 2

Class Mode Impact on ANT Components

ANT Component	Descriptive Stats (Online vs. In-person)	F (Before Adjustment)	p (Before Adjustment)	F (After Adjustment)	p (After Adjustment)	Significant Before?	Significant After?
Orienting	48.80 (SD=5.98) vs. 10.33 (SD=30.20)	13.876	0.001	3.556	0.068	Yes	No
Alerting	62.65 (SD=29.85) vs. 71.58 (SD=34.73)	0.666	0.42	3.441	0.073	No	No
Controlling	89.34 (SD=10.74) vs. 69.06 (SD=34.33)	11.548	0.002	0.009	0.925	No	No

What is worth mentioning here though, is that based on Table 2, it appears that the “WM.o.span” factor has a statistically significant effect on the dependent variable “ANT2.alerting” (p-value = 0). This means that there was a statistically significant difference between the means of the groups being compared for this factor.

TABLE 3

Descriptive Statistics for ANT2 Variables

Dependent variable	ANT. Orienting	ANT2.altering	ANT2.controlling
Class. Mode	**Mean**	**Mean**	**Mean**
In person	10.33	71.58	69.06
Online	48.8	71.58	89.33
Total	29.56	67.11	79.2
	Std. Deviation	Std. Deviation	Std. Deviation
In person	30.2	34.73	34.33
Online	5.98	29.85	10.74
Total	29.01	32.28	27.13
	N	N	N
In person	20	20	20
Online	20	20	20
Total	40	40	40

Table 3 provides means, standard deviations, and sample sizes for ANT2.Orienting, ANT2.alerting, and ANT2.controlling in both in-person and online classes. These descriptive statistics (Table 3) provide information about the central tendency (mean) and dispersion (standard deviation) of the "ANT2.controlling" scores in both in-person and online groups, as well as the combined total. The descriptive statistics for the dependent variable "ANT2.controlling" demonstrated that the mean for the "ANT2.controlling" variable in the in-person group was 69.0550, with a standard deviation of 34.33485. The mean for the "ANT2.controlling" variable in the online group was 89.3397, with a standard deviation of 10.74125. The combined mean for both groups was 79.1973, with a standard deviation of 27.13005. The descriptive statistics for the dependent variable "ANT2.alerting" showed that, as for in-person mode of instruction the mean for the "ANT2.alerting" variable was 71.5795, with a standard deviation of 34.73004. For the online group the mean for the "ANT2.alerting" variable was 62.6485, with a standard deviation of 29.85434. The combined mean for both groups was 67.1140, with a standard deviation of 32.28452.

TABLE 4

Table 4. ANCOVA for Achievement Test Scores by Class Mode and Cognitive Predictors

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	62.710[a]	8	7.839	1.911	.094
Intercept	16.490	1	16.490	4.019	.054
WM.reading.span	30.596	1	30.596	7.457	.010
WM.o.span	8.707	1	8.707	2.122	.155
WM.Sym.span	14.937	1	14.937	3.641	.066
IQ.n	19.621	1	19.621	4.782	.036
ANT.Orienting.diff	.024	1	.024	.006	.939
ANT.Alerting.diff	.088	1	.088	.022	.884
ANT.Controlling.diff	19.061	1	19.061	4.646	.039
class.mode	.892	1	.892	.218	.644
Error	127.190	31	4.103		
Total	18766.00	40			
Corrected Total	189.900	39			

a. R Squared = .330 (Adjusted R Squared = .157)

Table 4 shows the data analysis for the interactions between cognitive control skills and class mode indicates that there was not a statistically significant correlation between the interactions of cognitive control skills and class mode with the posttest score ($p>0.05$). This suggests that the combined effects of cognitive control skills and class mode did not have a significant influence on the participants' performance on the achievement test. To further explain it, it shows that there was not a statistically significant correlation between cognitive control skills difference (ANT.2-ANT.1) and achievement test score for both orienting and altering ($p>0.05$). However, there was a statistically significant negative correlation between ANT.controlling difference (ANT.controlling.2-ANT.controlling.1) and achievement test score ($p=0.039$).

