EFFECTS OF FORMAL TRAINING IN TRANSLATION ON WORKING MEMORY, EXECUTIVE FUNCTIONS AND LANGUAGE APTITUDE

MEHTAP GÜVEN ÇOBAN

BOĞAZİÇİ UNIVERSITY

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Mehtap Güven Çoban

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Executive Functions and Language Aptitude

The thesis of Mehtap Güven Çoban

has been approved by:

Prof. Naciye Gülcan Erçetin Koca _____
(Thesis Advisor)

Assist. Prof. Mehmet Akıncı _____
(Thesis Co-Advisor)

Prof. Belma Haznedar Keskin _____

Assoc. Prof. Şebnem Yalçın _____

Assoc. Prof. Fidel Çakmak _____
(External Member)

Assoc. Prof. Tanju Deveci _____
(External Member)

May 2025

DECLARATION OF ORIGINALITY

I, Mehtap Güven Çoban, certify that

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Signature……

Date ……...

ABSTRACT

Effects of Formal Training in Translation on Working Memory,

Executive Functions and Language Aptitude

The present study investigated the effects of formal training in translation on language aptitude (LA), working memory (WM), attention control (AC) and type of linguistic knowledge. The participants were 365 undergraduate students from Translation Studies (TS), Foreign Language Education (FLE) and Political Science (PS) departments. LA was measured through LLAMA test battery (Meara 2005). Executive Functions (EF) were measured by WM tasks including Operation Span (OSpan) and Symmetry Span (SymSpan) and AC including Flanker Squared, Simon Squared and Stroop Squared tasks. A timed grammaticality judgment test (TGJT), an untimed grammaticality judgment test (UGJT) and metalinguistic knowledge test (MKT) were administered. Results suggest that formal training in translation affects implicit learning and phonological processing (LLAMA D) and memory for novel sound-symbol associations (LLAMA E). The findings also suggest that TS students showed superior performance in metalinguistic knowledge. Principal Component Analysis (PCA) with Promax rotation revealed a three-factor solution. The cluster of the first component reflects a shared dimension of executive working memory (EWM) with high loadings from LLAMA F, SymSpan, Ospan, LLAMA B, LLAMA E and Simon. Second component captures explicit and rule-based language dimension with very high loadings from metalinguistic knowledge and explicit knowledge (composite score). The third component reflects the inhibitory control construct with loadings from Flanker, Stroop, LLAMA D and Simon with a small degree of loading.

ÖZET

Sistemli Çeviri Eğitiminin, Çalışma Belleği, Yürütücü İşlevler ve Dil Yatkınlığı Üzerindeki Etkileri

Bu çalışma, çeviri alanında edinilen sistemli eğitimin dil yatkınlığı, çalışma belleği, dikkat kontrolü ve farklı dilbilgisi türleri üzerindeki etkilerini incelemiştir. Araştırmaya Çeviribilim, Yabancı Dil Eğitimi ve Siyaset Bilimi bölümlerinden toplam 365 lisans öğrencisi katılmıştır. Dil yatkınlığı, LLAMA test bataryası aracılığıyla ölçülmüştür. Yürütücü İşlevlerden Çalışma Belleği, Operation Span ve Symmetry Span görevleri ile Dikkat Kontrolü ise Flanker Squared, Simon Squared ve Stroop Squared görevleri ile ölçülmüştür. Ek olarak, Zaman-Kısıtlı Dilbilgisel Yargı Testi, Zaman-Kısıtsız Dilbilgisel Yargı Testi ve Üstdilbilgisi Testi uygulanmıştır. Sonuçlar, çeviri alanında edinilen sistemli eğitimin örtük öğrenme ve fonolojik işlemlemeyi ve yeni ses-sembol ilişkilerinin kurulma işlemlemesinde belleği etkilediğini göstermektedir. Söz konusu bulgular ayrıca çeviribilim öğrencilerinin üstdilbilgisi açısından başarılı performans sergilediklerini ortaya koymaktadır. Promax rotasyonlu Temel Bileşen Analizi, üç faktörden oluşan bir çözüm ortaya koymuştur. Birinci bileşenin kümesi, LLAMA F, SymSpan, OSpan, LLAMA B, LLAMA E ve Simon'dan gelen yüksek yüklerle birlikte, ortak bir yürütücü çalışma belleği boyutunu göstermektedir. İkinci bileşen, metalinguistik bilgi ve açık bilgi (bileşik puan) üzerinden gelen çok yüksek yüklerle açık ve kurala dayalı bir dil boyutunu göstermektedir. Üçüncü ve son bileşen ise Flanker Stroop ve LLAMA D'den gelen yüksek yüklerle ve ek olarak Simon'dan gelen daha düşük düzeyde bir yükleme ile bir engelleyici kontrol yapısını yansıtmaktadır.

CURRICULUM VITAE

NAME: Mehtap Güven Çoban

DEGREES AWARDED
PhD in Foreign Language Education, 2025, Boğaziçi University
MA in Translation Studies, 2018, Okan University
BA in Foreign Language Education, 2003, Marmara University

AREAS OF SPECIAL INTEREST
Cognition, working memory, language acquisition, individual differences in language learning, translation studies, philosophy of language, L1 and L2 reading

PROFESSIONAL EXPERIENCE
Deputy Director, School of Foreign Languages, Istanbul 29 Mayıs University, Present
Director of International Office, Istanbul 29 Mayıs University, 2020 - Present
Deputy Director, School of Foreign Lang., Istanbul 29 Mayıs University, 2013 - 2019
Director of Continuing Education Center, Istanbul 29 Mayıs University, 2013 - Present
Director of English Preparatory Unit, Istanbul 29 Mayıs University, 2011 – Present
Vice Director of School of Foreign Languages, Yeni Yüzyıl University, 2010 – 2011
Book Translator - Babil Publish House, 2008 – 2011
Teacher Trainer in CTEFL and TESOL, Kent Language School, 2005 – Present
Director of Studies, Kent Language School, 2005 - 2010
Meeting Interpreter and Translator, Ima Textile Company, 2004 - 2005

AWARDS AND HONORS
Prof. Dr. Cem Alptekin Award - 2025

PUBLICATIONS
Journal Articles
Çoban, G. M. (2024), Yabancı Dil Eğitiminde Kalite ve Akreditasyon, Uluslararası Maarif Dergisi (pp. 39-43)

Book Chapters
Çoban, G. M. & Akıncı M. (in review). Çağdaş Dilbilim Felsefesi - History of Contemporary Linguistics. Ketebe Publication.

Çoban, G. M., & Akıncı, M. (in press). Enhancing grammatical and lexical competence in legal translation: A pedagogical framework for integrating AI-based tools. In International handbook of legal language and communication: From text to semiotics. Springer Nature.

Çoban, G. M., & Akıncı, M. (2025). Effects of Translation Practice as Consciousness-Raising on L2 Explicit, L2 Implicit, and Metalinguistic Knowledge. In Translation, Translanguaging and Machine Translation in Foreign Language Education (pp. 171-189). Cham: Springer Nature Switzerland. (SCOPUS Indexed)

Conference Proceedings
Çoban, G. M. (2018), Mobile Assisted Language Learning: Use of Mobile Applications in Vocabulary Learning. ICSES, Athens, Greece

Other Publications
Çoban, G. M. (Ongoing), Management in Foreign Language Education (Book Writing)

Çoban, G. M. Türkiye'de Zorunlu Eğitimde Yabancı Dil Öğretimi, EPAM

Translated (2013) "History of Twentieth -Century Political Thought" published by Cambridge University Press

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CHAPTER 1

INTRODUCTION

Translation Studies (TS) has emerged as a dynamic academic field established around translation and interpreting practices. Within this field, Cognitive Translation Studies (CTS) defines cognition with a set of mental processes involved in acquiring, storing, producing, manipulating, and using knowledge (Shreve & Diamond, 2016) with a specific focus on reasoning, problem-solving, attention, memory, perception and language processing (Shreve et al., 2018). Based on the literature in interpreting and translation studies, Albir and Alves (2009) outline the principal standpoints in cognitive approaches to translation. They stress that CTS primarily aims to describe the translation-specific stages, in particular related with comprehension, transfer, and production. Research in CTS emphasizes the importance of exploring the translational processes by delving into high-order cognitive operations such as memory retrieval, attention, processing, and problem-solving that regulate translation and interpreting processes.

Bilingualism, within this cognitive framework, is regarded as a distinct competence for translating and interpreting (Lörscher, 2012). Bilinguals are thought to be involved in cognitively demanding tasks while mediating between two languages. (Christoffels et al.,2003; Garrod & Pickering, 2004) with a set of overlays starting from comprehension process to final articulation.

In this vein, translation and interpreting act involve cognitively complex processes. Hurtado Albir (2017) views translation as a process that integrates textual manipulation, communication, and cognitive engagement. Albir (2017) describes translation as a cognitively demanding task, requiring the translator to comprehend a

text's meaning and then reconstruct it in another language by mobilizing cognitive and linguistic resources. Taken together, translation extends beyond linguistic boundaries; the cognitive capacities of the translator and their decision-making processes are equally influential (Rojo, 2015). Over the course of the translation and interpretation process, translators and interpreters keep their attention high on the incoming information (verbal or visual) as well as holding it in memory system (Christoffels et al.,2006; Köpke and Nespoulous, 2006; López-Gómez et al., 2007; Macnamara et al., 2014). Thus, operating at the interface of two different languages and delivering meaning across the linguistic boundaries is inherently a dynamic, fluid and interactive process which integrates language-related and extralinguistic components such as memory, use of conscious and intuitive information processing. Hammond and Cook (2023) draws attention to the translators' and interpreters' multicompetence by referring to all of the cognitive processes and mental capacities that the translators and interpreters make use of in their translation and interpreting performance. These cognitive processes and mental capacities may be associated with listening and analysis of input, memory processing and storage of both form and meaning, chunking of auditory sequences, semantic processing, planning, reconstruction and production (Gile, 2021). It may be posited that the cognitive demands of translation and interpreting processes are underpinned by distinct, albeit overlapping in certain aspects, cognitive components.

Following the growing interest in cognitive processes in CTS, scholars have turned their attention to the skills and aptitudes needed for translation and interpreting. In the subsequent years, the topic of skills required for translators and interpreters has gained increasing popularity (Blasco-Mayor, 2015; Bontempo &Napier, 2011; Liu & Pöchhacker, 2014; Russo and Salvador, 2004; Shang, 2024).

With the broader aim of defining aptitude in this domain, a substantial body of research has focused on individual differences (ID) variables so as to elucidate for the components of translation / interpretation competence (Rosiers et al., 2017). The canonical list of these ID variables consists of three main groups including (1) cognitive variables such as intelligence, learner styles, aptitude; (2) affective variables such as language anxiety, risk-taking, motivation and linguistic self-confidence; and (3) personality related variables such as ego permeability (flexibility), introversion and extraversion (Johnson, 2020).

From a cognitive standpoint, translation appears to be shaped by a constellation of factors, notably language aptitude, components of executive functioning including working memory and attention regulation, and the type of knowledge accessed during the process. First of all, it is pertinent to first explore the relevance of language aptitude in the context of translation and interpreting. As translation and interpretation are cognitively demanding tasks, they require more than bilingual proficiency. Translation and interpreting entail language comprehension, lexical access and retrieval, syntactic reformulation and semantic negotiation, some of which are higher-level processes that are underpinned by aptitude-related abilities such as phonemic coding, grammatical sensitivity and associative memory (Robinson, 2012). The efficiency and accuracy in both comprehension and restructuring phases in translation and interpreting contexts may be attributed to high language aptitude. Moreover, it has been demonstrated that aptitude interacts with WM and attention control (Li & DeKeyser, 2021; Wen et al., 2017). Secondly, WM and attentional control serve as essential cognitive factors for translation and interpreting which require concurrent processing of multiple linguistic and conceptual inputs. On the other hand, attention control aids in

maintaining cognitive resources by distinguishing task-relevant information and eliminating distractions (Miyake et al.,2000). The ability to maintain focused attention is crucial for translators and interpreters to ensure coherence and equivalence in their productions. Studies have indicated that individuals with high WM and enhanced attentional control tend to show high performance in terms of accuracy, fluency and translation strategies such as effective decision – making (Dong&Cai,2015; Timarová &Ungoed-Thomas, 2008). Such findings highlight the importance of executive functions in addressing intricate nature of bilingual processing inherent to translation and interpretation. Finally, the extent of one's linguistic knowledge, specifically in the context of L2 explicit, L2 implicit and metalinguistic knowledge, plays a fundamental role in translator and interpreter performance. L2 explicit knowledge facilitates translation in decision-making process about the analysis of form and function. On the other hand, L2 implicit knowledge functions automatically and unconsciously. It facilitates the process in reconstruction and meaning negotiation. Metalinguistic knowledge is identified as an ability for reflective analysis on language (Roehr-Brackin, 2014). These three types of knowledge operate in an integrative way during translation and interpretation. Explicit and metalinguistic knowledge facilitate and enhance accuracy and coherence whereas implicit knowledge aids in fluency in language processing (DeKeyser, 2003; Ellis, 2004). As a result, translation and interpretation performance depends on not only language proficiency, it also relies on the translators' and interpreters' explicit, implicit and metalinguistic knowledge. It is expected that depth of these knowledge is enhanced through translation as well. It may provide valuable insights to examine whether there are overlapping underlying elements among these knowledge types.

The measurement of constructs such as language aptitude, WM, attention control and linguistic knowledge continues to pose difficulties. Even though there exist established tools including LLAMA test battery (Meara, 2005), working memory tasks (Engle et al.,1999), Stroop Squared, Flanker Squared, Simon Squared (Burgoyne et al., 2023), these instruments may present certain limitations. For instance, language aptitude tests may not capture implicit elements precisely. WM measures vary in modality (Linck et al.,2014). In a similar vein, attention tasks may reflect overlapping processes. Furthermore, type of knowledge measures may lack in manifesting conceptual distinctions between different forms of knowledge (Roehr-Brackin, 2014).

Regarding the measurement of cognitive and linguistic factors in translation and interpreting studies, WM tasks - including verbal and visuospatial span tasks, and video-recorded L1-to-L2 sight translation task requiring cognitively effortful mental operations for training in simultaneous and consecutive interpreting – have been frequently employed (Agrifoglio, 2004). These instruments aim to assess performance and achievement in such areas as syntactic parsing, semantic processing, lexical access, use of unique vocabulary, ear-voice span (EVS), and delivery speed (Timarová et al., 2015).

Understanding individual differences in translation and interpretation cannot be separated from parallel advances in Second Language Acquisition (SLA). The field of SLA has evolved remarkably in the study of ID variables, particularly in relation to language aptitude. Earlier theoretical accounts of foreign language aptitude categorized it into four components: phonetic coding ability, grammatical sensitivity, memory abilities, and inductive learning ability (Carroll, 1990). Subsequent research has investigated whether language aptitude is an innate and

fixed trait (Roehr-Brackin & Tellier, 2019), or it is interrelated with learning methodology and context (Robinson, 2003; Safar & Kormos, 2008; Skehan, 2003, 2012). Other studies have explored its relationship to age (e.g., Abrahamsson & Hyltenstam, 2008; Granena & Long, 2013) intelligence (Li, 2016), and WM (Wen, 2019; Wen & Skehan, 2021). Recent studies refined foreign language aptitude by drawing more on SLA theories. To this end, Skehan (2003, 2012) proposed different components of aptitude in relation to the stages of information processing such as input processing, noticing, pattern monitor and integration. As Skehan (2012) argued, among these stages, input processing may be in connection with WM and attention control. Concurrently, pattern control may correspond to automatization, and the integration stage may be related to chunking and memory retrieval. This framework has emphasized the effects of cognitive IDs on L2 learning settings and their role in language outcomes. Within SLA research, as regards these cognitive IDs, language aptitude, WM and executive functions (EFs) have come into prominence as mediating factors (Dörnyei & Ryan, 2015; Granena & Long, 2013)

In line with these theoretical developments, research has shown that L2 learners show substantial variability in their L2 achievement. Unsworth and Engle (2007) argue that these differences may stem from a set of individual-specific features of memory systems, including active maintenance, recalling, and strategic research mechanisms. In parallel with this, Craik et al. (2018) have revealed the role of age as an influential factor on EFs, particularly in older adults as related with regression in retrieval from episodic and semantic memory. Correspondingly, Dörnyei and Skehan (2003) have made a case for reconceptualization of IDs from a more comprehensive point of view with an integrated approach to manifest

interrelations between cognitive processing models and instructional perspectives with support of empirical evidence.

Building on this foundation, methodological approaches in CTS have evolved over time. Early research predominantly relied on think-aloud protocols (TAPs) (Alves, 2015). Adopting a linear perspective, these studies are mostly based on eliciting information from the translators and interpreters about procedural details of the translation and interpretation to analyze top-down and bottom-up processes of translation. However, TAPs have been criticized for their ecological validity in capturing real-time translation behavior (Jääskeläinen & Tirkkonen, 2000). Subsequent studies demonstrated that working memory (WM) has emerged as a key focus in cognitive translation and interpreting studies (Timarová et al., 2015). WM research often employed complex span tasks combining storage and processing (Daneman & Carpenter, 1980; Engle, 2000; Engle & Kane, 2004), such as reading span and listening span. In the selection of these measures, fundamentally three criteria have been considered: (1) theoretical relevance of WM in translation and interpreting; (2) the empirical feasibility of these measures; and (3) their encompassing capacity to cover different dimensions of the translational activity (Timarová et al., 2015).

Despite the growing recognition of the cognitive dimensions of translation and interpreting -, there is limited body of research examining the cognitive effects of formal translation training, particularly in relation to language aptitude, WM, and executive functions. What is more, extant research suffers from methodological limitations and procedural shortcomings, which leaves a notable gap in the literature. Addressing this gap, the current study aims to contribute to explore the cognitive outcomes of formal translation training by examining the interplay among WM,

language aptitude, EFs, and different types of linguistic knowledge. To this end, a battery of cognition-related instruments was administered to a sample of 365 undergraduate students of Translation Studies, Foreign Language Education, Political Science and Economics (with approximately 120 participants in each group). These instruments are LLAMA tests (version 3) (Meara, 2005) as language aptitude measure; Operation Span and Symmetry Span tasks (Foster et al.,2015) as WM measures; Stroop Squared, Flanker Squared and Simon Squared tasks (Burgoyne et al., 2023) as attention control measures; and timed grammaticality judgment test (GJT), untimed GJT, and metalinguistic knowledge tests (Ellis, 2009) as explicit and implicit knowledge measure.

