Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Humanities
Department of Language and Literature

Phan Thi Minh Dung

The Role of Non-verbal Reasoning and Short-term Memory in Foreign Language Learning

Master's thesis in Master of Philosophy in English Linguistics and Language Acquisition
Supervisor: Mila Dimitrova Vulchanova
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ABSTRACT

This study examined the role of Non-verbal Reasoning (NVR) and Short-term Memory (STM) in learning English as a foreign language (EFL). 30 high-school students from different high schools in a central city in Vietnam participated in the study. The participants' average age was 16.6 years, they all spoke Vietnamese as their first language and had learned EFL at school. None of them had any reading or writing difficulties, or any visual or auditory impairments. A Raven's Progressive Matrices test, a non-word repetition (NWR) test, and English proficiency tests of grammar and vocabulary were used to assess the impact of NVR and STM on English proficiency. Results of the study showed a moderately positive correlation between (1) NVR and English grammar, and (2) STM, as measured by the English NWR test, and English vocabulary. These findings indicate a selective impact of NVR and STM on different domains of English proficiency. In addition, the fact that no significant correlation was found between background factors and English performance suggests the dominant role of these two cognitive factors in English competence. Finally, the present study yielded two main findings that recommend further research, i.e., (1) the lack of correlation between STM, as measured by the Vietnamese NWR test, and English vocabulary gives an indication that language knowledge and experience of the language tested can influence performance in NWR tests, and (2) the moderate correlation between NVR and STM, as measured by the English NWR test, implies that these two factors might not contribute particularly to grammar or vocabulary, but rather affect many aspects of L2 learning.

Keywords: non-verbal reasoning, short-term memory, foreign language learning, English learning, correlation.

ACKNOWLEDGEMENT

First of all, I wish to express my deepest gratitude to my two supervisors: Mila Dimitrova Vulchanova and Anne Dahl for guiding me on the right path with your helpful feedback, sympathy, and dedication. Without your support, I could not have finished this project on time. Working with you was an interesting and memorable experience for me. I will always be grateful to you for your help and kindness.

I am indebted to my family, my parents, my fiancé Stein-Erik, and my friends for all your great love and support. You kept me going on through ups and downs. This work might not have been possible without your encouragement. I love you all so much.

I would like to send special thanks to Mr. Ton Tu, Mr. Thanh, Brooke, Mark, Shady, August, Akvilé, Luan, and Hiep for your help with the project and your valuable advice. Your contribution to this research was awesome!

To all the students who took part in my project, thank you for being so helpful and enthusiastic during the data collection. You take a very important role in the success of this study, and without you, it could not have been completed.

To my M.Phil classmates and friends, it is my honor to know you and to go through this battle with you. I do appreciate our last two years with all the good memories. I wish you all the best. I will miss you a lot.

Finally, I would like to pay special regards to the Department of Language and Literature for creating good conditions for me to continue my master's program in my home country. I also wish to show my gratitude to all the lecturers, professors, as well as other academic and administrative staff for the invaluable assistance that you all provided during my study. My journey at NTNU was so beautiful thanks to all of you. Thank you NTNU for giving me a chance to make my dream come true. I was, am, and will always be proud to be a student of NTNU!

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LIST OF ABBREVIATIONS

CP	Critical Period
EFL	English as a Foreign Language
FL	Foreign Language
FLA	First Language Acquisition
FLL	Foreign Language Learning
L1	First Language
L2	Second Language
LA	Language Acquisition
LTM	Long-term Memory
NVI	Non-verbal Intelligence
NVR	Non-verbal Reasoning
NWR	Non-word Repetition
PL	Phonological Loop
PSTM	Phonological Short-term Memory
SLA	Second Language Acquisition
STM	Short-term Memory
WM	Working Memory

CHAPTER 1: INTRODUCTION

Human language, as an important part of human society, has been a favorite topic to researchers for ages. Language studies are crucial for the general development of human civilization since they not only deal with the issues of linguistics but also offer solutions to language learning-related problems. We all acknowledge that the goal of learning a language is the ability to use it effectively, but we hardly explain how language is developed, how it works, how we can speak and understand a language, or why some people study language better than others do. Hence, studies in language acquisition (LA) and linguistic development based on the premise of nature and nurture have been ongoing. Accordingly, the question of whether people's ability to learn a language depends on their inborn talent or their efforts and surrounding environment has been debated for a long time. Some researchers emphasize the roles of biological factors in LA (e.g., intelligence, reasoning, or aptitude, etc.), while others strongly support the contribution of environmental factors to LA (e.g., learning environment, materials, or learning strategies, etc.).

In this time of globalization, language (English as the most popular language) is considered to be a key to open the door to integration, trade, science, cultural exchange, and other social activities. Benefits of knowing a foreign language (FL) (e.g., boost career opportunities, improve cross-cultural understanding, or travel overseas more easily, etc.) are undeniable, so nowadays more and more people care about learning another language besides their mother language. As a result, foreign language learning (FLL) and the factors influencing this learning process have become major concerns not only among linguists but also among educators in order to develop effective teaching methods as well as enhance language learners' learning competence. The studies dealing with problems associated with second language learning and bilingualism have also been increasing gradually. The question is: why are some people able to learn languages more easily than others? This might be explained in that different individuals have various characteristics and that many factors related to these individual differences affect their FLL, such as intelligence, memory, age, education, motivation, and so on.