4.1. Summary of the Findings and the Proposed Model

1. **Role of Controlling Attention:** The consistent positive relationship between controlling attention and language development suggests that the ability to manage attentional resources and inhibit irrelevant stimuli is crucial for language acquisition. This is supported by both the regression analysis and interaction effects, indicating a potential focus area for targeted interventions.
2. **Limited Role of Orienting and Altering Attention:** Despite the presumed importance of these subcomponents, neither orienting nor altering showed a significant impact on posttest scores. This finding suggests that general attentional shifts and the ability to respond to cues may be less critical in complex tasks like language learning.
3. **Class Mode and Cognitive Control:** The class mode did not significantly affect cognitive control abilities, with the exception of the initial differences in orienting scores. This implies that the cognitive demands of language learning may overshadow any environment-specific influences on attention.

Based on the provided information and the observed relationships between cognitive control skill and language development, the hypothetical proposed model (Figure 2) can be modified to the following path diagram (Figure 4). This model includes an intercept term to account for the baseline language development scores and an error term to capture the variability that is not explained by the model. It illustrates how working memory reading, working memory span and working memory sym are directly related with language development, just as is the learners' IQ. Despite this, as for the cognitive control skills only its controlling component is directly associated with language development and/or the aptitude to develop in language.

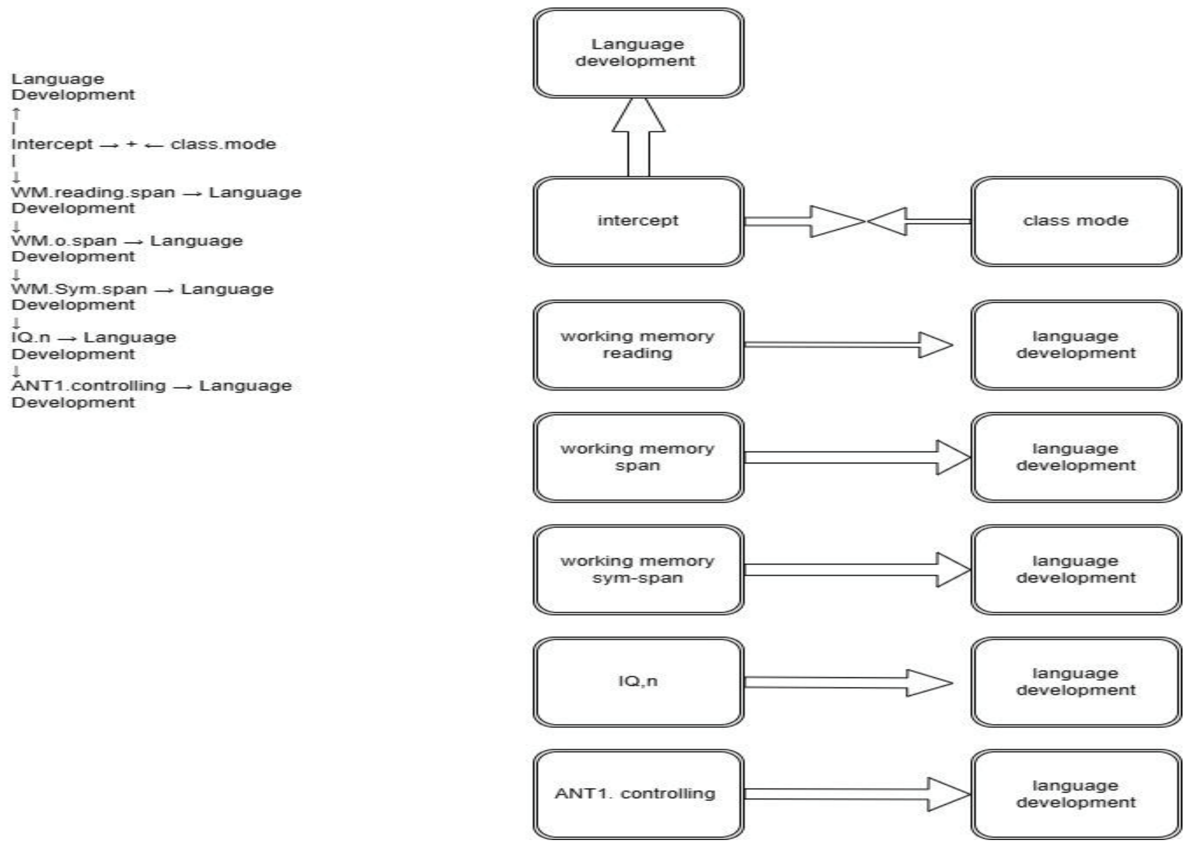


FIG. 4. *A MODEL FOR LANGUAGE DEVELOPMENT, COGNITIVE SKILLS AND LANGUAGE DEVELOPMENT*

5. Discussion

The first ANT measurement in the outset of the class showed that cognitive control has a significant positive correlation with language development as measured by the achievement test score. This result suggests that students with better ANT1.controlling skills (Attention network score in the beginning) may have higher language development abilities. The mode of the class (online vs. in-person) also had a significant impact on ANT2.orienting and ANT2.controlling (at the end of the course). Having said that, after adjusting for their respective baseline measures (that is ANT.1.orienting and ANT.1.controlling), the differences between these two class modes became non-significant.