CHAPTER 2

LITERATURE REVIEW

This chapter provides a detailed account of the theoretical perspectives and empirical research underpinning and guiding the present study. As a starting point, the conceptual foundations of language aptitude, WM, attention control, and type of linguistic knowledge will be discussed. Then, the measurement instruments related to these constructs will be examined in depth. Subsequently, the study will analyze how and to what extent these variables relate to translation and interpretation training. In the end, this chapter will present a summary of the reviewed literature, leading to the formulation of research questions and the corresponding hypotheses.

2.1 Language aptitude

2.1.1 Definition and nature of language aptitude

Even though language learning aptitude is presumably an intelligible construct, it remains inherently intricate. Long-established dictionary definition assumes an orthodox inclination; a capacity; natural ability to grasp and acquire knowledge of language. However, the operationalization of the construct presents considerable challenges. A widely recognized, albeit tautological, approach defines it as an individual's score on a language aptitude test such as Modern Language Aptitude Test (MLAT) (Carroll & Sapon, 1954), the Pimsleur Language Aptitude Battery (PLAB) (Pimsleur, et al., 2004) and LLAMA language aptitude test (Meara, 2005). The reason for this controversy results from the fact that it encompasses a wide range of factors affecting learning rate such as prior knowledge exposure, readiness to learn that sets the conditions for ultimate attainment (Doughty, 2014), individualistic

characteristics (Carroll, 1990; Snow, 1992). From an explanatory point of view, it may be suggested that language aptitude as a set of diverse cognitive abilities accounts for language learning rate and ultimate attainment in SLA. Scrutinizing these cognitive abilities provides us with a framework to better understand the nature of language aptitude, to develop more reliable items and tools to measure language aptitude, and to gauge an accurate focus on mental operations essential for successful foreign language learning.

A central debate in language aptitude research deals with whether it is a stable trait, or subject to change as a result of language learning experience (Safar & Kormos, 2008), age (Granena & Long, 2013), and other individual differences such as motivation (Dörnyei, 2010), anxiety (Alamer & Lee, 2024). In line with these studies, a more comprehensive ground has been proposed for language aptitude signaling for a componential structure (Carroll, 1990; Robinson, 2003; Snow, 1992; Skehan, 2012, 2015a, 2015b).

Core components of foreign language aptitude were originally proposed by Carroll in the 1950s. His model included four primary cognitive abilities: (1) phonetic coding ability emphasizing competence to recognize, memorize and manipulate sounds; (2) grammatical sensitivity referring to conceive and analyze syntactic structures; (3) memory abilities required for vocabulary retention; and (4) inductive learning ability highlighting the capacity for rule discovery from language input without receiving explicit instruction. Carroll (1990) has suggested that although the validity of the core elements of language aptitude are valid, further studies are needed to broaden the scope of its definition. Similarly, Carroll (1990) proposed the inclusion of additional cognitive traits verbal fluency, spatial abilities, and working memory (WM) as potential predictors of L2 learning rate. Moreover,

Carroll (1990) highlighted that high-order language skills such as translation and simultaneous translation must also be encapsulated within language aptitude studies. These developments paved the way for a more nuanced conceptualization of the construct and its cognitive dimensions.

From the 1950s through 1970s, language aptitude has received a great deal of interest. Thereafter, it has gained popularity and reached an exponential increase in research and publications (Doughty &Mackey, 2021; Granena, 2013,2020; Iizuka & DeKeyser, 2024; Li 2016; Li & DeKeyser, 2021; Robinson, 2012; Skehan, 2023; Wen et al., 2019; Yalçın, Çeçen & Erçetin, 2016). At the outset, following the proposal of MLAT in 1959 (Carroll & Sapon), High-Level Language Aptitude Battery (Hi-LAB) was introduced (Doughty et al., 2007) to explore and update the predictive and explanatory power of aptitude test measures by broadening the extent. Doughty et al. (2007) have added implicit learning measures to grammatical sensitivity, and expanded rote learning ability by including long-term memory and probability, emphasizing that ability for a rapid access and retrieval of stored information from long-term memory.

Among other language aptitude tests developed beyond the MLAT and PLAB, LLAMA language aptitude tests (Meara, 2005) have attracted attention in recent years, largely due to their online accessibility and easy-to-use administration. LLAMA is a language neutral test and primarily focuses on pattern recognition, memory, phonetic abilities and inductive learning. Its psychometric properties have been examined in recent validation studies. (Bokander & Bylund, 2020; Granena, 2013; Iizuka & DeKeyser, 2024).

Drawing on the points raised hitherto, it may be posited that early conceptualizations of language aptitude and psychometric measure models

substantially regard language aptitude as a stable trait that individuals manifest in different levels. Subsequent years have witnessed a shift in SLA, and it has been reflected in the research investigating language aptitude. Canale and Swain (1980) introduced the communicative competence model and attempted to incorporate language aptitude into their model as a capacity to develop language proficiency in communicative competence from grammatical, strategic, and pragmatic aspects. Additionally, strategic competence has been underlined as a significant factor influencing language aptitude models. Building on these developments, Skehan (1991) highlighted the crucial role of individual differences in SLA and put forward that language aptitude may pose potential effects on explicit and implicit learning processes. He reconceptualized language aptitude as a cognitive ability to learn a foreign language most efficiently. According to Skehan (1998), language aptitude consists of four main cognitive abilities: (a) phonemic coding ability referring to capacity to recognize, analyze and retain sounds in foreign language; (b) grammatical sensitivity accounting for learning via explicit and implicit instruction thanks to individuals' ability to understand grammatical structures and grasp their functions; (c) inductive language learning ability which matches to the competence to infer linguistic rules from the given input supporting implicit acquisitional processes; and finally (d) memory and rote learning ability underlining the capacity to masterfully store and retrieve lexical items which is significant for vocabulary acquisition and fluency development. He maintains that language aptitude substantially affects both implicit and explicit learning processes. That is to say, while high-aptitude learners are successful in both naturalistic and class settings, those with lower aptitude may need more structured and explicit instruction.

In subsequent years, Skehan (2003) integrated WM component into his language aptitude framework, suggesting that individuals with higher WM may have an enhanced capacity to process and retain linguistic input. Skehan's (2003) renewed language aptitude model aligns with the recent studies linking EFs with SLA. Overall, Skehan's approach to language aptitude is multi-componential and rooted in cognitive principles. Skehan views language aptitude as a somewhat stable trait, yet not absolutely fixed, highlighting that instructional factors, learner strategies, and WM capacity may all potentially affect the ultimate language attainment. His processing stage model consists of three phases. He firstly introduces noticing input stage which requires both WM capacity and phonemic coding ability. Then, he correspondences patterning input stage to grammatical sensitivity and inductive rule learning. And finally, he expounds the controlling input stage by proceduralization and automatization processes.

Concurrently, Robinson (2001, 2012) adds a new perspective to the language aptitude construct by defining an array of cognitive abilities related to language aptitude. This perspective advances the conceptualization of individual differences in SLA. Robinson (2007, 2012) portrays the complex nature of language aptitude with a complex configuration of interrelated abilities rather than its conception as a monolithic and fixed trait by introducing the Aptitude Complex Hypothesis (ACH). He refined language aptitude by giving rise to a more dynamic and multidimensional construct that adapts to and benefits from diverse language contexts and various learning conditions arguing that certain cognitive abilities may be enhanced through training unlike earlier theories.

In relation to the integration of WM to the language aptitude construct, Miyake and Friedman (1998) revealed that WM measure is a strong predictor of

syntactic comprehension by using English Listening Span Test (ELST) with Japanese students. They were asked to illustrate pictures to indicate the thematic roles of nouns in given sentences. In a similar vein, Robinson (2012) stresses that strong WM facilitates learners' linguistic input processing and fosters explicit and implicit learning strategies. By the same token, he points out that higher attention control enhances learners' ability to benefit from focus-on-form instruction as the ability to focus attention on linguistic input is crucial for acquiring grammatical structures. Overall, he underscores the aptitude-instruction interaction by explaining the interplay between different aptitude profiles and various types of learning settings (Robinson, 2012; Skehan, 2003). Similarly, Dekeyser (2003) introduced Explicit-Implicit Learning Hypothesis, suggesting that language aptitude plays a crucial role in explicit learning in instructional contexts while acknowledging the role of implicit learning in naturalistic acquisition.

With the rise of cognitive psychology, the 1990s and the 2000s witnessed cognitive revival of language aptitude when researchers incorporated a broader range of cognitive abilities including WM, attention, and learner strategies into the models of language aptitude (Alderson et al.,1997; DeKeyser, 2003; Doughty, 2019; Ellis, 2001; Erlam, 2005; Miyake & Friedman, 1998; Robinson, 2003, 2007, 2012; Sáfár &Kormos, 2008; Skehan, 2003, 2012; Sparks et al.,2011; Li, 2016; Wen, 2012; Wen et al., 2017;). In line with this shift, Paul Meara (2005) developed LLAMA tests, a set of computer-based, linguistically neutral aptitude tasks, primarily focusing on pattern recognition, memory, and phonetic abilities as a successor to MLAT.

With this growing interest in the cognitive and dynamic nature of language aptitude, more studies appeared investigating and enlightening different aspects of the construct. Granena and Long (2013) revealed that aptitude significantly predicted

morphosyntactic proficiency. They also reported that language aptitude compensates for the loss of implicit learning capacity, especially in adult language learners (Granena, 2013; Doughty, 2019). These recent studies conceptualize language aptitude as an innate, multi-componential ability that facilitates second language acquisition due to its cognitive functions of memory-based language processing, grammatical analysis, and phonetic coding (Granena & Long, 2013; Turker et al., 2021).

From the perspective of SLA within instructional contexts, Udry and Berthele (2021) examined how language aptitude, cognitive abilities, and affective factors contribute to success in early foreign language learning success. Applying exploratory and confirmatory factor analyses to two large datasets, they examined the latent structure of cognitive, linguistic, and affective variables in young L2 learners. Their study identified three core dimensions of learner variation: (1) a cognition/aptitude factor (concompassing language aptitude, IQ, working memory, field independence, and language of instruction), (2) an extrinsic factor (comprising external motivators such as parental and teacher support), and (3) an L2 academic emotion factor (including intrinsic motivation, language anxiety, and L2 self-concept). This three-factor model was validated across different learning contexts and target languages (French and English). Regression analyses showed that both cognitive aptitude and positive academic emotions significantly predicted L2 proficiency, whereas extrinsic motivation was negatively associated with L2 outcomes once other factors were controlled. These results underscore the interplay between cognitive and affective traits in early L2 learning and call attention to the limitations of relying on extrinsic incentives alone to foster long-term proficiency.

In another attempt to revise language aptitude from a comprehensive viewpoint, Wen (2021) refined language aptitude by proposing a Phonological/Executive (P/E) model, which places WM at the core of language aptitude. As its name suggests, the model distinguishes between two complementary components: phonological working memory (PWM) and executive working memory (EWM). With regard to PWM, it is responsible for encoding, storing, and rehearsing phonological information, and it plays a facilitative role specifically in vocabulary acquisition by means of memory retention. It is also essential for pronunciation, word recognition, and initial stages of linguistic exposure. On the other hand, EWM manages attentional control over both language input and output. It is argued that EWM conceivably supports and enhances syntactic parsing, explicit language learning, monitoring, and restructuring by regulating bilingual activation. Wen's model thus underscores the central role of both PWM and EWM in tasks exhibiting high complexity and bilingual processing such as four main skills in SLA and interpreting and translation.

Subsequent investigations were undertaken to validate earlier findings and to explore neurocognitive bases of language aptitude (Turker et al., 2021). A growing body of evidence indicates that individual differences in language aptitude may be associated with certain neuroanatomical structures. For instance, Hu et al. (2013) correlated auditory cortex with individual differences in phonetic learning. Moreover, Turker et al. (2021) associate strong language aptitude with the inferior parietal lobe. Similarly, they signal arcuate fasciculus, specifically differences in white matter tract as a strong neuroanatomical language aptitude.

Overall, there is substantial behavioral and neurocognitive evidence demonstrating the dynamic nature of aptitude. Thus, as such, recent scholarship

challenges the traditional notion that language aptitude is an unchangeable, innate trait. For instance, David Singleton (2017) critiques the long-standing assumption that aptitude remains stable and immune to training—a view rooted in the early Carrollian model. Instead, he emphasizes emerging evidence that key components, especially working memory and phonological sensitivity, are malleable and responsive to language learning experiences. Building on this foundation, more recent models have expanded the conceptualization of language aptitude by integrating cognitive constructs such as working memory, most notably through the Processing/Encoding (P/E) model. In a recent viewpoint, language aptitude has been refined by centering WM at the core through P/E model (Wen, 2021).

2.1.2 Language aptitude measures

Research into language aptitude has attracted growing attention in elaborating on the construct's nature (Bokander & Bylund, 2020; Li, 2022; Li & Zhao, 2021; Singleton, 2017; Wen et al., 2019). A substantial portion of work has predominantly addressed traditional aptitude - namely, explicit aptitude- which depends on learning experience and it is detachable from intelligence. On the other hand, the research on implicit aptitude was encouraged by the motivation to illuminate the cognitive aspects of high-level proficiency and to account for its maturational effects (; Granena & Long, 2013; Linck et al., 2013).

One of the earliest tests of language aptitude is the MLAT (Carroll-Sapon, 1959), designed for children aged 8-11. Based on Carroll's framework, it focuses on four core abilities: phonetic coding ability, grammatical sensitivity, rote learning ability, and inductive learning ability. It is made up of five subsets: (1) number learning requiring learners to learn numbers in a new language by measuring

memory; (2) phonetic script aiming to measure phonetic coding ability by requiring learners to identify sound-symbol correspondences; (3) spelling clues to measure English vocabulary and phonetic coding; (4) words in sentences to measure grammatical sensitivity through having test takers answer questions about English vocabulary, and (5) paired associates to measure rote memory. While these tests match three factors of Carroll (1959), they fail to entirely assess inductive language learning ability (Reed & Stansfield, 2023). MLAT was validated on a sample of 5,000 learners in the US. Li's (2016) meta-analysis revealed high predictive validity.

Following MLAT, Pimsleur (1966) created the PLAB for learners in grades 7-12. Initially considered as a substitute for the MLAT (Zhao et al., 2023), the PLAB incorporated Grade Points Average (GPA) and motivation into the test. Thus, it included six sub-tests, four of which directly assess language aptitude (vocabulary, language analysis, sound discrimination, and, sound-symbol association), while the rest measure GPA and motivation. It was validated on a sample of 6,000 language learners, yielding in high predictive validity (Pimsleur et al., 2004).

The tests emerging in the subsequent years were mostly grounded in contemporary SLA and cognitive psychology research (Skehan, 2015b). The majority of these tests predominantly measures explicit aptitude (Granena, 2019). Amid these developments, HI-LAB was developed in the 2000s at the University of Maryland to assess executive functions relevant to SLA. Initially, it targeted updating, inhibition, shifting, rote memory, and perceptual activity (Doughty et al., 2007). Later versions included short term memory (STM), executive capacity and control, rote memory, perceptual acuity, priming and induction consisting of explicit reasoning and serial reaction time (Doughty et al., 2019). The validation studies of Hi-LAB underlined three factors for predictive validity including implicit aptitude,

phonological short-term memory, and rote memory as key predictors (Hughes et al.,2023).

Among the modern aptitude tests designed to address practical and theoretical challenges, the LLAMA test battery (Meara, 2005) has achieved notable acceptance and application. It was developed with reference to the conceptual foundations of MLAT with the aim of enhancing reliability (Meara & Rogers, 2021; v3.2). Its free accessibility and practical administration have made them widely adopted in recent studies in language aptitude. The initial version of LLAMA test battery included five subtests: (1) LLAMA A measuring aural memory, (2) LLAMA B assessing vocabulary learning, (3) LLAMA C targeting grammatical patterns, (4) LLAMA D focusing on sound recognition, and finally (5) LLAMA E evaluating sound-symbol correspondence. Among these subtests, LLAMA A and LLAMA C were removed as they were not found to be sufficiently user-friendly. Later, LLAMA C test was revised and reintroduced as LLAMA F to measure grammatical inference (Rogers et al., 2023). Even though the rapid spread of LLAMA tests was not anticipated, they became broadly used research instruments by 2010 (Meara, 2005). This increasing popularity of LLAMA tests owe this to its cost-free availability, practicality, and the surge of renewed attention in aptitude research.

The second version (v2) of the LLAMA tests was released in 2018, making all four tests readily available on lognostics website. The latest version, LLAMA v3 currently includes LLAMA B, D, E, and F. Each of them has gone through some revisions to improve their reliability and validity. First, LLAMA B test has undergone slight changes since its inception. It has received good results from validation tests (; Bokander & Bylund, 2020; Rogers, et al. 2017). Second, LLAMA D test has seen adjustments in the words used for listening and in the scoring method

from a maximum score of 20 points to 40 points. The LLAMA E test has been revised to include a new scoring method rather than the binary forced-choice format to lower chance factor. LLAMA F, initially having binary options to assess grammatical inference, now requires test takers to construct sentences to increase scoring reliability.

2.1.3 Validation studies and limitations of LLAMA

Despite its increasing popularity, the LLAMA test battery has not undergone a comprehensive validation examination. Bokander and Bylund (2020) critically investigated its internal validity of LLAMA B, D, E, and F tests, on a sample size of 350 participants. They applied classical item analysis, Rasch (Rasch, 1960) modeling, and principal component analysis. The results revealed that only LLAMA B test indicated acceptable internal validity with good internal consistency ($\alpha = .81$) and fit the Rasch model. LLAMA D, E, and F showed low reliability with Cronbach alpha values ranging from $\alpha = .54$ to .74. Additionally, LLAMA showed a ceiling effect as explained by Bokander and Bylund (2020). It may be attributed to the predictable patterns of the test, enabling participants to develop test-wise strategies. Therefore, they recommend that LLAMA scores not be treated as a single, unified aptitude measure.

Izuka and DeKeyser (2024) further examined LLAMA D more closely in a study with participants from natural SLA settings. The findings demonstrated that LLAMA D did not correlate significantly with L2 gains, suggesting that its predictive validity for implicit learning remains questionable. Besides, Granena (2013) stated that LLAMA tests were not affected by educational background or

gender. However, Rogers et al. (2023) and Bokander and Bylund (2020) caution against its use in L1 and L2 mixed groups and young learners.

Suzuki (2021) examined the construct validity of LLAMA_D as a measure of implicit learning aptitude, employing incidental learning conditions, confidence ratings, and reaction time data. The findings indicated that performance accuracy on LLAMA_D primarily reflected explicit and conscious recall, rather than the implicit learning processes it was intended to measure. This discrepancy implies that the original version of LLAMA_D may fall short as a valid measure of implicit aptitude. The study underscores the need for revising and validating LLAMA_D to assess and enhance its effectiveness as a tool for evaluating procedural learning and fluency-related constructs.