Among these factors, cognitive factors (e.g., intelligence, reasoning, memory, etc.) do affect LA. In the field of LA, the studies on these factors (typically intelligence) and FLL are plentiful. As Kristiansen (1990) claimed "Foreign language learning is always also language learning. Therefore, it can be assumed to be connected with a person's intelligence" (p.2), many

approaches have been proposed to examine the importance of cognitive factors in Second Language Acquisition (SLA). However, not many of these studies are specific to the influence of both Non-verbal Reasoning (NVR) and Short-term Memory (STM) on FLL. Moreover, being conscious of the idea that perceiving the process of acquiring language as well as the factors affecting this operation is necessary to solve problems related to language learning, the researcher decided to conduct a study on '*The role of non-verbal reasoning and short-term memory in foreign language learning*'. The study aims to discuss the impact of NVR and STM capacity on learning English as a foreign language (EFL).

To conduct the study, an NVR test, a non-word repetition test (NWR), English proficiency tests of vocabulary and grammar, and a questionnaire were administered to the participants who were students at various high schools in a central coastal city in Vietnam. Accordingly, the participants' NVR and STM were measured by the NVR test and the NWR test, respectively. Meanwhile, their language competence was evaluated by the English proficiency tests of vocabulary and grammar. The scores obtained on the NVR tests were compared to the scores on the English vocabulary tests and English grammar tests to examine the relationship between NVR and English proficiency. Similarly, the scores on the NWR tests and the ones achieved on the English proficiency tests were collated to explore the connection between STM capacity and English proficiency. In addition, the answers to the questionnaire gave new findings into learning EFL. The theoretical background of NVR and STM in LA and FLL will be critically discussed in the next chapter.

As mentioned above, the purpose of this study is to analyze how strongly NVR skills and STM capacity affect English learners' proficiency, and thereby investigate their roles in learning EFL. To meet the purpose of the study, the following research questions were investigated:

1. Do scores on the Non-verbal Reasoning tests (as measured on the Raven's Matrices) predict scores on the English vocabulary tests and English grammar tests?

2. Does Short-term Memory capacity impact the acquisition of vocabulary (based on the results on the non-word repetition tests and English vocabulary tests)?

3. Which is the stronger predictor of English learning outcomes (as shown on the English proficiency tests), Non-verbal Reasoning or Short-term Memory?

The following chapters involve the existing literature on this topic, the research method used in the study, the data analysis, the discussion of the results, and the conclusion. Specifically, chapter two refers to the theoretical background of NVR, STM, and some non-cognitive factors in SLA based on some existing studies; this chapter also briefly introduces the Vietnamese language and language situation in Vietnam. In chapter three, the methodology of the study is discussed including the participants, the research design with instruments for data collection, and methods of data analysis; the ethical considerations are additionally included in this chapter. Chapter four is about the descriptive statistics presentation and data analysis. Finally, chapter five and chapter six denote the discussion of the findings and the conclusion, respectively.

CHAPTER 2: LITERATURE REVIEW

2.1 An overview of the factors influencing FLL

There are many unsolved questions and ongoing debates about LA. Do humans have an innate capacity for acquiring language? Were children born with an innate language mechanism, or do they develop language skills through interactions with others? These questions have been controversial among linguists, and the constant debate about the impact of biological factors and environmental factors (or the 'Nature or Nurture') has been a key issue so far. Studies on general LA also can help resolve problems related to SLA which is said to "constitute a formidable task for students at all levels of education" (Feenstra, 1968, p.1). Accordingly, many students who are excellent at other subjects struggle with FLL. In a class, it can be noticed that FL learners never show the same academic performance "even when they are taught by the same method with the same text by the same teacher over the same period of time" (Yoshihiro, 1988, p.164). In our daily life, some people are observed to acquire a language easier, faster, or better than others do (Grigorenko et al., 2000). To explain the reasons for the difficulty in acquiring a second language (L2), R. Gardner (1960) and Lambert (1963) assumed that the process of SLA involves two tasks - the acquisition of a new 'linguistic code' and the acquisition of cultural behavior patterns. To put it differently, L2 learning is a process where the learner must learn new symbols as well as the cultural-linguistic characteristics of that language. Many studies carried out on these two tasks have shown that successful FLL is a complex process that requires a combination of many factors rather than one particular outweighing the other (e.g., Feenstra, 1968; Skehan, 1989; Dörnyei & Skehan, 2003; etc.). However, it is mainly a combination of both cognitive factors (e.g. intelligence, reasoning, working memory, etc.) and non-cognitive factors (e.g. age, attitude, motivation, learning strategies, etc.) (Kristiansen, 1990; Long, 1997). These are individual factors (or individual differences) that are, as claimed by Dörnyei (2005), "dimensions of enduring personal characteristics that are assumed to apply to everybody and on which people differ by degree" (p.4).