While the interactions between ANT1.orienting, ANT1.alerting, ANT2. orienting and alerting and class mode did not show significant correlations with language development as measured by the posttest score, ANT2.controlling showed a significant difference between online and in-person classes. Still, after adjusting for ANT.1.controlling, the difference between class modes was not significant. The differences between cognitive control skills (ANT.2 - ANT.1) and achievement test score was not significant. However, there was a significant negative correlation between the ANT. controlling difference (ANT.Controlling.2 - ANT.Controlling.1) and the achievement test. Finally, the interactions between cognitive control skills and class mode were not significantly correlated with the posttest score. Thus, the result of this study revealed that there is no significant relationship between the interaction of class mode and cognitive control which shows that class mode, online or in person cannot alter one's cognitive control skills.

These results of the current study are consistent with previous literature that emphasizes the importance of cognitive control skills, particularly controlling attention, in language learning. This set of outcomes is in line with the emerging body of research that has found that young adult L2 learners' cognitive control abilities may be related to L2 learning (Bartolotti et al., 2011; Luque & Morgan-Short, 2021; Kapa & Colombo, 2014). The positive correlation between ANT1.controlling and their language development supports previous literature emphasizing the crucial role of controlling attention in language development. When students effectively control their attention, it enables them to direct their attention to relevant linguistic information, inhibit any distractions, and maintain cognitive resources for language processing (Sabourin &Vinerte , 2018). That is, strong controlling abilities can result in better language comprehension, vocabulary acquisition, and language production skills.

More generally, the positive relationship between controlling component of cognitive control skill and adult L2 proficiency is in line with previous research on relatively proficient to proficient bilinguals which suggested that cognitive control may be among the factors that enables bilinguals to functionally manage and utilize their languages (e.g., Chen et al., 2020; Hoshino & Thierry, 2012; Kang, Ma, Kroll, & Guo, 2020; Wu & Thierry, 2017). This is due to the fact that this measure of cognitive control is responsible for inhibition of previous information and makes it possible for language learners to accommodate new linguistic information.

In addition to this, the results also extend findings of a relationship between cognitive control and language development to elementary learners of a foreign language. Previous studies examined this relationship specifically on intermediate or proficient learners of an L2. In Luque and Morgan-Short's (2021) study, for instance, participants were intermediate learners. In contrast, our learners just started learning a new language or had long been away from this foreign language, and based on the result of the placement test, they were all elementary level. Thus, our results extend previous findings to a new population of L2 learners learning a new language at a new level.