2.1.4 Applications and cognitive interactions in SLA contexts

While concerns about the construct validity of specific LLAMA subtests remain, LLAMA tests have been widely used in SLA research. Several L2 studies have employed LLAMA to investigate the relationship between language aptitude and L2 proficiency, together with other cognitive variables such as WM and motivation. For instance, Huang, Steinkrauss, and Verspoor (2021) investigated how variability in language use predicts L2 writing proficiency by incorporating LLAMA tests. The study revealed that individual differences such as motivation, language aptitude, and WM did not significantly account for variance in either final proficiency or proficiency development. Similarly, Duman, Yalçın, and Erçetin (2021) examined the predictive power of WM and language aptitude in an L2 instructional context involving listening strategy instruction. They found that even though explicit listening strategy instruction significantly improved L2 listening comprehension,

WM or language aptitude did not emerge as significant predictors of post-instruction outcomes. Taken together, the findings suggest that in short-term, strategy-focused interventions, cognitive individual differences like WM and language aptitude may play a minimal role, highlighting the importance of instructional design over learner-based cognitive factors in such settings.

Even though language aptitude may be thought to play a limited role in strategy-dependent instructional settings, some studies highlighted its interaction with linguistic variables. With respect to the bilingual activation of two distinct languages, Bokander and Bylund (2020) examined the relationship between language aptitude and cross-linguistic influence during the early stages of L2 learning. The study provides relevance to understanding bilingual language processing dynamics as seen in translation and interpreting contexts. The study recruited 92 international learners of Swedish, whose first languages (L1s) were classified as either typologically similar (Germanic) or distant (non-Germanic). Findings showed that both language aptitude and cross-linguistic similarity significantly contributed to L2 achievement. Notably, language aptitude was a stronger predictor for learners whose L1 was more similar to Swedish. Additionally, the results underlined the importance of auditory processing ability especially in the initial stages of L2 learning. This finding aligns with theoretical claims that this component of aptitude is critical and required in early L2 language acquisition as the exposure is not rich and varied.

Expanding on the debate over whether language aptitude is a fixed trait or a malleable ability shaped by bilingual experience, Cox, Lynch, Mendes, and Zhai (2019) explored the contributions of both linguistic and nonlinguistic individual differences to bilinguals' capacity to learn additional languages. They examined how language proficiency, exposure, age of onset, and nonverbal IQ relate to various

components of language aptitude, using a sample of 80 Spanish–English bilinguals. The study revealed a positive association between balanced bilingualism, nonverbal intelligence, and language aptitude, with the strongest effects observed for grammatical inferencing skills. However, no significant associations were found between the predictor variables and aptitude for sound recognition, and age-related factors showed no influence on aptitude outcomes. These findings highlight that particular bilingual experiences and cognitive abilities may selectively contribute to the development of specific language aptitude subskills. Moreover, the study reinforces the perspective that language aptitude is both multi-componential and sensitive to contextual factors.

2.1.5 Language aptitude, translation training and practice

While much of the extant research on language aptitude has focused on general language learning, its applicability to translation and interpreting training has begun to receive growing scholarly attention. Interpreting and translating can be defined as an intricate meaning-making skill entailing a set of linguistic and cognitive abilities (Levý, Corness, & Jettmarová, 2011). Even though it is widely acknowledged that these activities require multi-faceted complex cognitive capacities, the field is still under development in terms of comprehensive theoretical perspectives (Li, et al., 2019; Pöchhacker, 2015; Setton & Dawrant, 2016;). Russo (2011) provides a historical overview of aptitude testing in interpreter selection and training, highlighting the evolution of test constructs and assessment practices. Russo (2011) focuses on key themes such as the cognitive and linguistic traits indicative of interpreting potential, appropriate testing methods, and the importance of test validity and reliability. The study highlighted that interpreting-related cognitive skills and

verbal fluency, synonymous to language production, have emerged as consistent predictors of aptitude across various studies. These findings suggest that specific linguistic abilities can be reliably measured and hold predictive value for the selection of interpreters.

In recent years, with a growing interest, more studies have been conducted concentrating on cognitive-oriented operations during translation and interpretation. These studies focus on STM and WM models (Lederer, 2012; Muñoz Martin, 2010). In efforts to define the core skills for translation and interpretation, cognitive flexibility comes into prominence due to its central function significant within executive control mechanisms (Timarová & Ungoed-Thomas, 2008). The field has also integrated IDs, including linguistic self-confidence (proficiency level) (Fraser, 2011), motivation, and language anxiety (Jiménez & Pinazo, 2001) into its frameworks on correlational studies. Concerning domain-general cognitive abilities in translation and interpretation studies, researchers of simultaneous interpreting (SI) have primarily investigated cognitive processing through listening, comprehending, planning, inferencing, and alternately activating and suppressing two languages. Rampinini, Balboni, Golestani, and Berthele (2024) demonstrate that components of language aptitude align with skills required for translation and interpretation. For instance; cognitive demands of translation entail quick parsing and restructuring at syntactic level (corresponding to grammatical sensitivity), tackling unfamiliar lexical items (corresponding to vocabulary knowledge), and memory capacity (corresponding to rote memory) to provide equivalence and reformulation. Therefore, it may be inferred that formal training or experience in translation might potentially result in enhancement of the cognitive components by means of the use of skills such as comprehending, planning utterance, alternately activating and

suppressing two languages, analyzing text and/or the speaker's goals, inferencing, conveying meaning in in real time (Macnamara et. al, 2014).

What is more, beyond cognitive measures, affective and stylistic variables from SLA have also been integrated into the field. In parallel with the existing literature in SLA, Timarová and Salaets (2014) explored the roles of learning styles, motivation, and cognitive flexibility in interpreter training, focusing on self-selection and aptitude-related factors. Timarová and Salaets (2014) addressed a gap in interpreter training research by examining non-traditional predictors of success, specifically learning styles, motivation, and cognitive flexibility. Their study compared interpreting students with non-interpreting undergraduate students using the Inventory of Learning Styles, the Achievement Motivation Test, and the Wisconsin Card Sorting Test. The findings indicated that interpreting students exhibited greater cognitive flexibility and were less affected by anxiety. These results suggest that certain cognitive and affective traits may play a role in successful interpreter training, supporting the view that aptitude for interpreting extends beyond language proficiency to include psychological and cognitive dimensions.

Adopting a causal-comparative design, Shaw (2014) explored the cognitive and motivational components of interpreting competence among interpreting students. The research included both spoken language (mainly conference) and signed language (mainly public service) interpreting students from four European institutions. Participants were classified as either entry-level or advanced based on their prior coursework in simultaneous interpreting. Using a computerized neuropsychological screening and an achievement motivation test, the study measured traits such as visual memory, concentration, and internality which characterizes self-confidence -in other words internal causes of success. The findings

revealed that spoken and signed language interpreting students differed significantly in visual memory, concentration, and internality. Furthermore, advanced students showed greater concentration and a stronger intrinsic motivation to learn new concepts compared to entry-level students. These results suggest that both cognitive traits and motivational dispositions may play an important role in interpreting aptitude, with some variation based on modality (spoken vs. signed) and experience level.

Macnamara, Moore, Kegl, and Conway (2014) examined closely whether domain-general cognitive abilities and personality traits could distinguish levels of interpreting skill among sign language interpreters. The study compared highly skilled interpreters with less skilled ones across a range of cognitive domains, including processing speed, working memory, fluid intelligence, task switching, cognitive control, and mental flexibility. It also examined personality-related variables such as risk-taking orientation, emotional-cognitive integration, and intrinsic motivation for cognitively demanding tasks. The results revealed significant differences between the groups, suggesting that a combination of cognitive and personality characteristics may underlie individual differences in interpreting competence. These findings support the idea that stable, domain-general cognitive abilities—rather than language-specific factors alone—can predict interpreting proficiency and long-term success in the field.

As a recent study on an aptitude model for translating and interpreting drawing on viewpoints from translanguaging theory, Han, Wen, Lin, and Wei (2023) conceptualize translation and interpreting as inherently translanguaging activities, through which meaning is constructed via continuous, dynamic interaction between the individual and their sociocultural environment. Building on translanguaging

theory, the authors argue that these practices involve the ongoing creation of layered "translanguaging spaces" shaped by interactional moments. Based on this perspective, they propose a comprehensive model of aptitude for translating and interpreting—the 3M model—consisting of Macro, Meso, and Micro levels. Each level encompasses interconnected factors that collectively contribute to the cognitive and sociolinguistic processes involved in meaning-making during translation and interpreting. This study provides a precious contribution to cognitive translation studies with the proposed model.

Nonetheless, there does not exist research investigating directly the effects of formal training in interpreting and translation on cognition, in particular influence of aptitude, in a comprehensive manner. The current study aims to fill this gap in the literature.

2.2 Working memory

2.2.1 Definition and nature of working memory

Research on working memory (WM) has shown that span measures of WM capacity are strong predictors of higher-order cognitive abilities such as comprehension, inferencing, problem-solving, and even general intelligence (Engle & Kane, 2004). Early theories of memory, particularly during the 1970s and 1980s were grounded in an information-processing perspective with a focus on short term memory (STM). Baddeley and Hitch (1974) focused their investigations on the conceptualization of STM and they broadened the discussions by proposing a WM model. This new WM aspect underscored the significance of immediate memory from a functional perspective by its capacity to store incoming information. Their approach aims to elaborate more on the interrelationship between the storage and processing

structures. In subsequent studies, WM is defined as a part of the holistic cognitive system which is temporarily holding and manipulating information required for complex processes such as comprehension, learning, reasoning, problem-solving and attention. In order to present a comprehensive definition for the WM construct from multiple theoretical perspectives, Baddeley (2000) proposed the multi-component model of WM. In his view, WM is regarded as a system consisting of multiple components involving a central executive, phonological loop, visuospatial sketchpad, and an episodic buffer Baddeley, 2000; Baddeley & Hitch, 1974). From a complementary perspective, Miyake and Shah (1999) view WM as a system of controlled attention that allows the active maintenance of task-relevant information in the presence of interference and distraction. By the same token, Conway, Kane and Engle (2003) put emphasis on the limited capacity feature of WM that requires the maintenance and manipulation of information in the case of any distraction that may cause mental uncertainty. In this framework, its vital role in higher-level cognition is stressed.

In a similar vein, Kane and Engle's (2002) attention control model reconceptualizes WM capacity as a competence to sustain task goals and keep attention high, resisting interference and distraction rather than simply being a storage for the given information. Their perspective accentuates on executive attention and cognitive control, arguing that high WM capacity facilitates the maintenance of task goals and suppression of irrelevant information and shifting when needed. From a different but related perspective, Cowan's (2005) Embedded-Processes Model defines WM as a part of long-term memory (LTM) system, activated by means of attention as well as providing temporary storage and manipulation of information during cognitively complex tasks. Building on earlier

theories, Engle (2018) makes a revisit to WM and executive attention subjects and rectifies earlier perspectives on the interrelations among WM capacity, executive attention and fluid intelligence. He brings forward that WM tasks predominantly involve the maintenance of information, yet fluid intelligence tasks are mostly dealing with the capacity to extricate from irrelevant information. This refined perspective underscores that as well as the vital importance of the relevant information, the suppression of irrelevant information is also pivotal for cognitive flexibility and problem-solving. Engle (2018) contends that the key determinant of individual differences in WM capacity lies in the capacity to maintain focus on task-relevant information while resisting interference from distractions. This perspective is supported by findings from paradigms such as the antisaccade task, where individuals with high-WM capacity consistently demonstrate greater resistance to reflexive attentional shifts. Although earlier studies proposed a direct link between WM capacity and fluid intelligence (Gf), more recent analyses using structural equation modeling indicate that many effects once attributed to WM capacity are more accurately explained by Gf. Engle suggests that WM capacity is primarily concerned with sustaining attention and managing ongoing cognitive representations, whereas Gf is more related to the flexible disengagement from incorrect or irrelevant information. Despite these differences, both rely on a shared executive control system, which explains their strong intercorrelation. This refined view highlights the centrality of attention regulation in cognitive performance, particularly in domains such as reasoning, comprehension, and learning.

Similarly, Burgoyne and Engle (2020) search through the crucial role of attention control in a series of cognitive tasks such as WM capacity, fluid intelligence and sensory discrimination. They mainly stress two essential functions

assisted by attention control: maintenance of relevant information and disengagement of irrelevant information. The functions are considered fundamental for the enforcement of cognitively complex tasks. For example; in WM tasks attention control helps to suppress possible interference and distractions. Correspondingly, in fluid intelligence tasks, attention control favors disregarding the irrelevant information and encourages embracement of new problem-solving strategies (Burgoyne et al., 2020). Notably, they underline the necessity and importance of creating more reliable and valid measures of attention control.

Overall, in the context of individual differences, attention control has been identified as a core mechanism underlying working memory. Rather than being a mere storage capacity, it is processing efficiency that plays a more critical role. This insight is particularly relevant to complex cognitive tasks such as language learning, translation, and interpreting.

2.2.2 Working memory measures

WM engages dynamically with other cognitive functions, forming the foundation for higher-order thinking. WM tasks are often classified as simple span and complex span tasks depending on the requirements of the tasks. Simple span tasks require solely storage whereas complex span tasks require both storage and processing (Conway et al., 2005). To exemplify, simple span tasks demand participants to store information like digits, letters, or spatial location, and recall these items either in the given order or in reverse without any synchronous processing task (Engle et al., 1999). These tasks, including digit span, letter span, and word span, principally measure STM capacity rather than the full construct of WM (Baddeley, 2000).

In contrast, complex span tasks demand participants hold information while simultaneously carrying out a processing task (Engle et al., 1999). In the operation span task, for instance, the participants solve simple mathematical equations while recalling letters (Turner & Engle, 1989). The reading span tasks require evaluating sentence plausibility while recalling the final word of each sentence (Daneman & Carpenter, 1980). In the symmetry span tasks individuals make symmetry judgments whilst recalling spatial locations (Kane et al., 2004). The rotation span tasks involve rotating given letters as mental operation, coincidentally remembering the direction of arrows (Unsworth & Engle, 2005). Overall, the tasks as noted above measure WM capacity, specifically the competence to hold and manipulate information by being exposed to cognitive load while suppressing interference (Engle et al., 1999; Miyake et al., 2000). In sum, while simple span tasks do not contain processing components, they put a lower cognitive demand as compared to complex span tasks. Whilst simple span tasks show lower real-world relevance, complex span tasks' real-world relevance is assumed to be higher.

As regards the validity and reliability of WM measures, several studies stand out and offer robust evidence. Among these studies, contributing to a reconceptualization of WM, Unsworth, Heitz, Schrock, and Engle (2005) initially reconceptualized WM compared simple span and complex span tasks. Their findings indicated that complex span tasks are strong predictors of cognitive processes, including academic attainment and reasoning. Both operation and symmetry span tasks yielded internal consistency estimates of above 0.80. They have also reported that complex span tasks had higher construct validity and predictive power when compared to simple span tasks. Furthermore, the outcomes of the study also

emphasize that partial scoring methods provide robust measurement of individual differences.

In a related study, Conway et al. (2005) also present compelling evidence concerning the validity of reading span, symmetry span, rotation span, and operation span tasks by uncovering their correlations with fluid intelligence, reasoning abilities, and language comprehension. They note high internal consistency - Cronbach's alpha values over 0.80.

Taken together, complex tasks are psychometrically robust, have a strong theoretical foundation, and are widely used in cognitive research.

2.2.3 Enhancement of cognitive processes through translation and interpreting practices

Translation and interpreting are cognitively intensive activities. Considering the critical role of working memory in accounting for individual differences in performance, it may serve as a valuable lens through which to better understand the underlying processes involved. To better understand the cognitive underpinnings of translation and interpreting, researchers often examine domain-general abilities. Among these, working memory stands out as a particularly influential construct.

During the interpretation process, interpreters constantly attend to the incoming information, concurrently holding the received information in memory. The cognitively intensive nature of interpreting has led aptitude-related research in interpreting studies to focus predominantly on working memory. However, the studies have yielded inconclusive results. Köpke and Nespoulous (2006) indicated that interpreting students had better WM capacity as compared to expert interpreters, suggesting that lengthy interpreting experience has a negative impact on WM. On the

other hand, Padilla et al. (2005), Christoffels et al. (2006) and Timarová et al. (2014) suggested that interpreters show higher performance in WM than non-interpreters. These results inform us that experience in interpretation brings a positive impact to WM. WM is considered as an essential element of SI aptitude.

Throughout the translation and interpretation process, translators and interpreters pay attention to the incoming information, being in different modalities, and output while effortfully keeping received information in memory synchronously (Cowan et al., 2005; Macnamara et al., 2014). The translator and interpreter do analyses, take decisions depending on the inferences and analyses, and use diverse cognitive abilities to manage the process (Macnamara, et al., 2014). A substantial body of research investigated whether translating and interpreting practice promotes WMC (Morales et al., 2015; Nour et al., 2020a) and what kind of changes appear in interpreting students (Dong et al., 2018). However, the findings remain somewhat inconclusive. For instance, Köpke and Nespoulous (2006) indicated that students of interpreting outperformed expert interpreters in WM tasks, concluding that the length of interpreting experience may be detrimental to WM. On the other hand, Dong et al. (2018) found that consecutive interpreting training enhances WMC. In another study, Christoffels et al., (2006) reported that interpreting students outperformed both bilingual non-interpreting students and English instructors in WM tasks including reading span, speaking span, and word span. These results demonstrate that WM capacity is a key skill improved through interpreting training and experience rather than being a sole byproduct of general bilingualism. However, it has been observed that language proficiency is a moderating variable and strong determinant of lexical task performance, including picture naming and word translation as the results of the study revealed that teachers outperformed interpreting students significantly. Another

study that serves as a bridge between translation studies and cognitive psychology, Bajo et al. (2001) suggested that translators and interpreters exhibit enhanced WM due to the nature of translating and interpreting act that requires high demands of WM including processing of input, accessing lexical and semantic knowledge, reorganizing, segmenting texts and producing output.

One of the recent meta-analyses (Ghiselli, 2022) focusing on WM tasks in interpreting studies reveals that verbal WM tasks, in particular reading and listening span, exhibit high reliability for studying cognitive advantages in translating and interpreting. Even though the findings support the interpreter advantage hypothesis, this has been seen particularly for the tasks that mimic interpreting conditions.

The observed discrepancies in the research may be attributed to several reasons. First, the narrow participant demographics may be inadequate to capture significant effects (Macnamara et al., 2014). Second, the task measures may not be appropriate in terms of validity and reliability (Macnamara et al., 2014). Third, it is suggested that the methodology followed may be insufficient in addressing the research questions (Ghiselli, 2022). Finally, a key point to consider is that performance in the real-world complex conditions is influenced by the interaction and coordination of various cognitive skills and functions. Therefore, it may be posited that existing studies may have failed to capture complex interactions that may be playing pivotal roles while limiting their analysis to direct associations between each measure and a limited population (Macnamara et al.,2014).

Taken together, this study aims to explore whether working memory, which accounts for key cognitive processes, can also serve as an explanatory factor for translation performance.

2.3 Attention

2.3.1 Nature and measures of attention control

While working memory (WM) has long been considered a key predictor in applied fields such as human factors, recent evidence suggests that WM assessments often conflate storage capacity with attentional regulation, obscuring the true cognitive mechanisms at play. Attention control (AC) is recognized as a domain-general capacity and an essential executive function that constitutes the basis of WM and fluid intelligence (Burgoyne & Engle, 2020; Shipstead et al., 2016). In parallel, recent developments in cognitive psychology increasingly emphasize AC as a core determinant of performance in cognitively demanding tasks. In this context, Pak, McLaughlin, and Engle (2024) argue that AC - rather than memory storage per se - is a more accurate predictor of successful performance in complex and multitasking environments. Building on earlier work (e.g., Engle, 2002; Redick et al., 2016), the authors developed a series of streamlined "Conflict Squared" tasks (adapted versions of Stroop, Flanker, and Simon paradigms) to assess AC through the dual processes of maintaining task-relevant goals and disengaging from interference. These novel measures proved both time-efficient and psychometrically robust, predicting over 75% of the variance in multitasking outcomes, substantially more than traditional WM and earlier AC measures. Furthermore, the authors highlight the greater fairness of these tasks in applied settings, noting their reduced susceptibility to cultural or demographic biases. Taken together, the findings reinforce the importance of incorporating attention control into models of cognitive performance, particularly for designing targeted and equitable interventions in human factors domains.

Burgoyne and Engle (2020) argue that AC substantiates two separate, yet to be interdependent, functions: maintenance and engagement. Here, maintenance

accounts for being able to follow task-relevant information while disengagement explains the ability to suppress irrelevant information. Across the literature, it is noted that attention control is expounded on diverse terms. Baddeley (2000, 2012) suggests that attention control is a primary function of the central executive component, regulating to focus, divide and switch attention. Elaborating on this foundational framework, Friedman and Miyake (2004, 2012) claim that attention control is manifested in three distinct but related processes, which include inhibition, shifting, and updating.

Correspondingly, Kane and Engle (2003) define attention control as the cognitive capacity to sustain focus on goal-relevant information while filtering out distractions and suppressing automatic responses. Examining the empirical studies as a whole, latent variable analyses establish that attention control plays a key role in accounting for the association between WM and fluid intelligence (Tsukahara et al., 2020). Collectively, these views are in parallel with the perspectives that regard attention control as a domain-general executive mechanism which accounts for a large portion of the variance of the individual differences in cognitive performance.

In a recent study, Draheim, Tshukara, and Engle (2024) replicated and extended the toolbox approach to improve the measurement of AC in IDs research. Conventional attention tasks, including the Flanker and Stroop paradigms, have been criticized for inadequate reliability and weak construct validity in capturing individual differences (Draheim et al., 2024). In response to these issues, Draheim, Tsukahara, and Engle (2024) replicated and extended the "toolbox approach," offering a refined set of tasks - such as the antisaccade, Stroop DL, and SACT - that rely on accuracy-based scoring rather than reaction time. These revised tasks demonstrated strong reliability and consistent associations with both WM and fluid

intelligence (Gf). Importantly, their analyses showed that AC completely mediated the relationship between WMC and Gf, providing compelling evidence that attention control plays a central role in sustaining task goals, resisting distraction, and updating information. Their factor analysis confirmed that attention control emerges as a distinct construct, separate from but related to WM and processing speed. Overall, these findings reinforce the theoretical significance of AC and emphasize the need for psychometrically sound measures in research on individual cognitive differences, including applications in language processing, translation, and interpreter training.

The current study aims to use Stroop, Flanker and Simon tasks to measure attention control as they are robust tools as demonstrated by Draheim et al. (2024). These classic paradigms measure selective attention and cognitive control presenting incongruent stimuli and expecting participants to inhibit automatic responses. However, these measures are believed to have poor reliability resulting from the way these measures are used as response time difference scores as the outcome measures (Burgoyne et al., 2023). As mentioned in a detailed account, in response to this problem, Burgoyne et al., 2023) developed three attention control tasks as Stroop Squared, Flanker Squared and Simon Squared. They are named as "squared" as they include additional conflict in the updated version. Each of them takes a shorter time - less than three minutes to administer. As opposed to previous versions, these tasks enhanced reliability and validity and they explain a significant portion of variance in multitasking performance.

These updated tasks exhibit good internal consistency (Cronbach's α=.95) and strong test-retest reliability (r=.67) (Burgoyne et al., 2023). From a practical

aspect, these three squared tests of attention will help the researchers save time to administer measurement of other constructs.

2.3.2 Attention control and translation training and practice

Extant literature on the cognitive effects of translating and interpreting primarily focuses on three aspects of EFs, including WM, switching and inhibition. Even though the results of the studies yield consistent outcomes concerning the cognitive benefits of translating and interpreting (Ghiselli, 2020; Mellinger & Hanson, 2019) and switching, interference and multitasking (Dong & Li, 2020), mixed results have been reported as regards cognitive advantages of translation and interpreting in inhibition tasks including Flanker, Simon, Stroop and Antisaccade tasks.

In one such study, Babcock and Vallesi (2017) present evidence supporting that interpreters show enhanced cognitive control in sustained attention. On the other hand, they could find no significant differences between interpreters and control groups in switching and inhibitory control. Another study was conducted by Timarová and Salaets (2014) investigating cognitive flexibility in interpreting students. Despite not referring directly to inhibitory regulation, cognitive flexibility was measured by the Wisconsin Card Sorting Test which requires attention shifting. The findings revealed that interpreting students exhibit better attention regulation than their non-interpreting bilingual controls. In addition, using Stroop tasks, task-switching paradigms and n-back tasks, Dong and Liu (2016) compared professional translators, professional interpreters, and monolinguals to see the effects of translating and interpreting. The findings revealed that both interpreters and translators showed higher cognitive control in switching and updating. However, there were no significant differences among the groups in the Stroop task.

Despite the increasing number of studies investigating the relationship between interpreting and translating experience and enhanced attention control, further studies are needed to explain the underlying factors and mechanisms of these cognitive advantages in diverse population demographics. As the current study includes both cognitive and linguistic measures in the investigation of translation and interpretation, the research aims to produce more comprehensive results with respect to the relationship of attention control and translation/interpretation experience.

2.4 Type of knowledge tests

Besides cognitive and linguistic factors, the present study aims to uncover the relationship between translation and interpretation experience and different types of linguistic knowledge (i.e. explicit, implicit, metalinguistic) by investigating how formal training in translation and interpreting influences learners' different types of linguistic knowledge, particularly in terms of explicit, implicit, and metalinguistic dimensions. While numerous studies in SLA have examined the roles of working memory, attention control, and language aptitude, relatively little attention has been paid to how professional language mediation—such as translation and interpreting—shapes underlying linguistic knowledge. Translation training inherently requires a high level of language awareness, reflection on grammatical structures, and metalinguistic reasoning, which may foster the development of explicit knowledge and facilitate the automatization of implicit knowledge. By addressing this underexplored intersection, the study aims to contribute to a more comprehensive understanding of how domain-specific expertise in language mediation may interact with individual differences to influence language learning outcomes.

2.4.1 Nature and measures of L2 explicit, L2 implicit and metalinguistic knowledge test

The crucial role of explicit knowledge in SLA is a topic that has been extensively studied, theorized and debated, especially within the scope of its relation to implicit knowledge. The studies have yielded differing outcomes to elucidate how these types of knowledge are acquired, processed, and accessed through language learning and practices. Rod Ellis (2004) proposes a far-reaching framework to analyze in-depth and understand the nature of L2 explicit knowledge. According to Ellis (2004), L2 explicit knowledge is inherently conscious, declarative and verbalizable about language forms and functions. It is sorted in declarative memory and accessed through controlled processing.

Ellis (2004) emphasizes that explicit and implicit knowledge are cognitively and functionally distinct. This view coincides with Paradis' (1994) non-interface hypothesis. However, Ellis acknowledges that there exists interaction between the two language systems at the performance level. Conversely, DeKeyser (2003) proposes a strong interface hypothesis, suggesting that rule-based explicit knowledge can be proceduralized into an automatized knowledge by means of sufficient amount of practice. In line with these perspectives, Schmidt's (1990) Noticing Hypothesis underscores the role of conscious attention to linguistic form. Subsequently, to address the issue of measurement of implicit and explicit L2 knowledge on an empirical study, Ellis (2005) operationalized two knowledge types based on certain central dimensions, including awareness, attention, verbalizability, and processing speed. Through a principal component analysis, he found that imitation, oral narrative, and timed GJT tasks, loaded on the implicit knowledge factor, and untimed GJT and metalinguistic tests loaded on the explicit knowledge factor. The two

components accounted for 54% of the total variance with substantial factor loadings, indicating strong construct validity. Furthermore, the internal consistency for each test was high. Cronbach's alpha was reported as .86 for the metalinguistic knowledge test, .89 for the untimed GJT, and .77 for the timed GJT, supporting the reliability of these tasks as consistent measures of explicit and implicit knowledge (Ellis, 2005).

Correspondingly, in the context of this current research, investigating the effects of translation training on cognitive functions, Ellis' (2004, 2005) framework provides a clear approach to examine whether translation practice correlates with proceduralized knowledge and/or explicit metalinguistic competence. In the following years, Ellis and Roever (2021) extend earlier work by refining the criteria for implicitness. The division of the taxonomy of their tests shows similarity to the previous tests as categorized into two classes: tests measuring implicit knowledge and tests measuring explicit knowledge. These tests differentiate from the earlier ones in respect to their focus, reaction time, and use of the metalinguistic content (Ellis & Roever, 2021). Notwithstanding, subsequent studies, Suzuki and DeKeyser (2017) revealed that these tests may measure automatized explicit knowledge rather than implicit knowledge. These discussions are crucial to this current study as it aims to explore whether formal training in translation enhances learners' automatic access to grammatical structures and/or strengths explicit metalinguistic awareness as translation and interpreting predominantly require both conscious analysis of linguistic structures and forms and procedural demands in real-time language use.

Suzuki and DeKeyser (2017) proposed that automatized explicit knowledge could serve as a developmental stage to implicit knowledge. Using structural equation modelling, they tested whether automatized explicit knowledge was a significant predictor of implicit knowledge. The results revealed that the

automatization of explicit knowledge through practice may contribute to the development of fluent and proceduralized outcomes even if such knowledge is entirely implicit in nature.

Taken together, these theoretical frameworks congregate the view that explicit knowledge plays a critical role in language development. It is deeply intertwined with attention and metalinguistic ability which are central to this thesis's investigation into the cognitive outcomes of translation practice. In light of this, the current study will utilize the timed GJT, untimed GJT and metalinguistic knowledge tests as validated measurements to assess implicit and explicit knowledge.

2.4.2 Translation practice and L2 explicit, L2 implicit and metalinguistic knowledge

Translation and interpreting naturally require the use of explicit knowledge, automatized knowledge, and metalinguistic knowledge during real-time language processing, language use and production besides other cognitive functions (Kumpulainen, 2016).

Since translation, by definition, is a multifaceted process involving the establishment of form-meaning correspondences between a source text and a target text, metalinguistic awareness can play a crucial role in this process. The existing studies, albeit few, highlight the importance and relevance of metalinguistic knowledge in translation tasks. Rojo and Valenzuela (2013) contend that most of the translation difficulties stem from not only lexical and syntactic challenges, but also due to inability to access appropriate grammatical constructions during translation. While translating, translators need to have high awareness on linguistic structures as well as semantic and pragmatic functions. Rojo and Valenzuela (2013) conducted an eye-tracking study, suggesting that translators had more fixations and regressions

while processing complex structures. They argued that linguistic complexity increases cognitive load and attention and this condition is intricately linked to metalinguistic awareness in order to translate. These mental operations during translation require an interplay between conscious and intuitive processing. These findings support that explicit, implicit and metalinguistic knowledge are essential for translators in dealing with complex linguistic structures.

Additionally, another study carried out by Halverson (2018) examines the implicit presence of metalinguistic awareness in think-aloud protocol (TAP) extensively used in early cognitive translation studies. Halverson (2018) underlines that translation act requires conscious metalinguistic monitoring and evaluation, which differentiates from other bilingual tasks. She emphasized that the unique nature of translation with its linguistic complexity, lexical richness, explicit in nature, and high reliance on metacognitive processing deserves deeper investigation within cognitive research. Moreover, Güven Çoban and Akıncı (2025) conducted a research investigating the effects of translation on L2 explicit, L2 implicit and metalinguistic knowledge. The results indicated enhancement in L2 explicit and metalinguistic knowledge.

The current study aims to shed light upon potential constructs to account for the underlying factors that regulate translation act.

2.5 Summary and research questions

Conceptualization of language aptitude has evolved throughout the years from being a fixed trait to an innate ability which may be shaped through learning exposure and practice. The investigations in language aptitude analyzes it from two primary perspectives: explicit aptitude and implicit aptitude. At the intersection of aptitude

research in SLA and cognitive translation studies lies a shared focus on individual differences, particularly in WM, attention control and affective factors, all of which are believed to play a crucial role in language processing and translation performance. While the existing aptitude literature in translation studies predominantly focuses on how aptitude, working memory and attention control influence translation performance, there remains a notable gap regarding whether and how translation experience itself impacts the development of these cognitive constructs. As regards limitations, narrow population demographics, the use of task measures that lack comprehensiveness and methodology followed in addressing research questions are given.

Attention control has been a frequent focus in both SLA research and translation and interpreting studies. Although the number of studies remains relatively limited, existing research has primarily concentrated on two core components of attention control: switching and inhibition. Due to the contradictory results in the extant literature, further empirical research involving diverse participant groups to clarify the role of attention control in language processing and interpreting performance.

As translation and interpretation inherently draws on both explicit and implicit knowledge as well as metalinguistic awareness, how and to what extent interpretation and translation is influenced by type of knowledge needs in-depth analysis. In the light of the aforementioned considerations, this study addresses the following questions:

1. What are the effects of field of study (TS, FLE, PS) and training level (novice vs advanced) on the combined outcomes of WM, LA, EFs and type of knowledge?

2. Are there overlaps between WM, LA, EFs and type of knowledge, or do these variables form distinct and independent constructs?

A main effect of field of study is expected on WM, LA, EFs and type of knowledge. TS students were hypothesized to show significantly better performance on WM, LA, EFs and type of knowledge compared to other groups (Hypothesis 1). The underlying components of translation and interpreting align with components of LA (Rampinini et. al, 2024) and formal training in translation is hypothesized to enhance LA skills including learning new words, listening for new words, sound-symbol correspondence and grammatical inference. Building on the findings reported in prior studies in WM and language aptitude in cognitive translation studies, translation and interpreting students showed better WM capacity and translating and interpreting presents cognitive advantages and enhancement in WMC (e.g. Christoffels et al., 2006; Dong et al., 2018; Ghiselli, 2022; Padilla et al., 2005; Timarová et al., 2014). Next, drawing on the results reported in existing research, depending on the findings that WM is a system which plays crucial role in controlled attention to resist distraction and interference (Miyake & Shah, 1999), the interpreting students are expected to show better performance in inhibitory control as evidenced in the previous literature (e.g. Babcock and Vallesi, 2017; Mellinger & Hanson, 2019; Zhao & Dong, 2020) compared to non-interpreting students. Then, the interpreting students are expected to show higher awareness in metalinguistic and explicit knowledge aligning with the existing literature (e.g. Halverson, 2018; Rojo &Valenzuela, 2013).

A main effect of training level was hypothesized for all measures (Hypothesis 2). It was expected that advanced learners, regardless of their academic major, would outperform novice learners across all tasks due to their prolonged engagement with

cognitively and linguistically demanding academic content. The improvement should be particularly evident in translation students, yet still observable across all groups due to the cumulative effect of academic training.

An interaction effect between field of study and training level was hypothesized for type of knowledge but not for other measures. Specifically, TS students are expected to show higher performance. However, no interaction is expected for LA, WM and EFs (Hypothesis 3). Type of knowledge—particularly explicit knowledge of linguistic rules and metalinguistic terminology—is believed to be closely tied to the nature of academic instruction and training. Translation Studies programs emphasize conscious manipulation of language**,** explicit grammar knowledge**,** and reflective use of metalinguistic terminology. Over time, TS students are exposed to formal instruction in contrastive grammar, text analysis and translation strategies which may foster development in metalinguistic and explicit language knowledge (González Davies, 2004). While FLE may include some metalinguistic instruction, it is typically less rigorous or applied in nature than in TS. PS curricula, on the other hand, are not designed to enhance linguistic or metalinguistic skills. Therefore, novice-advanced differences in type of knowledge are expected to be less pronounced in these groups. In contrast, WM, LA, and EFs are considered more domain-general cognitive abilities, which develop independently of the specific academic field. While academic training may enhance them to some extent, the enhancement is expected to be similar across fields (Miyake et al., 2000; Bialystok, 2009; Wen, 2016).

Regarding EF components, tasks measuring inhibitory control are expected to form a unified dimension independent from WM tasks relying on literature (e.g. Draheim et al., 2024) signaling attention control as a uniform construct (Hypothesis

4). Additionally, in line with the findings that literature present (e.g. Bokander and Bylund, 2020; Granena & Long, 2013; Suzuki, 2021), LLAMA B, LLAMA E and LLAMA F subtests are hypothesized to load on explicit knowledge and LLAMA D subtest to load on implicit knowledge and WM and attention tasks.

CHAPTER 3

METHODOLOGY

3.1 Participants and the context of the research

The current study was conducted at a foundation university during the academic terms 2023-2024 (fall and spring semesters) and 2024-2025 (fall semester). A total of 365 university students from the departments of Translation Studies (*n* = 119), Foreign Language Education (*n* = 122), and Political Science (*n* = 90) and Economics (*n*=35), where the medium of instruction is English. The sample consists of 210 female students (57.5 %) and 155 male students (42.5 %). All participants passed the English Preparatory Program by a minimum score of 70, which is equivalent to IELTS Academic Module score 5.5 (as validated by the university during 2013-2015). The participants were not offered any compensation to take part in the study. They were just informed briefly that they would be able to obtain information as regards their WM, attention control, language aptitude and L2 type of knowledge performance at the end of the study.