Furthermore, the results of this study also support the hypothesis of inhibitory control (IC) (Green, 1998) and the Adaptive Control Hypothesis (ACH) (Green & Abutalebi, 2013) at least indirectly. According to the ACH, reactive cognitive control may allow the human mind and brain to accommodate the existence of two languages. Furthermore, the ACH argues that bilingual language control may also involve the ability to coordinate different cognitive control processes to achieve proficiency in the new language. Indeed, the results of this study suggest a role for control in developing a new language which is a more complex task than alerting and orienting. However, we did not find additional evidence for the ACH model as our results did not show a specific role for alerting and orienting cognitive control. By large, in line with previous studies, we interpret these findings as evidence that cognitive control can impact language learning for efficient L2 selection and use to take place (Luque & Morgan-Short, K. 2021).

Also, as for the class mode, the differences in ANT2.orienting and ANT2.alerting between online and in-person classes, which became non-significant after adjusting for ANT.1.orienting and ANT.1.alerting, suggest that the class mode may not have a direct impact on these specific cognitive control skills. This finding aligns with the literature indicating that cognitive control skills are relatively stable across different learning environments (Ni, 2013). In other words, this finding is consistent with literature indicating the relative stability of cognitive control skills across different learning environments.

Finally, as the final proposed model shows students' performance can differ from one to another based on their IQ, working memory and their attention. The model is in line with what Harley and Hart (1997), Kormos (2000), and Tagarelli, Borges-Mota, and Rebuschat, (2011) assert. Their research focused on investigating the role that individual differences in cognitive abilities play in L2 learning and found these factors as accounting for some of the large variability found among adults learning an L2. According to this view, attention is very closely linked to working memory, and can even be seen as a subcomponent of working memory (Montgomery et al., 2009). The proposed model of this study suggests that while working memory and IQ were only controlling variables, the results of the study confirmed the previous findings in the literature that both variables have a positive influence on language development and can contribute to overall language skills of the language learners. Plus, controlling component of the cognitive control skill.

6. Conclusion and Implications of the Study

Overall, the findings of the present study indicate that cognitive control skills, particularly controlling attention, play a more pivotal role in language development compared to orienting and alerting attention. The class mode (online vs. in-person) did not have a significant direct impact on cognitive control skills or language development outcomes. Although there was an initial difference in ANT2.Orienting between class modes, this difference became non-significant after accounting for baseline orienting attention levels (ANT1.Orienting). These results suggest that instructional settings alone cannot alter cognitive control skills significantly and, thus, may not directly influence the relationship between cognitive control and language development.

From a pedagogical perspective, these findings suggest that educators and language institutions should prioritize developing learners' cognitive control, particularly controlling attention**,** which includes the ability to inhibit distractions and maintain focus on complex linguistic tasks. Targeted interventions to strengthen this skill (e.g., cognitive training tasks) could be incorporated into language learning curricula to boost overall language proficiency. Additionally, given that the mode of teaching (in-person vs. online) did not have a significant impact on the development of language skills, teachers can use this flexibility to adapt to various teaching contexts (e.g., during remote learning or in hybrid models) without concern for diminished learning outcomes, provided that cognitive control skills are adequately supported.

The study contributes to the ongoing debate about the role of cognitive control in second language acquisition (SLA) by emphasizing that different subcomponents of attention (orienting, alerting, and controlling) may have varying degrees of relevance to language development. The observed positive impact of controlling attention but not orienting or alerting on language proficiency challenges theories that assume a uniform contribution of all cognitive control components to language learning. This finding calls for a nuanced view that differentiates between attentional subcomponents when theorizing about cognitive skills in language acquisition.