The educational background of the participants is varied. The Translation Studies program offers a wide range of courses through which the students have an opportunity to translate and interpret. These courses include interpreting practices aiming to develop competencies and skills required for interpreting with an emphasis on basic sounds and accent patterns of English; consecutive interpreting including active listening, performing multiple functions simultaneously, note-taking techniques, planning utterances, interacting with audience while managing time pressure; creative text translation enabling students to have experience in translation of words, idioms, slogans; literary translation aiming to develop practical dimensions

of various translation form such as poetry, short story, drama; sight translation to teach learners rapid text analysis in written translation. The Political Science and Economics departments and the Foreign Language Education department do not offer courses for translation and interpreting skills. The medium of instruction is delivered in English in these departments.

3.1.1 Scope and components of formal training in translation

The formal training received by students in translation programs is multifaceted, encompassing a diverse range of theoretical foundations, practical applications, and domain-specific knowledge. The curriculum is carefully structured to develop the core competencies required in both written and oral translation across various fields and modalities. Below is an overview of the scope and content of such training, as exemplified by a representative undergraduate translation studies program.

3.1.2 Core translation competencies

The curriculum includes comprehensive training in oral translation practices such as consecutive interpreting and sight translation, where students develop skills in active listening, note-taking, short-term memory, and strategic planning of target language output. Special attention is given to voice control, accurate pronunciation, and terminological precision**,** particularly in domain-specific contexts (e.g., finance, medicine, and law).

3.1.3 Specialized domain training

Students are introduced to the ethical, cultural, and operational aspects of community interpreting in public service settings through courses where they simulate real-life scenarios (e.g., hospital consultations, court hearings, and natural disaster responses).

These courses foster critical awareness of cultural mediation, interpersonal dynamics, and professional codes of conduct in high-stakes environments.

3.1.4 Simultaneous and conference interpreting

Advanced courses such as Conference Interpreting provide students with exposure to simultaneous interpreting techniques across complex domains like politics, economics, law, and medicine. Through repeated practice and critical reflection, students gain fluency in managing real-time cognitive load and delivering accurate interpretations under pressure.

3.1.5 Textual and literary translation

Formal education also addresses the textual dimensions of translation through courses like Special Field Translation, Literary Translation, and Poetry Translation, which delve into genre conventions**,** stylistic adaptation**,** textual analysis, and intercultural sensitivity. These courses develop students' ability to handle aesthetic and rhetorical challenges in translating literary texts and EU documentation (e.g., Text Translation).

3.1.6 Media and creative translation

Students gain familiarity with media translation practices in Media Translation and Press and Media Interpreting, where they explore subtitling, dubbing, live interpretation for media broadcasts, and the influence of ideology, culture, and representation. Additionally, Creative Text Translation emphasizes transcreation and cultural localization of marketing and advertising texts, enhancing students' creativity and adaptability in commercial contexts.

3.2 Instruments

In the current study, all participants took one standardized placement test to measure their proficiency level; language aptitude test (LLAMA test consisting of four subtests); to measure the EFs of the participants three combined attention control tasks (attention squared tasks) and two WM capacity tasks (Operation Span and Symmetry Span); one test to measure L2 implicit knowledge (timed grammaticality judgment (TGJT)) and two tests to measure L2 explicit knowledge (untimed grammaticality judgment test (UGJT) and metalinguistic knowledge test (MKT)).

3.2.1 Placement exam

The English Placement Test (EPT) developed by the University of Michigan (2006) was applied to measure the English proficiency level of the participants. This is a standardized test consisting of 100 questions. The test is divided into four sections as grammar and vocabulary, listening, reading and the test is administered within a fifty-minute time limit. The maximum achievable score is set to 100.

3.2.2 Language aptitude tests (LLAMAs)

The LLAMA test battery was first introduced in 2005. The present study used the version 3 (v3). It started LLAMA version 4 (v4) as of 2025. The latest version is now available on the lognostics website: www.llamatests.org.

In LLAMA v3, both LLAMA_E and LLAMA_F tests have undergone considerable changes. However, LLAMA_B test has remained unchanged as this test has already demonstrated strong validation outcomes (Bokander and Bylund, 2020; Meara and Rogers, 2019). This test requires participants to study this screen in two minutes. At the end of the study, the test automatically starts the second phase which is designed for testing vocabulary learning. In this test stage, participants are required

to identify overall 20 objects by clicking on the button that shows the name of the objects one by one. Regarding scoring, one point is awarded for each item identified accurately by the participant. Scores range between 0 and 20.

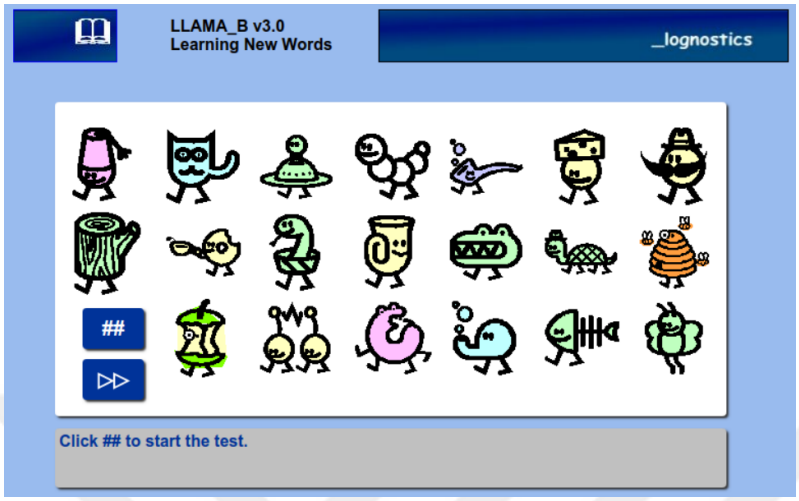


Figure 1. LLAMA B: Learning new words

The LLAMA D (v3) is designed for listening to new words. It has only one phase. It consists of 40 items. The test is based on playing sound files one at a time. The participants are expected to decide if the sound they hear is a new sound or a repeated sound. They click on the button displayed on the screen. The button is divided into two: ‘new word’ button on the left and the ‘repeated word’ button on the right. As there are 40 items in the test, scoring ranges from 0 to 40.

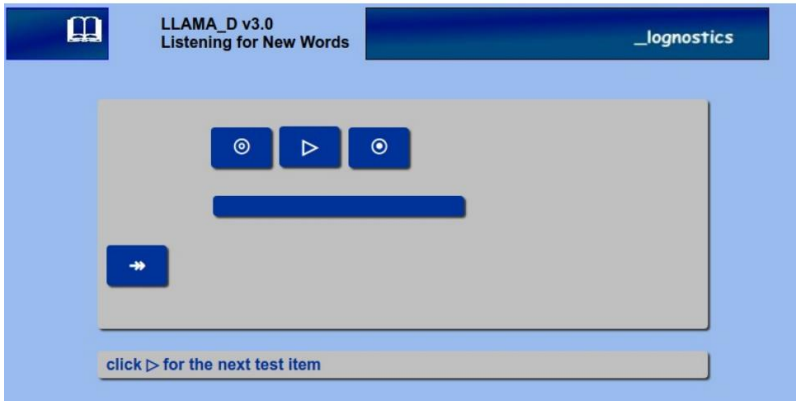


Figure 2. LLAMA D: Listening for new words

The third LLAMA E subtest is designed to assess sounds-symbol correspondence. Major changes have been made on LLAMA E. The previous studies have reported that the items in LLAMA E were said to be either very easy or difficult by the test-takers. This situation allowed participants to make predictions depending on their prior knowledge and experience in formal phonetics. The test consists of two stages. In the first stage, the participants study the material for two minutes by clicking on the buttons which play a sound file. They are expected to learn the patterns in relation to the letters shown on the screen and the sound files they hear. Then, the testing stage comes. At this stage, they are expected to click on the button, which corresponds to the sound file that they have listened to. This test contains 20 test items. Accordingly, scoring ranges between 0 and 20.

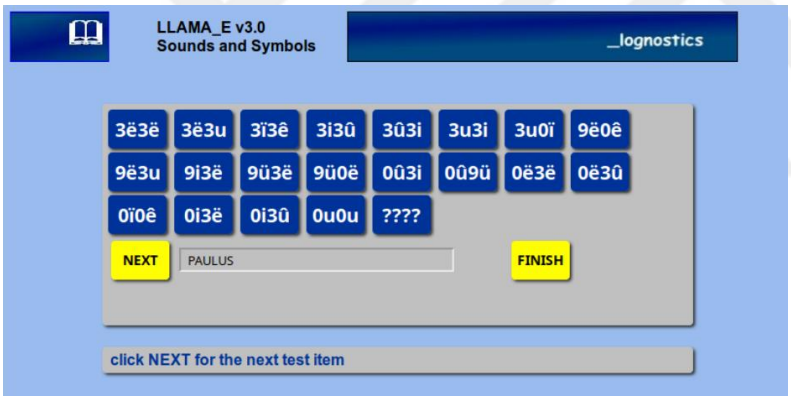


Figure 3. LLAMA E: Sounds and symbols

The fourth subtest is LLAMA F. It is designed to measure competence for grammatical inference. This test has also undergone notable changes in version 3. The test has two stages: studying the material and testing. The phase for studying takes four minutes. In the earlier versions, five minutes were given. Yet, it was revealed that additional time allowance does not affect the results (Rogers et al., 2016). The test was designed in an artificial language, PATSI, which has a small range of vocabulary with 20 words and exhibits simple morphological and syntactic

properties, (1) adjectives following nouns, (2) verb or preposition initial sentences, (3) nouns with singular markers, (4) affixes with difference forms (as in the case of grammatical gender), (5) numerals preceding the noun. The test consists of two stages: studying the grammatical rules and testing. The participants are given four minutes to study. In this stage, participants are shown pictures to study and infer grammatical features. In the earlier version, the participants were required to select from a binary choice to assess their learning. The new version requires them to construct sentences in the testing phase. Each grammatical feature is tested in equal proportion (four times). Concerning scoring, the results ranged between 10 and 20 points as the test consisted of 20 items. Each item is awarded one point.

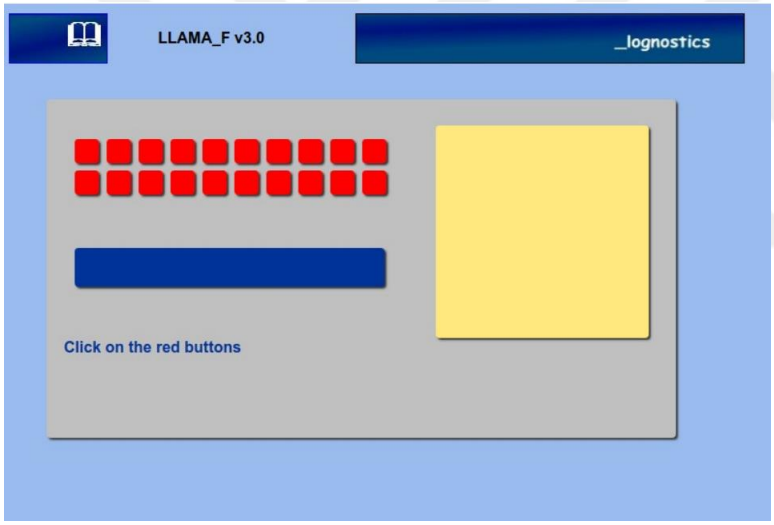


Figure 4. LLAMA F: Grammatical inference

3.2.3 WM span tasks: Operation span

Operation Span (OSpan) task evaluates WM by means of a dual-task procedure alongside with an interference (Kane et al., 2004; Unsworth et al.,2005). It starts with a trial phase. It involves solving simple mathematical equations and, in immediate sequence, viewing a letter to be remembered. The participants have three to seven cycles, ranging unpredictably within each trial. Upon the completion of each

sequence, participants are expected to remember the letters in the given order. Performance scoring is based on the partial -credit unit scoring method. It calculates the total number of the correctly remembered letters in the correct sequence (Turner & Engle, 1989). The present study used the Foster Shortened version (Foster et al., 2015) of operation span with three blocks and the standard memory set-sizes (Unsworth et al., 2005) which are the same as the standard version. The figure five shows a general design of OSpan task.

3.2.4 WM span tasks: Symmetry span

Symmetry span (SymmSpan) task (Kane et al., 2004; Unsworth et al., 2009) follows a similar methodology with OSpan. It starts with a trial phase. In a comparative manner, in the SymmSpan task, participants engage in a symmetry judgment task instead of solving simple mathematical equations. Participants are expected to decide whether the displayed shape is symmetrical (vertically) or not. It exhibits only one-way vertical symmetry. This part replaces the math problem solving stage. Then, the participants are required to recall the position of red squares placed in a 4 x 4 grid instead of memorizing the letters as in the OSpan task. The number of symmetry-location pairings changes between two and five in each trial. Scoring method depends on the calculation of the total number of the red square locations which are recalled correctly in the given order.

The present study employed The Foster Shortened version (Foster et al., 2015) which allows the researcher to select the number of the blocks to be administered. The study used SymmSpan with three blocks which is the same as the standard version with standard memory set sizes (Unsworth et al., 2005). The figure five shows a general design of SymmSpan task.

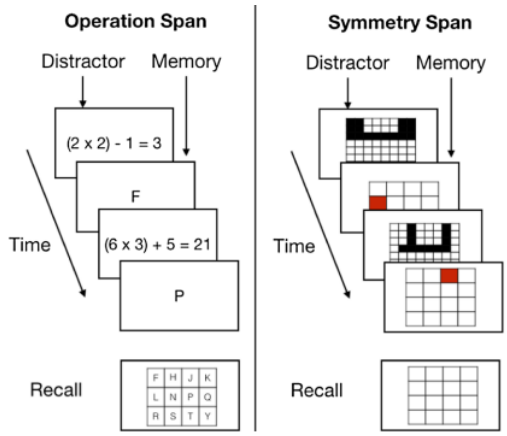


Figure 5. Working memory: Operation span and symmetry span

3.2.5 Attention control: Squared tasks

The Stroop squared, the Flanker squared and the Simon squared tasks (Burgoyne et al.,2023) were developed to provide a heightened level of conflict in the classic interference paradigms. Hence, the tasks are named as ‘squared’. These tasks were also designed to be cost-effective in terms of time. The participants are allocated 90 seconds to complete the task. Regarding scoring, each correct answer is awarded by one point. On the other hand, one point is subtracted for every incorrect response.

In the Stroop squared task, after the practice session, participants see a target stimulus located at the centre of the screen. There are two options under the stimulus. The target stimulus is the word ‘RED’ or ‘BLUE’. However, it is presented in either blue or red. Participants are required to react depending on the colour of the stimulus, not according to the word’s semantic content. Participants are required to direct their attention toward the semantic content of the word and disregard its colour. For example, if the target stimulus says ‘RED’ but written in ‘BLUE’, the response must be ‘BLUE’. Overall, participants are expected to focus simultaneously on the display colour of the target and the semantic content of the word.

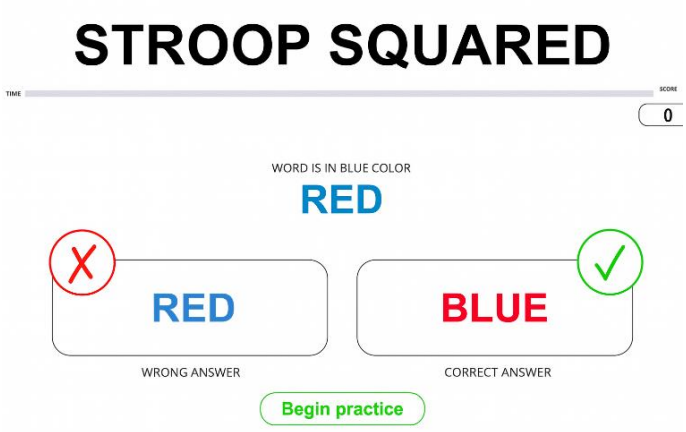


Figure 6. Attention control: Stroop squared

In the Flanker squared task, the participants start with a practice session. Similarly, the participants are presented with a target stimulus and two options under the stimulus. The structure of the target and response is made up of five-arrow sequences. Participants are required to choose the option whose central arrow is aligned with the outer arrows of the target stimulus. The primary challenge for the participants is to focus on the flanking arrows of the target and central arrow of the responses simultaneously.

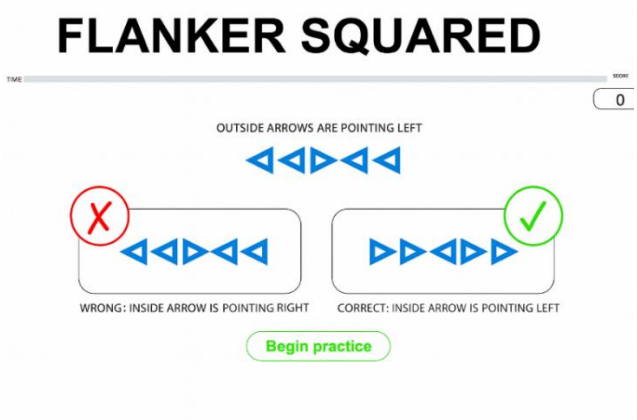


Figure 7. Attention control: Flanker squared

In the Simon squared tasks, participants first take the practice trial and then the test starts. The participants are presented with a target stimulus and two options

as in the Stroop squared and the flanker squared tasks. The target consists of a single arrow. The options below are the words ‘RIGHT’ and ‘LEFT’. Participants are expected to identify the response indicating the direction of the target arrow, meaning if the arrow is pointing left then the participant must choose the ‘LEFT’ option. Here, the critical constraint lies in allocating attention to multiple stimuli simultaneously. They are required to attend to the direction of the arrow and the semantic content of the options while suppressing attention on the target’s position.

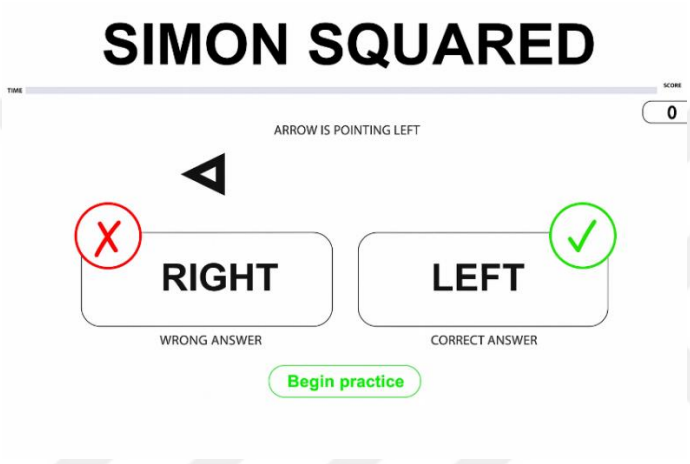


Figure 8. Attention control: Simon squared

3.2.6 Type of knowledge: L2 implicit and L2 explicit

The present study employed a timed grammaticality judgment test (TGJT) which requires metalinguistic judgment for the measurement of implicit L2 knowledge. This test was adapted from R. Ellis and colleagues (2009) and it was delivered in a computerized environment by using E-prime 3.0. The test includes 34 sentences which consist of both grammatical and ungrammatical sentences in an even distribution (17 grammatical and 17 ungrammatical items). The participants are required to decide whether the sentence displayed on the screen is grammatical or not by clicking on the response button located below the sentence in a fixed time period (7 seconds). Each correct item is awarded by one point and incorrect items or

unresponded items are scored zero. The sentences in the TGJT are presented in Appendix A.

In order to measure L2 explicit knowledge, an untimed grammaticality judgment test (UGJT) was used, which was adapted from R. Ellis and colleagues (2009). This test was also delivered in a computerized environment through E-Prime 3.0. It consists of 34 sentences equally divided between grammatical and ungrammatical sentences. The participants are expected to make a judgment as regards the grammaticality of the sentences by clicking on the response button placed below the sentence. Each correct response is awarded by one point and incorrect and blank responses receive zero points. The sentences in the TGJT are presented in Appendix B.

Metalinguistic knowledge test (MKT) was used to measure L2 explicit knowledge. This test was also adapted by R. Ellis and colleagues (2009) based on a prior measure of metalinguistic knowledge, which is a foundational instrument developed by Alderson et al. (1997). The present study used the revised version. The new version includes an open-ended question format that requires participants to provide somewhat detailed accounts for the common errors. In the first stage, participants are presented with 15 ungrammatical sentences, each of which contains one error. The error is underlined. The participants are expected to explain the errors. Interrater scoring was employed during the evaluation phase in order to ensure the reliability and objectivity of the scoring process. Utilizing more than one rater helps minimize subjective bias and allows for consistency in the assessment of participants' responses, particularly in tasks that involve qualitative judgment or open-ended items. To assess the level of agreement between the first and second raters after final scoring adjustments, Cohen's Kappa was calculated. The analysis

indicated that Kappa coefficient of $\kappa = .709$, $p < .001$. This result shows a statistically significant and substantial level of agreement between the two raters.

Concurrently with this test, participants are presented with another short task which was adapted by R. Ellis and colleagues (2009) based on earlier measures of Anderson et al. (1997). This task requires participants to read a short passage and find one example from the passage for some grammatical features indicated in the table including definite and indefinite article, verb, noun, preposition, passive verb, conditional verb, adjective, adverb, countable noun, relative pronoun, auxiliary and modal verb, past participle, conjunction, agent, comparative form, pronoun. With respect to scoring, the participants are awarded by one point for identifying the rule and 1 point for the explanation. For the second part, participants receive one point for each correctly identified grammatical feature. The tests are presented in Appendix C.

3.3 Design and procedure

In total, 365 university students were recruited for the study. Ethical approval was obtained on April 3, 2023, with decision number 2023/04-6 (See Appendix D). The data was collected from freshmen, sophomore, junior and senior groups. Freshmen and sophomore groups were classified as novice, and junior and senior groups as advance. The Political Science group consists of participants from both the Department of Political Science and the Department of Economics. The distribution of participants across departments and levels is displayed in Table 1.

Table 1. Distribution of The Participants

Department	Novice	Advanced
TS	59	60
FLE	62	60
PS	61	63

Note: Translation Studies (TS), Foreign Language Education(FLE), Political Science (PS)

Table 2 outlines the dependent variables, independent variables, covariate and the groups of participants to provide an overview of the research design. Overall, there are three groups included in the study.

Table 2. Variables

DVs	IVs	Covariate
Language Aptitude: LLAMA tests (B, D, E, F) WM: Operation Span, Symmetry Span EF: Stroop, Flanker, Simon Type of linguistic knowledge: Explicit, Implicit, Metalinguistic (Composite scores created)	Field of Study: TS, FLE, PS Training Level: Novice and Advanced	Proficiency test (L2)

Note: Translation Studies (TS), Political Science (PS), Foreign Language Education (FLE), Working Memory (WM), Executive Functions (EF), Dependent Variable (DV), Independent Variable (IV)

The present study adopted a cross-sectional design with between-subjects factors. This design is appropriate for comparing groups and investigating variable relationships without experimental manipulation. It is also well-suited to analyze group differences and the interplay of variables. As an observational and non-experimental design, the cross-sectional approach allows the comparison of performance among different participant groups – in the present context, university

students from varied academic disciplines and training levels – on cognitive and linguistic tasks.

The data collection process took 18 months. A total of 13 tests were administered in four sessions. LLAMA tests, EFs tests, TGJT and UGJT tests were delivered in a computerized environment. Other tests, proficiency and MKT, were based on a paper-and-pencil format. 10-minute time intervals were provided between WM tasks and attention control tasks. Data collection was carried out individually in a quiet room, with each participant scheduled for a separate appointment.

Consent form was obtained from all participants at the beginning of the study. They were provided with a brief explanation of the research and informed that they could withdraw from the study at any time. In the first session of data collection, EPT test was applied. The test is administered within a 50-minute time frame. It includes listening, grammar and vocabulary, reading sessions.

In the second session, the participants were given L2 implicit and L2 explicit knowledge tests. TGJT and UGJT tests are conducted in computerized environment. Counter-balancing was applied for these group tests. Each of them starts with a practice session and follows with the real test. In TGJT, a sentence appears on the screen for 7 seconds. Participants decide if the sentence is grammatically 'correct' or 'incorrect' by clicking on the buttons located below the sentence. UGJT test is designed in the same way without time pressure. MKT test is based on paper-pencil with an average 15-minute time limit. Overall, this session takes 35 minutes. To assess the internal consistency of the MKT, a reliability analysis was conducted using Cronbach's alpha. The test consisted of 34 items designed to measure participants' explicit understanding of linguistic structures. The analysis revealed a high level of internal consistency, with a Cronbach's alpha of .89, indicating that the

items reliably measured the same underlying construct (α = .89; N = 34). This suggests that the test is a reliable tool for assessing metalinguistic knowledge in the current study.

In the third session, participants took WM tasks and attention control tasks. The time interval for 10 minutes was provided in between these two, and counter-balancing was applied to avoid practice effect. Attention squared tasks have a fixed time limit. It takes 9 minutes. Each WM task takes 15 minutes, including one practice session and 3 blocks. Overall, this session takes 40 minutes.

In the fourth session, participants took LLAMA language aptitude tests, which consist of 4 distinct subtests. Counter-balancing was not applied here as it was suggested by the developers of the tests that the given order must be followed in the conduct of the tests. It starts with LLAMA D test which takes two minutes for studying the material and approximately 4 to 6 minutes for the testing phase. The second subtest is LLAMA D. This test does not provide a practice session. There is no time-limit for the test and it takes about 3 to 5 minutes depending on the participants' pacing. The third subtest is LLAMA E. The learning session takes two minutes. The testing stage takes approximately 8 minutes. The final test of this session is LLAMA F. The test phase, which followed a 4-minute learning phase, took approximately 15 minutes to administer. Counter-balancing was applied between tasks and sessions. Table 3 shows an overview of the data collection process.

Table 3. Data Collection Process

Session	Tests	Length
Session 1	EPT	50 min
Session 2	TGJT, UGJT, MKT	35 min
Session 3	WMs (Operation Span - Symmetry Span) Attention Control Tasks (Flanker Squared, Stroop Squared, Simon Squared)	40 min
Session 4	LLAMA Tests (LLAMA B, LLAMA D, LLAMA E, LLAMA F)	40 min

Note: English Proficiency Test (EPT), Timed Grammaticality Judgment Test (TGJT), Untimed Grammaticality Judgment Test (UGJT), Metalinguistic Knowledge Test (MKT), Working Memory (WM)

3.4 Data trimming and outlier analysis

Prior to analysis, the data was checked for missing values. A small proportion of the data points were missing across the variables (n = 8 in PS group, n = 4 in TS group; 3.29%). To maintain statistical power, missing values were replaced using log-transformed regression. By means of this approach, missing values were predicted using observed values in a linear regression model, following Tabachnick and Fidell (2019). Multivariate outlier analysis was checked using boxplot and Mahalanobis distance. 22 outliers were detected and removed. A composite score was computed for L2 explicit knowledge and L2 implicit knowledge test scores as the correlation between these two variables was high, r (341) = .73, p < .001.

CHAPTER 4

RESULTS

This chapter reports the outcomes and the findings of the statistical analyses addressing the research questions. First, cognitive effects of translation on EFs, LA and types of knowledge will be presented. Then, latent structure of cognitive and linguistic variables will be presented alongside with factor loadings and outcomes of construct overlap.

4.1 Descriptive statistics of cognitive and linguistic variables

Table 4 presents the descriptive statistics, including the means, standard deviations, minimum and maximum values, for each variable measured in the study across the entire participant sample. These statistics provide an overview of the distributions of the working memory, attention control, language aptitude, and knowledge measures prior to inferential analysis.

Table 4. Descriptive Statistics for The Entire Sample

	N	*Min*	*Max*	*Mean*	*SD*	*Skew.*	*Kurt.*
Proficiency	343	70	100	86.71	6.443	-.188	-.749
MKT	343	4	48	28.13	10.306	-.212	-.831
COMPEXP	343	16.5	33.5	26.520	4.0853	-.448	-.656
Flanker	343	0	57	28.20	11.764	-.343	.262
Simon	343	24	84	55.98	10.892	-.262	-.017
Stroop	343	0	58	24.99	13.074	-.155	-.478
LLAMA B	343	0	20	8.46	4.008	.388	-.256
LLAMA D	343	6	18	13.46	2.842	-.816	-.010
LLAMA E	343	0	19	7.73	4.285	.480	-.441
LLAMA F	343	1	20	9.94	4.198	.158	-.592
OSPAN	343	35	75	60.33	8.828	-.652	-.019
SYMSPAN	343	10	42	29.43	6.929	-.507	-.271

Note: Metalinguistic Knowledge Test (MKT), Composite Score Explicit Knowledge (COMPEXP), Operation Span Task (OSPAN), Symmetry Span Task (SYMSPAN), Skewness (Skew), Kurtosis (Kurt).

The descriptive statistics for all variables measured in the study across the full sample (N = 343) are presented in Table 4. Metalinguistic knowledge exhibited a wide range (4 to 48, M = 28.13, SD = 10.31). The composite knowledge score ranged from 16.5 to 33.5 (M = 26.52, SD = 4.09). With respect to attention control tasks, the highest mean scores were observed in Simon task (M = 55.98, SD = 10.89). On the other hand, the mean scores of Stroop task (M = 24.99, SD = 13.07) was slightly lower than Flanker task (M = 28.20, SD = 11.76) with relatively normal distributions. Working memory performance was measured by Operation Span (M = 60.33, SD = 8.83) and Symmetry Span (M = 29.43, SD = 6.93). Language aptitude was assessed

via the LLAMA subtests. The highest mean scores were found in LLAMA D (M = 13.46, SD = 2.84) and the lowest mean scores were observed in LLAMA E scores (M = 7.73, SD = 4.29. Skewness and kurtosis values for all variables remained within acceptable ranges.

Pearson product-moment correlation coefficients were calculated. The results are presented in Table 5. Metalinguistic knowledge was strongly associated with the composite knowledge score (r = .660, p < .001), confirming that these are theoretically related constructs. The composite score also showed moderate correlations with several LLAMA subtests, particularly LLAMA E (r = .278, p < .001) and LLAMA F (r = .217, p < .001), as well as with both working memory tasks—OSPAN (r = .239, p < .001) and Symmetry Span (r = .196, p < .001).

The LLAMA subtests displayed varying levels of association. LLAMA E and LLAMA F were most strongly correlated (r = .397, p < .001), suggesting shared pattern learning. LLAMA B was moderately correlated with WM (Symmetry Span: r = .295, p < .001) and weakly correlated with EF measures (e.g., Stroop: r = .191, p < .001), indicating cognitive overlap with vocabulary learning aptitude. In contrast, LLAMA D showed weak and non-significant correlations with all cognitive measures and aptitude subtests supporting its distinct and potentially implicit construct nature, aligned with recent aptitude literature (e.g., Iizuka & DeKeyser, 2024).

Table 5. Pearson Correlation Matrix Among EFs, LA, and Knowledge Measures (N = 343)

	Variable	1	2	3	4	5	6	7	8	9	10	11	12
1	Proficiency	—											
2	MKT	.359**	—										
3	COMPEXP	.421**	.660**	—									
4	Flanker	.170**	.171**	.174**	—								
5	Simon	.192**	.055	.232**	.391**	—							
6	Stroop	.152**	.097	.151**	.375**	.223**	—						
7	LLAMA B	.127*	.090	.130*	.264**	.214**	.191**	—					
8	LLAMA D	-.033	.014	.022	.086	.040	-.012	.068	—				
9	LLAMA E	.183**	.238**	.278**	.237**	.231**	.165**	.307**	.027	—			
10	LLAMA F	.197**	.199**	.217**	.181**	.194**	.184**	.344**	-.083	.397**	—		
11	OSPAN	.169**	.098	.239**	.208**	.296**	.126*	.251**	.002	.287**	.214**	—	
12	SYMSPAN	.091	.097	.196**	.286**	.377**	.144**	.295**	-.003	.235**	.301**	0.408**	_

Note: Metalinguistic Knowledge Test (MKT), Composite Score Explicit Knowledge (COMPEXP), Operation Span Task (OSPAN), Symmetry Span Task (SYMSPAN). *$p<.05$ **$p<.01$

4.2 Effects of formal training in translation: EFs, LA, types of knowledge

The first research question addressed the combined effects of field of study (TS, FLE, PS) and training level (novice vs advanced) on the measures of WM, LA, EFs and type of knowledge. In order to ensure L2 proficiency was not a confounding variable a 2 × 3 two-way ANOVA was conducted with proficiency as the dependent variable. There was a significant main effect of field of study, $F(2, 337) = 11.76$, $p < .001$, partial $\eta^2 = .065$ and there was a significant effect of level, $F(1, 337) = 22.32$, $p < .001$, partial $\eta^2 = .062$ between groups. As a result, L2 proficiency was set as a covariate. A series of MANCOVA and ANCOVA analyses were conducted. The rationale for using MANCOVA was to include L2 proficiency as a covariate.

Since language proficiency was included in the analysis as a covariate, a 2 x 3 MANCOVA was applied to examine the field of study and training level on the combined outcomes of WM, LA, EFs and type of knowledge.

4.2.1 Assumptions of MANCOVA

Checking the linearity assumption of analysis through scatter plot matrices and correlation matrix, a composite score was computed for UGJT and TGJT test scores based on an observation of a strong correlation between these two variables was high, r (341) = .73, $p < .001$, demonstrating a substantial shared variance. The new variable was named as CompExp (Composite Explicit Knowledge). Even though UGJT and TGJT are designed to tap into different dimensions of L2 grammatical knowledge, the indicated high correlation may be revealing overlapping as a potential outcome of L2 proficiency. The approach aligns with practices in data reduction (Tabachnick and Fidell, 2019).

Subsequently, a Box's M test was conducted to assess the assumption of homogeneity of covariance matrices. The results indicated that the covariance matrices were equal across groups. Thus, the assumption was met for all the variables. Finally, as the last procedure in assumption checking, a test for homogeneity of regression slopes assumption was conducted by analyzing the interaction between the independent variables and the covariate. The assumption was violated for LLAMA F. As a result, it was decided to use separate ANCOVAs for the subtests of LLAMA. MANCOVA was applied to the remaining variable groups. With respect to LLAMA F, assumption of homogeneity of regression slopes is a prerequisite for ANCOVA as well. A three-way interaction term (training level x field of study x proficiency) was included in the model. As the interaction was found statistically significant, $F(5, 333) = 2.60$, $p = .025$, partial $\eta^2 = .038$. This result suggests that the relationship between the covariate (L2 proficiency) and the dependent variable (LLAMA F) varied across different combinations of training level and field of study indicating a violation of the homogeneity of regression slopes

assumption. However, as the interaction effect is close to small, ANCOVA was applied to LLAMA F as well.

4.2.2 MANCOVA results for EFs: Attention squared tasks

Table 6 provides the descriptive statistics across field of study (TS, FLE, PS) and level of training (novice vs advanced) for attention squared tasks.

Table 6. Descriptive Statistics for EFs: Attention Squared Tasks

			Training Level							
			Novice				Advanced			
			Mean	SD	Min	Max	Mean	SD	Min	Max
Flanker	Field of	TS	31	10	10	57	30	11	5	53
	study	PS	28	12	0	54	27	12	0	51
		FLE	27	13	0	55	27	12	0	56
Simon	Field of	TS	57	10	31	75	57	10	30	79
	study	PS	53	11	24	78	56	11	25	75
		FLE	56	11	30	80	56	11	33	84
Stroop	Field of	TS	27	12	5	53	27	10	3	51
	study	PS	23	13	0	49	27	13	0	57
		FLE	23	15	0	55	23	14	0	58

Note: Translation Studies (TS), Political Science (PS), Foreign Language Education (FLE)

For the Flanker task, performance appeared relatively stable across groups. TS students showed slightly higher mean scores than PS and FLE students in both novice (M = 31, SD = 10) and advanced levels (M = 30, SD = 11). In the Simon task, all groups performed similarly, with average scores ranging from 53 to 57. While novice TS students had the highest mean score (M = 57, SD = 10), PS novices had the lowest mean (M = 53, SD = 11), which increased in the advanced group (M = 56, SD = 11). The Stroop task showed more pronounced differences. TS participants performed consistently (M = 27, SD = 12 for novices; M = 27, SD = 10 for advanced). In contrast, PS novices had a lower mean score (M = 23, SD = 13) compared to their advanced counterparts (M = 27, SD = 13).

A 2 x 3 between -subjects multivariate analysis of covariance (MANCOVA) with training level and field of study as independent variables on the three attention control measures controlling for proficiency, *Wilks' Λ* = .949, $F(3, 336) = 6.02$, $p = .001$, $\eta^2 = .051$ indicated that the interaction between training level and field of study was not significant, *Wilks' Λ* = .986, $F(6, 668) = 0.809$, $p = .563$, partial $\eta^2 = .007$. The main effect of level was not significant, *Wilks' Λ* = .988, $F(3, 336) = 1.36$, $p = .256$, $\eta^2 = .012$. The main effect of field of study was also non-significant using *Wilks' Λ* = .971, $F(6, 672) = 1.66$, $p = .129$, $\eta^2 = .015$.

4.2.3 MANCOVA results for EFs: WM tasks

Table 7 provides the descriptive statistics across field of study (TS, FLE, PS) and training level (novice vs advanced) for WM tasks.