Moreover, the study supports models of cognitive control that prioritize inhibitory control and cognitive flexibility as critical factors in complex cognitive tasks such as language learning. This extends theories like the Executive Control Model in bilingualism research by highlighting controlling attention as a key determinant of language performance, rather than other attentional processes that may be more relevant in different cognitive domains.

For language institutions and educational policymakers, the study's findings indicate that investments in digital or hybrid learning platforms can be equally effective for language development as traditional in-person settings. This flexibility can reduce logistical constraints, lower operational costs, and expand access to language learning opportunities globally. However, institutions should focus on training educators to support cognitive control development through specialized tasks and classroom strategies that emphasize controlling attention.

Additionally, the study suggests that cognitive assessments (such as working memory and attention control tests) should be considered when designing language programs. Screening for these skills could help educators identify learners who may need additional support and tailor interventions to optimize individual learning outcomes.

The present study raises questions about the epistemological assumptions underlying traditional views of cognitive control in language development. While many studies treat cognitive control as a monolithic construct, the present findings challenge this notion by showing differential impacts of its subcomponents. This points to the need for more granular research that recognizes the multifaceted nature of cognitive control. Moreover, it encourages a reevaluation of how language proficiency itself is conceptualized, suggesting that control of cognitive processes may be more intertwined with language learning outcomes than previously acknowledged.

The current study is not without limitations. We tested 40 elementary adult learners. An increased sample size would make it more possible to look at more complex relationships and interactions between different aspects of cognitive control and language development. It would also be compelling to examine various proficiency levels, for different language pairs, even in interaction with different learning contexts and instructional practices. Another limitation of the present study is that language development was considered at one point in time, while it is a dynamic process that generally takes place over the years, and thus, what a year or two years of language development practice can reveal about this relationship is definitely more illuminating.

Finally, the obtained result could have changed if in the outset of the study the participants were purposefully channeled into one class or the other. As most of the students who took part in the online class from the beginning had better cognitive control skills and the difference at the end could not clearly reveal whether the class had any impact on this relation or not.

A research design to understand whether cognitive control abilities contribute to L2 development over time through a longitudinal could allow to gain more insight into the direction of the relationship between cognitive control and L2 development as well as to better understand the ways in which increased L2 exposure and different learning trajectories might modulate this relationship. This would also inform the ongoing debate regarding the cognitive consequences of bilingualism (See Bartolotti, Marian, Schroeder & Shook, 2011; Darcy, Mora, & Daidone, 2016; Grant et al., 2015; Kapa & Colombo, 2014; Linck, Kroll, & Sunderman, 2009; Linck & Weiss, 2015; Stone & Pili-Moss, 2016). Further research in this domain could benefit from an expanded sample size including diverse learner populations, including individuals with varied linguistic backgrounds, proficiency levels, and ages. Dynamic assessment methods could also be employed to capture changes in language proficiency over time, enhancing our understanding of the interplay between cognitive control and language learning outcomes.

References

Arthur Jr, W., & Day, D. V. (1994). Development of a short form for the Raven Advanced Progressive Matrices Test. *Educational and Psychological measurement*, *54*(2), 394-403.

Bachman, L. F., & Palmer, A. S. (1996). *Language Testing in Practice: Designing and Developing Useful Language Tests*. Oxford University Press.

Bartolotti, J., Marian, V., Schroeder, S. R., & Shook, A. (2011). Bilingualism and inhibitory control influence statistical learning of novel word forms. *Frontiers in psychology*, *2*, 324. https://doi.org/10.3389/fpsyg.2011.00324

Bialystok, E., Craik, F.I.M., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: Evidence from the Simon task. *Psychology and Aging*, *19*, 290–303.

Bialystok, E., Majumder, S., & Martin, M.M. (2003). Developing phonological awareness: Is there a bilingual advantage? *Applied Psycholinguistics. 24*, 27–44.

Blake, R., Wilson, N. L., Cetto, M., & Pardo-Ballester, C. (2008). Measuring oral proficiency in distance, face-to-face, and blended classrooms. *Language Learning and Technology*, *12*(3), 114-127.

Boumeester, M., Michel, M.C., & Fyndanis, V. (2019). Sequential multilingualism and cognitive abilities: Preliminary data on the contribution of language proficiency and use in different modalities. *Behavioral Sciences*, *9*(9), Article 92.

Bourelle, A., Bourellr, T., Knutson, A., & Spong, S. (2016). Sites of multimodal literacy: Comparing student learning in online and face-to-face environments. *Computers and Composition*, *39*, 55-70.

Braver, T. S. (2012). The variable nature of cognitive control: a dual mechanisms framework. *Trends in Cognitive Sciences*, *16*(2), 106-113. DOI: 10.1016/j.tics.2011.12.010

Bunting, M. F., Cowan, N., & Saults, J. S. (2006). How does running memory span work? *Quarterly Journal of Experimental Psychology*, *59*(10), 1691-1700.

Carroll, J. B. (1993). *Human Cognitive Abilities: A Survey of Factor-Analytic Studies*. Cambridge University Press.

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytic studies.* Cambridge University Press. https://doi.org/10.1017/CBO9780511571312

Chen, M., Ma, F., Wu, J., Li, S., Zhang, Z., Fu, Y., & Guo, T. (2020). Individual differences in language proficiency shape the neural plasticity of language control in bilingual language production. *Journal of Neurolinguistics, 54*, 100887. https://doi.org/10.1016/j.jneuroling.2020.100887

Chen, Y., Li, L., Wang, M. and Wang, R. (2022). Which Cognitive Factors Predict L2 Grammar Learning: Cognitive Control, Statistical Learning, Working Memory, or Attention? *Front. Psychol*. *13*, 943988. doi: 10.3389/fpsyg.2022.943988

Chenoweth, N., & Murday, K. (2003). Measuring student learning in an online French course. *Calico Journal*, *20*(2), 285-314.

Christiansen, M. H., & Chater, N. (2008). Language as shaped by the brain. *Behavioral Brain Science*, *31*, 489–509.

Coelho, C., Lê, K., Mozeiko, J., Krueger, F., & Grafman, J. (2012). Discourse production following injury to the dorsolateral prefrontal cortex. *Neuropsychologia*, *50*, 3564–3572.

Conway, A. R. A., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review*, *12*(5), 769-786.

Darcy, I., Mora, J. C., & Daidone, D. (2016). The role of inhibitory control in second language phonological processing. *Language Learning*, *66*(4), 741–773.

Dempster, F.N. (1991). Inhibitory processes: A neglected dimension of intelligence. *Intelligence*, *15*, 157-173.

Despain, J. S. (2003). Achievement and attrition rate differences between traditional and internet-based beginning Spanish courses. *Foreign Language Annals*, *36*(2), 243-257.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135-168.

Dörnyei, Z. (2007). *Research methods in applied linguistics: Quantitative, qualitative, and mixed methodologies*. Oxford University Press.

Dörnyei, Z., & Skehan, P. (2003). *Individual Differences in Second Language Learning*. In C. Doughty & M. H. Long (Eds.), *The Handbook of Second Language Acquisition* (pp. 589–630). Blackwell Publishing.

Duncan, J., Emslie, H., Williams, P., Johnson, R., & Freer, C. (1996). Intelligence and the frontal lobe: The organization of goal-directed behavior. *Cognitive Psychology*, *30*,257-303.

Endo, Y., Saito, Y., Otsuki, T., Takahashi, A., Nakata, Y., Okada, K., & Sasaki, M. (2014). Persistent verbal and behavioral deficits after resection of the left supplementary motor area in epilepsy surgery. *Brain and Development*, *36*(1), 74-79.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion*, *7*(2), Article 336.

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, *14*(3), 340-347.