Table 7. Descriptive Statistics for EFs: WM Tasks

			Training Level							
			Novice				Advanced			
			Mean	SD	Min	Max	Mean	SD	Min	Max
OSPAN	Field of study	TS	60	8	36	75	62	10	40	75
		PS	59	9	36	75	60	9	35	75
		FLE	60	9	36	75	60	8	38	71
SYMSPAN	Field of study	TS	29	7	12	41	31	6	18	41
		PS	29	7	11	42	29	7	10	41
		FLE	29	7	10	39	29	8	10	42

Note: Translation Studies (TS), Political Science (PS), Foreign Language Education (FLE), Operation Span (OSPAN), Symmetry Span (SYMSPAN)

Performance on the OSPAN task was consistent across field of study and training levels. Mean scores ranged from 59 to 62. TS students had the highest advanced-level mean ($M = 62$, $SD = 10$). Symmetry Span scores were also consistent across field of studies and training levels, with a range from 29 to 31. The only

notable increase was in the TS group. Advanced participants showed a slightly higher mean score (M = 31, SD = 6) than novices (M = 29, SD = 7).

A 2 x 3 between -subjects multivariate analysis of covariance (MANCOVA) was conducted, with level (novice vs. advanced) and field of study (TS, PS, FLE) to examine their effects on three WM tasks (Ospan and SymSpan), controlling for proficiency. The interaction between training level and field of study was not significant, *Wilks' Λ* = .994, $F(4, 670) = 0.523$, p = .719, partial η^2 = .003. There were no statistically significant multivariate effects for level *Wilks' Λ* = .997, $F(2, 335) = 0.54$, p = .586, partial η^2 = .003; and field of study *Wilks' Λ* = .996, $F(4, 670) = 0.30$, p = .881, partial η^2 = .002.

4.2.4 ANCOVA results for language aptitude: LLAMA tests

Table 8 provides the descriptive statistics across field of study (TS, FLE, PS) and level of training (novice vs advanced) for LLAMA tests.

Table 8. Descriptive Statistics for LLAMA Tests

			Training Level							
			Novice				Advanced			
			Mean	SD	Min	Max	Mean	SD	Min	Max
LLAMA B	Field of	TS	9	5	2	20	10	4	2	20
	study	PS	8	4	1	17	8	4	0	18
		FLE	8	4	2	19	9	4	1	16
LLAMA D	Field of	TS	15	1	12	18	13	3	7	18
	study	PS	13	3	6	18	13	3	6	17
		FLE	13	3	6	18	13	3	6	18
LLAMA E	Field of	TS	8	4	1	18	9	5	1	19
	study	PS	6	4	1	17	7	4	0	17
		FLE	8	4	2	17	8	4	1	18
LLAMA F	Field of	TS	9	5	1	19	10	4	2	20
	study	PS	8	4	1	17	10	3	3	19
		FLE	11	5	2	19	11	4	2	20

Note: Translation Studies (TS), Political Science (PS), Foreign Language Education (FLE)

Performance on LLAMA B was relatively similar across groups, with average scores ranging from 8 to 10. Advanced level TS students had the highest mean (M = 10, SD = 4). Scores on LLAMA D were consistently high across all groups, with means ranging from 13 to 15. Notably, novice TS students had the highest mean (M = 15, SD = 1). PS and FLE participants showed no meaningful differences between novice and advanced levels (M = 13 for both). TS students again showed the highest means, increasing from novice (M = 8, SD = 4) to advanced (M = 9, SD = 5). FLE students outperformed others overall, with a stable mean of 11 across both levels, suggesting strong grammatical inferencing abilities.

The combined effects of the level of training and field of study on LLAMA measures were investigated through a 2x3 between-subjects univariate ANCOVA as the assumption of homogeneity of regression slopes for MANCOVA was not sustained for LLAMA F.

The ANCOVA results on LLAMA B, controlling for L2 proficiency as a covariate, indicated that training level was not significant, $F(1, 338) = 1.39$, $p = .239$, partial $\eta^2 = .004$. The effect of field of study was also statistically non-significant, $F(2, 338) = 2.73$, $p = .067$, partial $\eta^2 = .016$.

The ANCOVA results on LLAMA D scores revealed that the training level was statistically significant with a small effect size, $F(1, 338) = 9.02$, $p = .003$, partial $\eta^2 = .026$. The effect of field of study was also significant with a medium effect, $F(2, 338) = 7.85$, $p < .001$, partial $\eta^2 = .044$. Pairwise comparisons revealed significant differences among the groups in LLAMA D scores. TS students scored significantly higher than both FLE students, $t(338) = 3.70$, $p = .001$ and PS students, $t(338) = 3.03$, $p = .008$.

The ANCOVA results on LLAMA E indicated that the effect of level was not significant, $F(1, 338) = 0.58$, $p = .449$, partial $\eta^2 = .002$. However, the effect of field of study was significant, $F(2, 338) = 3.85$, $p = .022$, partial $\eta^2 = .022$. Pairwise comparisons revealed significant differences in LLAMA E scores between TS and PS. TS students scored significantly higher than Political Science students, $t(338) = 2.59$, $p = .030$.

The ANCOVA results on LLAMA F indicated that neither level ($F(1, 338) = 2.42$, $p = .121$, partial $\eta^2 = .007$) nor field of study ($F(2, 338) = 2.07$, $p = .128$, partial $\eta^2 = .012$) reached statistical significance, indicating that differences in level or field of study did not significantly impact LLAMA F scores after controlling for proficiency.

4.2.5 MANCOVA results on linguistic knowledge

Table 9 provides the descriptive statistics across field of study (TS, FLE, PS) and level of training (novice vs advanced) for type of knowledge tests.

Table 9. Descriptive Statistics for Type of Knowledge Tests

			Training Level							
			Novice				Advanced			
			Mean	SD	Min	Max	Mean	SD	Min	Max
MKT	Field of	TS	30	8	12	45	35	9	15	48
	study	PS	19	8	5	38	19	9	4	42
		FLE	31	7	16	47	34	8	15	47
COMPEXP	Field of	TS	27.4	3.2	18.5	33.0	29.4	2.9	19.0	33.5
	study	PS	22.3	3.3	17.5	28.0	23.5	4.0	16.5	33.0
		FLE	27.5	2.9	20.0	33.5	28.8	2.4	22.0	33.0

Note: Metalinguistic Knowledge Test (MKT), Composite Explicit Knowledge Score (COMPEXP)

TS and FLE students scored higher in metalinguistic knowledge than PS students at both levels. Among novices, TS ($M = 30$, $SD = 8$) and FLE ($M = 31$, SD

= 7) exhibited higher mean scores than PS (M = 19, SD = 8). In the advanced group, TS (M = 35, SD = 9) and FLE (M = 34, SD = 8) outperformed PS (M = 19, SD = 9). A similar pattern was observed in explicit knowledge scores. TS and FLE students exhibited the highest scores at both levels. The means range from M = 27.4 to 29.4 for TS and M = 27.5 to 28.8 for FLE. PS students scored lower, M = 22.3 (SD = 3.3) for novices and M = 23.5 (SD = 4.0) for advanced students.

Since a high correlation (r=.73) was observed between UGJT and TGJT, a composite score was computed by averaging the scores of UGJT and TGJT. The MANCOVA analysis on the composite score and MKT revealed that the interaction between level and field of study was not statistically significant, *Wilks' Λ* = .979, $F(4, 672) = 1.79$, $p = .129$. The overall multivariate effect of level was statistically significant, *Wilks' Λ* = .971, $F(2, 337) = 4.95$, $p = .008$, partial $\eta^2 = .029$. A significant multivariate effect was also found for field of study, *Wilks' Λ* = .569, $F(4, 674) = 54.88$, $p < .001$, partial $\eta^2 = .246$, reflecting a large effect size.

In order to probe into the multivariate effects, 2 X 3 between subjects univariate ANCOVAs were conducted, to examine the effects of level and field of study on MKT and CompExp. For MKT, significant main effect was found for field of study, $F(2, 338) = 84.35$, $p < .001$, partial $\eta^2 = .333$, indicating a very large effect. Level also indicated a small but statistically significant effect, $F(1, 338) = 4.63$, $p = .032$, partial $\eta^2 = .014$. Pairwise comparisons revealed significant differences in MKT scores between TS and PS, while controlling proficiency. TS students scored significantly higher than PS students on metalinguistic knowledge test, $t(338) = 11.58$, $p < .001$. No significant difference was found between TS and FLE students, $t(338) = 0.50$, $p = 1.000$. FLE students scored significantly higher than PS students,

$t(338) = 11.14$, $p < .001$. Pairwise comparisons also revealed that advanced learners scored significantly higher than novice learners on metalinguistic knowledge, $t(338) = 2.15$, $p = .032$

For composite score, significant main effect was found for field of study, $F(2, 338) = 93.40$, $p < .001$, partial $\eta^2 = .356$, indicating a strong influence of field of study. Level also indicated a small but statistically significant difference between novice and advanced participants, $F(1, 338) = 8.76$, $p = .003$, partial $\eta^2 = .025$. Pairwise comparisons revealed significant differences in composite scores between TS and PS, while controlling proficiency. TS students scored significantly higher than PS students on composite score, $t(338) = 12.22$, $p < .001$. FLE students scored significantly higher than PS students, $t(338) = 11.69$, $p < .001$. No significant difference was found between TS and FLE students, $t(338) = 0.61$, $p = 1.000$. Pairwise comparisons also revealed that advanced learners also scored significantly higher than novice learners on composite explicit knowledge, $t(338) = 2.96$, $p = .003$.

4.3 Latent structure of cognitive and linguistic variables

In order to address the second research question regarding the structure between WM, LA, EFs and type of knowledge, an exploratory factor analysis (EFA) was conducted to identify the underlying structure among the measured variables. Prior to the analysis, assumptions required for the analysis were checked. The Kaiser-Meyer-Olkin (KMO) measure was .74, indicating adequate sampling for factor analysis (Kaiser, 1974). Bartlett's test of sphericity was statistically significant, $\chi^2(45) = 715.01$, $p < .001$, suggesting that the correlations between items were sufficiently large for EFA. The communalities after extraction ranged from .425 to .836,

indicating that all variables retained a moderate to high proportion of variance explained by the extracted components. Notably, MKT and CompExp (composite explicit knowledge) had the highest communalities (.836 and .789, respectively), suggesting they were well-represented in the factor solution. A Principal Component Analysis (PCA) was conducted using Promax rotation. The analysis extracted three components with eigenvalues greater than 1, which together explained approximately 51.49% of the total variance in the data, with Component 1 explaining 28.67%, Component 2 explaining 12.84% and Component 3 explaining 9,98%.

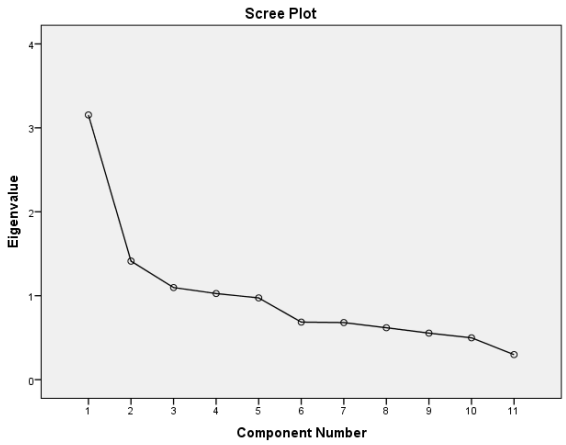


Figure 9. Scree plot

The scree plot revealed a clear inflection point after the third component, supporting the retention of three components (see Figure 9). This is consistent with the Kaiser criterion (eigenvalues > 1) and suggests a three - factor solution is appropriate for the data.

Table 10. Rotated Factor Loadings

	Component 1	Component 2	Component 3
LLAMA F	.702	.133	-.237
SYMSPAN	.701	-.104	.056
OSPAN	.649	-.017	-.027
LLAMA B	.590	-.074	.103
LLAMA E	.560	.248	-.059
Simon	.480	-.086	.350
MKT	-.077	.928	.032
CompExp	.074	.851	.070
Flanker	.199	.028	.706
Stroop	.097	.029	.614
LLAMA D	-.375	.089	.571

Note: Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Principal Component Analysis (PCA) with Promax rotation revealed a three-factor solution, with clear and interpretable loadings. Component 1 appears to represent a language aptitude–working memory composite, as it includes high loadings from LLAMA F, SymSpan, OSPAN, LLAMA B, LLAMA E and Simon. This cluster likely reflects a shared dimension of executive working memory. Component 2 is defined by very high loadings from Metalinguistic Knowledge and the Composite Explicit Knowledge Score. This factor captures explicit, rule-based, and metalinguistic awareness. Component 3 consists of Flanker, Stroop, LLAMA D and Simon, which are measures of executive function, particularly inhibition and conflict monitoring. This component reflects the inhibitory control construct.

4.4 Summary of the findings

The present study aims to investigate the effects of field of study (TS, FLE, PS) and training level (novice vs advanced) on the combined outcomes of WM, LA, EFs and type of knowledge and to explore whether there exist overlaps between WM, LA,

EFs and type of knowledge or they form distinct and independent constructs. The first research question focuses on revealing the effects of field of study and training level. In this regard, the effects of the study field and level of training, significant results were observed on LLAMA D and LLAMA E. Translation students outperformed FLE and PS students on LLAMA D in terms of both study field and level of training. As regards LLAMA E, even though the effect of level was not significant, TS students scored higher than PS students. With respect to type of knowledge tests, significant main effect was found for study field and level of training on MKT. TS students and FLE students outperformed PS students on MKT. Regarding CompExp, TS and FLE students outperformed PS students. In terms of level of training, advanced students outperformed novice students on both MKT and CompExp.

For the second research question, the focus was to reveal the underlying structure among WM, LA, EFs and type of knowledge. To this end, it was hypothesized that inhibitory control task measures are predicted to form a unified dimension indicating attention control as a uniform construct.

Promax rotation was conducted to analyze the underlying structure of cognitive and linguistic measures. Three components were extracted that may be labelled as Executive Working Memory (EWM) including LLAMA F, SymSpan, OSPAN, LLAMA B, LLAMA E and Simon (Component 1); Explicit Linguistic Knowledge including MKT and CompExp (Component 2); inhibitory control including Flanker, Stroop and LLAMA D (component 3). Additionally, Simon showed moderate loading on Component 1 and also exhibited some inclination toward Component

CHAPTER 5

DISCUSSION

5.1 Findings for effects of formal training in translation

With respect to the effects of translation training on language aptitude, it was hypothesized that TS students will show significantly better performance on WM, LA, EFs and type of knowledge. The first hypothesis has been confirmed partially. The univariate ANCOVA results revealed that there were no significant effects of field of study and training level on LLAMA B which tests vocabulary learning and LLAMA F which is a measure for grammatical inference. These results may imply that these aspects of LA may remain unaffected from potential cognitive changes from the field of study and training level. These results can be accounted by the fact that LLAMA B and LLAMA F are often conceptualized as more innate and relatively stable components of language aptitude. These components are associative memory and grammatical inference and pattern learning. Moreover, translation training and practice might develop and enhance domain-specific skills for the most part rather than the aptitude traits as the ones that are measured by LLAMA B and F. This perspective is consistent with previous findings that different components of aptitude may contribute to L2 learning at different stages of learning from varied and distinct aspects (Bialystok & Barac, 2012; Yalçın & Spada, 2016). From another point of view, LLAMA tests may not be robust and sensitive enough in detecting subtle gains obtained from translation training and practice. Additionally, the finding may suggest that translation training and practice may be affecting other components of language aptitude, ability for implicit learning with focal attention (Iizuka and DeKeyser, 2024) and phonemic coding ability. Conversely, significant effects were

revealed for LLAMA D which is a measure of sound recognition and LLAMA E which measures sound-symbol associations. TS students outperformed FLE students on LLAMA D. Similarly, TS students scored higher than PS students on LLAMA E. These findings highlight that pattern recognition and rule inference dimension of LA may be influenced by the study field. This result aligns with Skehan's (2016) view that underscores the modular nature of LA suggesting that different aspects of LA may respond in varying degrees to instruction. LLAMA D evaluates the implicit ability to identify new words from listening input and LLAMA E measures the ability to associate novel sounds with certain symbols. Those two skills may be relevant to the translation contexts where students are exposed to distinct language systems, orthographies and phonologies.

On the other hand, the absence of effects on LLAMA B which measures new vocabulary learning through associative memory may support findings by Granena (2013) highlighting that aptitude subtests tapping memory may be less sensitive to instruction. Overall, these results provide support for the view that describes LA as a componential and differentiated construct, specifically in pattern recognition and rule induction (Roehr-Brackin & Tellier, 2019; Skehan, 2016). It may be posited that translation training may potentially enhance cognitive skills required in language learning. The results did not confirm the hypothesis as regards the effects of field of study and training level on WM and EFs. In terms of the association between attention control and cognitive effect of translation on inhibition, multivariate analysis did not reveal a significant effect of study field or level of training. This finding may suggest that formal translation training may not result in a measurable effect on inhibitory control considering the fact that participants of this study are just at undergraduate level. On the other hand, these findings are in conflict with some

studies (Christoffels et al., 2006; Dong et al., 2018; Ghiselli, 2022; Morales et al., 2015; Padilla et al., 2005; Timarová et al., 2014; Yudes et al., 2011) in the literature, revealing cognitive benefits in relation to translation and / or interpreting experience. For instance, Yudes et al. (2011) indicated that interpreters who had more professional experience outperform monolinguals and bilinguals in tasks which require interference suppression, as in the Stroop task. In a similar vein, Morales et al. (2015) revealed enhanced performance among simultaneous interpreters on the Flanker test. This result may suggest that high-level language engagement may reinforce domain-general EFs.

On the other hand, there are studies which pose questions as regards possible cognitive advantages of translation and / or interpretation. For example, Garcia (2014) demonstrated no EF advantages in interpreting students in comparison to their bilingual controls on Simon tasks. However, Timarová et al. (2014) indicated that a possible association between interpreting/translation and EFs was affected by factors such as WM and task features.

These inconclusive results may be explained by individual variability. Timarová and Ungoed-Thomas (2008) underscored that translation and interpreting depends on both EFs and metacognitive factors. Moreover, Prior and Gollan (2013) highlighted that it is not straightforward to overgeneralize translation-related EF advantages as these benefits may often be related to task and population. Overall, considering the given challenges, cognitive effects of translation and interpretation may not be robustly generalizable as they may strongly be affected by task type, depth and quality of training and individualistic characteristics.

With respect to WM measures, the current study did not find any significant effects field of study and training level and disconfirmed Hypothesis 1. These

findings exhibit a contrast with a number of studies (Babcock & Vallesi, 2017; Mellinger & Hanson, 2019; Zhao & Dong, 2020) that have reported enhanced WM in professional translators and interpreters. For instance, Babcock and Vallesi (2015) reported high performance on complex span tasks among professional interpreters in comparison with their bilinguals who do not have any interpreting experience. This result has been attributed to the cognitively high attentional demands of simultaneous translation. In another study, Signorelli et al. (2012) suggested that interpreters outperformed their bilingual controls in updating tasks, exhibiting a better performance in information maintenance and manipulation.

Depending on the given findings, the results of the present study with respect to WM may inform us that WM advantages are less likely to emerge in the early stages of training. What is more, potential cognitive benefits may be related to the type of translation activity. In parallel with this, Timarová et al. (2014) demonstrated that students of translation and interpreting did not show any advantage in WM when compared to their bilinguals. However, significant differences were observed among professional interpreters and translators who received longer and sustained experience. Furthermore, Dong and Xie (2014) claim that enhancement and improvement in WM may be related specifically to interpreting experience rather than written translation training as interpreting inherently requires more cognitive demands on online processing. This present study involved students mostly engaged in written translation, with limited experience of consecutive and simultaneous translation. As a result, the exposed cognitive load may not have been strong enough to induce improvement or enhancement in WM.

From another perspective, the complex span tasks which were used in the present study measure domain-general WM. Therefore, it may be posited that

potential WM advantages resulting from translation training may depend on the task and may be emerging in verbal contexts. Ghiselli (2022) reported that a medium-sized working memory advantage is evident among interpreters and interpreting students compared to non-interpreters, but only on tasks utilizing verbal stimuli; this advantage does not extend to non-verbal tasks. Additionally, as Engle and Kane (2004) argue that WM is a complex construct and different tasks may tap different components. In line with this, variability in participants' baseline cognitive abilities may have concealed the effects between the groups.

Hypothesis 1 also assumed that translation and interpreting students are expected to show higher performance in metalinguistic knowledge and explicit knowledge. The hypothesis has been confirmed with the findings. With respect to the group comparisons in the types of knowledge across different study fields, TS students significantly outperformed both FLE and PS students on the MKT test. This test requires the identification and explanation of certain language structures as well as naming of them. On the other hand, FLE students outperformed TS and PS students on the composite score (explicit knowledge test). This test requires the ability to analyze and apply grammar rules by means of error correction tasks. The findings of the present study support that different academic studies prioritize and foster distinct forms of explicit language knowledge as reported in previous studies (Ellis, 2004; Halverson, 2018; Roehr-Brackin, 2014; Rojo &Valenzuela, 2013). TS students' high performance in metalinguistic knowledge tests may be attributed to the formal linguistic content and practices of grammatical analysis incorporated into translation curricula. Rojo (2015) maintained that translation tasks encourage the learners to interact with and reflect on language as analytic focus. They inherently place conscious attention to form and cross-linguistic comparison. Similarly, Parinaz

and Biria (2018) demonstrated that translation students showed high performance at language analytic tasks in MKT, suggesting that translation can impact on L2 learners' metalinguistic knowledge. Consistently with this, Güven Çoban and Akıncı (2025) reported that translation-based instructional practice resulted in enhancement in metalinguistic knowledge. These findings also align with Elder and Manwaring (2004) that metalinguistic knowledge is strongly acquired in academic contexts in which language analysis is central.

In relation to high performance of FLE students over TS and PS students on the composite score, FLE students receive structured training in their curricula involving pedagogical grammar and language instruction. These academic contexts nurture proceduralized explicit knowledge by supporting students' competence to effectively apply grammatical rules (DeKeyser, 2003). PS students showed the lowest performance both in MKT and explicit knowledge. One possible explanation for this result is the fact that PS students do not receive formal instruction in language pedagogy or translation-related courses. This finding supports the view that explicit and metalinguistic knowledge requires intentional focus and training (Ellis, 2005). Altogether, these outcomes strengthen the argument that the perception that explicit knowledge is task and training specific and language based academic contexts foster different knowledge profiles.

Hypothesis 2 expects a main effect of training level for all measures. It has been confirmed partially. The effect of training level was found to be statistically significant across several measures, albeit with varying effect sizes. Specifically, for LLAMA D, which assesses grammatical inferencing ability, the effect of training level reached statistical significance between novice and advanced level TS students. However, the effect size was small, suggesting that while advanced training may

contribute to improved performance, its impact on this subcomponent of language aptitude is limited. This finding aligns with previous literature indicating that grammatical inferencing may be influenced by individual cognitive profiles and prior language learning experiences (Roehr-Brackin, 2014).

In contrast, both the Metalinguistic Knowledge Test (MKT) and the composite score (explicit knowledge) revealed significant effects of training level. TS students outperformed their novice counterparts. These findings indicate that advanced training in translation is strongly associated with heightened metalinguistic awareness. The pronounced difference between novice and advanced TS students on these measures suggests that formal translation training plays a key role in the development of explicit language knowledge. Hypothesis three with a prediction on interaction effect for field of study and training level for type of knowledge has been disconfirmed.

5.2 Underlying dimensions of cognitive and linguistic measures

Third research question focuses on exploring the structure underlying WM, LA, EFs and type of knowledge. Hypothesis 4 has been partially confirmed. A three-component model emerged from the exploratory factor analysis, capturing key dimensions of cognitive and linguistic performance. The first component loaded on the three LLAMA subtests (B, E, F), both working memory tasks (Operation Span and Symmetry Span), and the Simon task. This component appears to reflect a Cognitive-Linguistic Integration Factor, capturing the interaction between language learning aptitude—such as vocabulary learning, grammatical rule inference, and phonetic memory—and domain - general executive functions like working memory and conflict resolution. This finding aligns with Wen et al., (2017) proposal of

Executive Working Memory (EWM) as a unifying construct that underpins complex language learning behaviors. The concept of EWM, as proposed by Wen et al., (2017, 2023), redefines working memory as a flexible, control-driven system governed by executive attention and cognitive regulation, especially within the context of language learning. EWM combines the core executive functions of updating, inhibition, and shifting with traditional working memory processes, creating a domain-general control system that facilitates the handling of complex linguistic input and the performance of cognitively demanding tasks.

Wen argues that language learning exerts heavy demands on EWM, as learners must continuously monitor incoming language, update their mental representations accordingly, suppress any form of distraction and irrelevant information, and shift between form, meaning, and use. For example, grammatical inferencing, syntactic processing, and lexical recall all involve handling of linguistic information in real time which interact with EWM.

This framework clarifies why aptitude tests that tap into grammatical inferencing (e.g., LLAMA E) and tasks that require attentional control (e.g., Simon task, complex span tasks) may load on the same latent factor in factor analyses. It also potentially accounts for why some learners outperform others in language learning. Because they possess more efficient executive attention control systems integrated within their working memory (Wen et al., 2017). This result diverges from the evidence presented by Sevdeğer et al. (2016). They reported that WM and language aptitude are distinct constructs emerging under the aptitude construct. This outcome was explained by the modality of the aptitude subtests. It was implied that WM capacity has an essential role in the redefined aptitude construct, but the two

cognitive skills are fundamentally different and not substitutable. On the other hand, the present study reveals the presence of both WM tasks and LLAMA subtests in the same factor. This finding may support the view that aptitude and WM are not entirely distinct and may indicate a reliance on common underlying cognitive resources (Granena, 2013; Li, 2016).

Component 2 loaded by metalinguistic knowledge and composite explicit knowledge. appears to reflect a Rule-Based Linguistic Factor. They both draw on the ability to consciously access grammatical knowledge, utilize metalanguage, and reason analytically about language. This factor supports the perspective that explicit knowledge forms a distinct cognitive dimension, especially among instructed learners (Ellis, 2004; Roehr-Brackin, 2014). This clear dissociation from aptitude and WM highlights that explicit knowledge tends to develop through structured and targeted learning experiences rather than being a component of domain-general cognition.

Component 3 was loaded by the Flanker, Stroop, and LLAMA D, with partial loading from the Simon task. It appears to form an Inhibitory Control Factor as this cluster brings together classic inhibitory control measures with LLAMA D, which taps sound-symbol association. This finding aligns with Iizuka and DeKeyser (2024). They questioned the implicit nature of LLAMA D. In their study, LLAMA D scores showed no correspondence with other implicit aptitude measures. Conversely, they were negatively correlated with performance on the Serial Reaction Time (SRT) task, under conditions where participants' focal attention was explicitly directed toward the stimuli. They interpreted this result as evidence that LLAMA D relies on controlled attention and inhibitory processes, rather than tapping into unconscious or

incidental learning. In this sense, the factor loading of LLAMA D alongside inhibitory control tasks in the current study reinforces the view that LLAMA D engages attention - dependent functioning.

One possible interpretation is that this factor reflects domain-general attentional control required for managing interference in cognitive tasks. It also plays an important role in associating forms and meanings in early language learning (Skehan, 2016). The partial loading of the Simon task on both Component 1 and 3 suggests that it taps into both conflict monitoring and inhibition, consistent with prior findings (Bialystok et al., 2008; Dong & Liu, 2016).

Taken together, the factor structure observed in this study captures and highlights the multidimensional nature of cognitive and linguistic abilities in the context of translation and language learning. It aligns with the recent proposals for integrative models which reveals the dynamic interaction among cognitive and linguistic factors and explicit metalinguistic knowledge (Li, 2016; Wen et al., 2023). Further studies are required to investigate whether these components predict performance on translation tasks and enhance these latent dimensions with different participant demographics.

CHAPTER 6

CONCLUSION AND PEDAGOGICAL IMPLICATIONS

6.1 Conclusion

This thesis sought to examine the cognitive and linguistic effects of formal translation training by examining the roles of working memory, language aptitude, attention control, and linguistic knowledge among students from Translation Studies (TS), Foreign Language Education (FLE), and Political Studies (PS) study fields at both novice and advanced levels. Multivariate analyses and exploratory factor analysis were conducted. The results of the study revealed significant group-level differences, on certain dimensions of language aptitude (LLAMA D and LLAMA E), metalinguistic knowledge, suggesting a potential impact of translation training.

Findings indicated that TS students outperformed their peers in metalinguistic knowledge test and certain aptitude subcomponents, while FLE students scored significantly higher in explicit knowledge. The EFA analysis further identified three latent dimensions aligning with theoretical distinctions between cognitive control, linguistic knowledge, and aptitude-memory interactions. Notably, LLAMA B, E, F and working memory tasks clustered together with Simon. This result supports recent perspectives (e.g., Wen, 2017) about a latent construct as executive working memory. These results demonstrate the dynamic nature of translation competence and its potential to affect cognitive representation beyond linguistic skill sets.

Despite its contributions, the study is not without limitations. The cross-sectional design restricts causal inference, and the used cognitive tasks may not fully capture real-world translation performance. Additionally, the participant profile

includes only undergraduate student who are enrolled at translation and interpretation department. Future studies are required including the participation of translator and interpreters with different levels of expertise. Future research should also employ longitudinal or experimental designs to explore the developmental trajectories of cognitive and linguistic abilities in translators.

In sum, this thesis contributes to the growing body of research on cognitive translation studies focusing on cognitive and linguistic functions and offering empirical evidence about formal translation training.

6.2 Pedagogical translation as a language learning tool

The findings of the current study underline the potential of pedagogical translation. Pedagogical translation refers to the use of translation as a learning activity rather than a professional skill. It may potentially serve as an effective tool for fostering explicit knowledge, metalinguistic awareness, and cognitive engagement in language classrooms. Pedagogical translation can support form-focused instruction by prompting learners to reflect on linguistic components, thereby raising grammatical awareness and deepening syntactic processing (Cook, 2018; Laviosa, 2014). In particular, translation tasks can engage working memory by requiring learners to temporarily store, analyze, and reconstruct linguistic content, while utilizing language aptitude components such as pattern recognition and associative learning (DeKeyser, 2003; Wen et al., 2017).

Depending on these perspectives, instructors might incorporate translation tasks into the curriculum. Learners may be assigned to translate short authentic texts from L1 to L2 and vice versa. These tasks may include post-stages where learners

reflect on their syntactic preferences, lexical use, and grammatical transformations. Such tasks not only provide repeated exposure to target structures but also allow learners to develop metacognitive strategies for monitoring and correcting language output. Furthermore, think-aloud translation tasks can be used to scaffold explicit knowledge and enhance learners' awareness of L2 grammar (Khezrlou, 2021).

Given that the present study suggests strong associations between translation training and cognitive-linguistic measures, pedagogical translation may serve as a valuable instructional strategy not only for Translation Studies students but also for learners in general language education settings.

6.3 Pedagogical translation: Implications for curriculum design

From the perspective of pedagogical translation, translation tasks are not only language learning tools but also cognitive training opportunities that promote reflection, rule awareness, and strategic competence (Cook, 2018; Khezrlou, 2021). For translator training, Anthony Pym (2013) emphasizes the importance of problem-solving, decision-making, and risk management in authentic translation contexts—skills that depend heavily on executive functions and working memory. Pym (2013) advocates for a shift from a "product-oriented" to a "process-oriented" view of translation competence, emphasizing the translator's evolving cognitive strategies rather than merely the final target text.

Furthermore, translation curricula may benefit from working memory or aptitude tests as diagnostic tool during the early stages of training. This would guide instructors to offer tailored course contents and tasks for learners. For example,

novice translators with lower WM scores might be guided through pre-task planning routines, self- reflection tasks to support their development.

APPENDIX A

TIMED GRAMMATICALITY JUDGMENT TEST ITEMS

1. I haven’t seen him for a long time.

2. I think that he is nicer and more intelligent than all the other students.

3. The teacher explained the problem to the students.

4. *Liao says he wants buying a car next week.

5. *Martin completed his assignment and print it out.

6. *We will leave tomorrow, isn’t it?

7. He plays soccer very well.

8. *Did Keiko completed her homework?

9. *I must to brush my teeth now.

10. *If he had been richer, she will marry him.

11. *He has been living in New Zealand since three years.

12. Pam wanted to know what I had told John.

13. *They had the very good time at the party.

14. *Between 1990 and 2000 the population of New Zealand was increased.

15. *Liao is still living in his rich uncle house.

16. *Martin sold a few old coins and stamp to a shop.

17. *I have been studying English since a long time.

18. *I can to speak French very well.

19. *Joseph miss an interesting party last weekend.

20. Keiko eats a lot of sushi.

21. Bill wanted to know where I had been.

22. Did Cathy cook dinner last night?

23. Rosemary reported the crime to the police.

24. Mary is taller than her sisters.

25. *Hiroshi live with his friend Koji.

26. Keum wants to buy a computer this weekend.

27. *She writes very well English.

28. If she had worked hard, she would have passed the exam.

29. *Tom wanted to know whether was I going.

30. I must finish my homework tonight.

31. Keiko has been studying in Auckland for three years.

32. That book isn't very interesting, is it?

33. Her English vocabulary increased a lot last year.

34. Hiroshi received a letter from his father yesterday

*Ungrammatical

APPENDIX B

UNTIMED GRAMMATICALITY JUDGMENT TEST ITEMS

1. *Keum went to the school to speak to her children teacher.

2. *The teacher explained John the answer.

3. *I saw very funny movie last night.

4. *This building is more bigger than your house.

5. Does Keum live in Auckland?

6. Liao left some pens and pencils at school.

7. *If he hadn't come to New Zealand, he will stay in Japan.

8. *My car is more faster and more powerful than your car.

9. Joseph flew to Washington to meet the President's advisor.

10. *Joseph wants finding a new job next month.

11. Liao works very hard but earns very little.

12. Japan is a very interesting country.

13. I can cook Chinese food very well.

14. They enjoyed the party very much.

15. *The boys went to bed late last night, is it?

16. *She wanted to know why had he studied German.

17. *He reported his father the bad news.

18. Keiko spoke to the professor's secretary.

19. Liao stayed at home all day and finished the book.

20. Hiroshi found some keys on the ground.

21. They did not come at the right time.

22. If he had bought a ticket, he might have won the prize.

23. Martin says he wants to get married next year.

24. *An accident was happened on the motorway.

25. *Keum lives in Hamilton but work in Auckland.

26. *She likes always watching television.

27. *Did Martin visited his father yesterday?

28. Something bad happened last weekend.

29. *Keum bought two present for her children.

30. She is working very hard, isn't she?

31. *The bird that my brother caught it has died.

32. *The boat that my father bought it has sunk.

33. The book that Mary wrote won the prize.

34. The car that Bill has rented is a Toyota

*Ungrammatical

APPENDIX C

METALINGUISTIC KNOWLEDGE TEST ITEMS

Part 1

1. I must have to wash my hands.

2. Hiroshi wants visiting the United States this year.

3. If Jane had asked me, I would give her some money.

4. Learning a language is more easier when you are young.

5. Keiko grew some rose in her garden.

6. His school grades were improved last year.

7. Martin lost his friend book.

8. Keum happen to meet an old friend yesterday.

9. Because he was late, he called taxi.

10. They were interested in what was I doing.

11. Does Liao has a Chinese wife?

12. Jenny likes very much her new job.

13. They have already finished, isn't it?

14. He has been saving money since 10 years.

15. The cake that you baked it tastes very nice.

Part 2

The materials are delivered to the factory by a supplier, who usually has no technical knowledge, but who happens to have the right contacts. We would normally expect the materials to arrive within three days, but this time it has taken longer.

Grammatical feature	Example
definite article	__the_____
verb	_____
noun	_____
preposition	_____
passive verb	_____
conditional verb	_____
adjective	_____
adverb	_____
countable noun	_____
indefinite article	_____
relative pronoun	_____
auxiliary verb	_____
modal verb	_____
past participle	_____
conjunction	_____
finite verb	_____
infinitive verb	_____
agent	_____
comparative form	_____
pronoun	_____

APPENDIX D

ETHICS COMMITTEE APPROVAL

İSTANBUL 29 MAYIS ÜNİVERSİTESİ
BİLİMSEL ARAŞTIRMA VE YAYIN ETİĞİ KURULU
(Karar Sureti)

Toplantı Tarihi: 03.04.2023
Toplantı Sayısı : 2023/04

KARAR NO: 2023/04-6: Üniversitemiz Yabancı Diller Yüksekokulu Yabancı Diller Bölümü öğretim görevlisi Mehtap Güven ÇOBAN'ın "Formel Çeviri Eğitiminin İşler Bellek, Yönetici İşlevler ve Dil Yetisi Üzerindeki Etkileri" konulu bilimsel çalışma ve araştırma yapmaya ilişkin talebi incelenmiş olup, yapılan değerlendirme sonucunda "Formel Çeviri Eğitiminin İşler Bellek, Yönetici İşlevler ve Dil Yetisi Üzerindeki Etkileri" konulu bilimsel çalışmada etik açıdan bir sakınca olmadığına oybirliği ile karar verildi.

ASLI GİBİDİR
03.04.2023

Prof. Dr. Feridun M. EMECEN
Başkan

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