Ganji, M., & Khoobkhahi, H. (2021). The correspondence between teachers' guide recommendations and actual teaching of Iranian English teachers: Vision Series in focus. *Iranian Journal of Applied Linguistics, 24*(2), 82-108. DOI: 10.18869/acadpub.ijal.24.2.82

Gardner, R. C. (1985). *Social Psychology and Second Language Learning: The Role of Attitudes and Motivation*. Edward Arnold.

Grant, A. M., Fang, S. Y., & Li, P. (2015). Second language lexical development and cognitive control: A longitudinal fMRI study. *Brain and Language*, *144*, 35–47.

Harley, B., & Hart, D. (1997). Language aptitude and second language proficiency in classroom learners of different starting ages. *Studies in Second Language Acquisition*, 379-400.

Hockly, N. (2015). Developments in online language learning. *ELT Journal*, *69*(3), 308-313. https://doi.org/10.1093/elt/ccv020

Isenberg, N. A. (2010). *A comparative study of developmental outcomes in web-based and classroom-based German language education at the post-secondary level: Vocabulary, grammar, language processing, and oral proficiency development.* (Publication no. 746773121) [Doctoral dissertation]. ProQuest Dissertation and Theses Global.

Ishigami, Y., Eskes, G., Tyndall, A., Longman, R., Drogos, L., & Poulin, M. (2016). The Attention Network Test-Interaction (ANT-I): reliability and validity in healthy older adults. *Experimental Brain Research*, *234*(3), 815-827.

Jafarigohar, M., & Mortazavi, M. (2016). Promoting metacognition in EFL classrooms through scaffolding motivation. *Iranian Journal of Applied Linguistics*, *19*(1), 1-24. DOI: 10.18869/acadpub.ijal.19.1.1

John B., C., Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytic studies.* United Kingdom: Cambridge University Press.

Johnson, G. (2006). Internet use and cognitive development: A theoretical framework. *E-Learning and Digital Media*, *3*(4), 565-573.

Kapa, L. L., & Colombo, J. (2014). Executive function predicts artificial language learning. *Journal of Memory and Language*, *76*, 237–252.

Kormos, J. (2000). The role of attention in monitoring second language speech production. *Language Learning*, *50*(2), 343-384.

Kroll, J. F., Michael, E., Tokowicz, N., & Dufour, R. (2002). The development of lexical fluency in a second language. *Second Language Research*, *18*(2), 137-171.

Lai, G., & O'Brien, B. A. (2020). Examining language switching and cognitive control through the adaptive control hypothesis. *Frontiers in Psychology*, *11*, Article 1171.

Levy, B. J., McVeigh, N. D., Marful, A., & Anderson, M. C. (2007). Inhibiting your native language: The role of retrieval-induced forgetting during second-language acquisition. *Psychological Science*, *18*(1), 29–34.

Linck, J. A., & Weiss, D. J. (2015). Can working memory and inhibitory control predict second language learning in the classroom?. *Sage Open*, *5*(4), Article 2158244015607352. https://doi.org/10.1177/2158244015607352

Linck, J. A., Kroll, J. F., & Sunderman, G. (2009). Losing access to the native language while immersed in a second language: Evidence for the role of inhibition in second-language learning. *Psychological Science*, *20*(12), 1507–1515.

Linck, J. A., Schwieter, J. W., & Sunderman, G. (2020). The differential role of executive functions in the cognitive control of language switching. *Languages*, *5*(2), Article 19.

Luque, A., & Morgan-Short, K. (2021). The relationship between cognitive control and second language proficiency. *Journal of Neurolinguistics, 57*, Article 100956.

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2009). Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies. *US Department of Education*.

Miyake, A., & Friedman, N. P. (2012). The Nature and Organization of Individual Differences in Executive Functions: Four General Conclusions. *Current Directions in Psychological Science*, *21*(1), 8–14.

Montgomery, J. W., Evans, J. L., & Gillam, R. B. (2009). Relation of auditory attention and complex sentence comprehension in children with specific language impairment: A preliminary study. *Applied Psycholinguistics*, *30*, 123-151.

Ni, A. (2013). Comparing the effectiveness of classroom and online learning: Teaching research methods. *Journal of Public Affairs Education*, *19*(2), 199-215.

Nour, S., Struys, E., & Stengers, H. (2019). Attention network in interpreters: The role of training and experience. *Behavioral Sciences*, *9*(4), Article 43.

Oswald, F. L., McAbee, S. T., Redick, T. S., & Hambrick, D. Z. (2015). The development of a short domain-general measure of working memory capacity. *Behavior Research Methods*, *47*(4), 1343-1355.

Ouzia, J., Bright, P., & Filippi, R. (2019). Attentional control in bilingualism: An exploration of the effects of trait anxiety and rumination on inhibition. *Behavioral Sciences, 9*(8), Article 89.

Petersen, S. E., & Posner, M. I. (2012). The attention system of the human brain: 20 years after. *Annual Review of Neuroscience*, *35*, 73-89.

Plomin, R. (1999). Genetics and general cognitive ability. *Nature*, *402*, C25-C29.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, 13, 25-42.

Quigley, M. & Blashki, K. (2003) Beyond the Boundaries of the Sacred Garden: children and the Internet. *Educational Technology Review*, *11*, 70-77.

Raven, J., Raven, J. C., & Court, J. H. (2000). *Manual for Raven's Progressive Matrices and Vocabulary Scales*. Oxford Psychologists Press. https://doi.org/10.1007/978-0-387-79948-3_1069

Robinson, P. (2001). *Individual Differences and Instructed Language Learning*. John Benjamins Publishing Company.

Roelofs, A., & Piai, V. (2011). Attention demands of spoken word planning: a review. *Frontiers in Psychology, 2*, Article 307.

Rogers, J., & Revesz, A. (2020). *The Routledge Handbook of Research Methods in Applied Linguistics*. Routledge.

Sabourin, L., & Vīnerte, S. (2018). Cognitive control among immersed bilinguals: Considering differences in linguistic and non-linguistic processing. *Bilingualism: Language and Cognition*, *22*(3), 590-605.

Salthouse, T. A., Atkinson, T. M., & Berish, D. E. (2003). Executive functioning as a potential mediator of age-related cognitive decline in normal adults. *Journal of experimental psychology: General*, *132*(4), 566.

Skehan, P. (1989). *Individual Differences in Second-Language Learning*. Edward Arnold Publishers.

Smalle, E. H. M., & Möttönen, R. (2023). Cognitive control in bilingual language processing: Evidence from interactional contexts. *Journal of Cognitive Neuroscience*, *35*(8), 1327-1341. doi:10.1162/jocn_a_01923

Stone, H., & Pili-Moss, D. (2015). Executive function and language learning: Differentiating vocabulary and morpho-syntax. In *Papers from the 10th Lancaster University Postgraduate Conference in Linguistics & Language Teaching 2015* (p. 53).

Strijkers, K., Yum, Y. N., Grainger, J., & Holcomb, P. J. (2011). Early goal-directed top-down influences in the production of speech. *Frontiers in Psychology*, *2*, Article 371.

Sullivan, M. D., Janus, M., Moreno, S., Astheimer, L., & Bialystok, E. (2014). Early stage second-language learning improves executive control: Evidence from ERP. *Brain and Language*,*139*, 84-98.

Tagarelli, K. M., Mota, M. B., & Rebuschat, P. (2011). The role of working memory in implicit and explicit language learning. In *Proceedings of the annual meeting of the cognitive science society* (Vol. 33, No. 33).

Vygotsky, L.S. (1978). *Mind in Society: The development of higher mental process*. Cambridge, MA: Harvard University Press.

Zhang, D., Zhao, J. L., Zhou, L., & Nunamaker, J. F. Jr. (2004). Can e-learning replace classroom learning?. *Communications of the ACM*, *47*(5), 75-79.