Unlike first language (L1) which is triggered by birth and obtained naturally (Chomsky, 1957), L2 is gained actively and consciously, and SLA is influenced by both internal (e.g., age, aptitude, attitude/ motivation, anxiety, etc.) and external (e.g., teaching context, learning environment, culture, etc.) factors (e.g., J. Brown, 1995; Ellis, 2008, etc.). While many of these factors are also relevant in First Language Acquisition (FLA), SLA is generally more

characterized by individual factors. For examples, in terms of age, according to the Critical Period Hypothesis (CPH) (Lenneberg, 1967), there is a critical period (CP) (i.e., before puberty) to acquire L2 with the same degree of proficiency as the L1; after this period, the process is difficult since there is a decline in the ability to acquire L2 after puberty/ lateralization. The effects of the CP make an observable difference between FLA and SLA, i.e., if humans miss the CP for FLA, they will lose the ability to acquire language, especially grammar and syntax; while the CP for SLA mainly affects phonology or the learner's ability to gain native-like accent. When it comes to input, a crucial distinction between L1 opposed to L2 vocabulary learning is that the L2 learner does not have to learn new concepts when learning a new word as he/ she makes use of word knowledge previously acquired during the FLA process (Nation, 2001). This is a common trait amongst L2 learners, i.e. to use L1 knowledge in an SLA process - a tool not available in FLA. Also, while FLA occurs naturally and does not require education or guidance, SLA needs constant and explicit instructions and education. Furthermore, one unique feature of SLA is fossilization which is possibly caused by age (the decline in plasticity at a CP affects the mastery of certain linguistic characteristics), lack of desire for articulation (no effort is made to follow target language norms due to different social and psychological factors), communicative pressure (on ideas above learners' linguistic proficiency), and the attribute of the feedback on learners' use of L2 (fossilization is triggered by positive cognitive feedback but hindered by negative feedback) (McLaughlin, 1987; Ellis, 1994; cited in Ipek, 2009); this hardly happens to FLA. As mentioned earlier, while L1 knowledge is gained subconsciously since a child was born, L2 knowledge is developed more consciously, so SLA must be under influence of affective factors such as self-esteem, motivation, attitude, or anxiety, etc. These factors make a significant difference between FLA and SLA. Specifically, motivation encourages SLA, i.e., learners with strong motivation tend to be more successful in L2 learning (e.g., R. Gardner & Lambert, 1972; Dörnyei, 2001, etc.). Learners do not need any motivation to acquire their L1, but without a desire to learn L2, it is very difficult for both L2 learning and teaching. Similarly, self-esteem related to the fear of making mistakes, or anxiety referring to "the worry and negative emotional reaction when learning or using a second language" (MacIntyre, 1998, p.27) appears more often in SLA but it does not arise in FLA.

A detailed review of the research regarding the individual differences in SLA follows with the cognitive factors (i.e., intelligence, aptitude) and non-cognitive factors (i.e., attitude, motivation, learning strategies, age, and input).

2.1.1 Cognitive factors in FLL

To begin with, we will go through two cognitive elements in FLL, i.e., intelligence and aptitude.

2.1.1.1 Intelligence in FLL

There has been a debate among scholars about whether intelligence may influence FLL. Some researchers claim that intelligence does influence FLL (e.g., R. Gardner & Lambert, 1972; Genesee, 1976; Jensen, 1969, 1980; etc.) while others doubt the relationship between intelligence and FL acquisition (e.g., Vygotsky, 1962; Ellis, 1985; Pinker, 1995; etc.). In the 1950s, Chomsky claimed that children were born with an innate capacity (or LAD - language acquisition device) to acquire language. Accordingly, children do not learn language through imitation (as shown through simple grammar mistakes they make) alone, but they acquire language by applying the major principles of the language and its grammatical structures from the LAD. This shows an important role of the inborn ability in LA. On the other hand, Pinker (1995) argued that children with atypical mental development or mental delay (e.g., Hydrocephalic children or children with William Syndrome) can learn a language as well as other children, which means that LA does not depend on general intelligence. This view is further supported by Ghonchepour and Moghaddam (2018) claiming that "children do not learn language based on general intelligence" (p.28). In SLA, studies show different influences of intelligence on different skills, i.e., there are low-level or no correlations between intelligence and communicative aspects of SLA (Genesee, 1976), but there are stronger correlations between intelligence and skills "used in the formal study of the language, such as reading, writing, language analysis, and vocabulary study" (Fernandez-Corugedo, 1999, p.29). Some other approaches suggest that FLL is affected by intelligence, but it does not mean that people with low IQ scores are unable to learn an L2 (Ghonchepour & Moghaddam, 2018). The results from Ghonchepour and Moghaddam's study on the role of intelligence in learning EFL also showed a weak relationship between intelligence and English achievement in general, and between reading comprehension and grammar in particular. This implies that intelligence has a role in FLL but it is not the only factor affecting the SLA. Notwithstanding the debate, what we can conclude from all the studies is that intelligence has no negative impact on FLL.

Like the disputation over the role of intelligence in FLL, the definition of intelligence is also controversial among psychologists and learning researchers. According to Wechsler (1944), "Intelligence is the aggregate or global capacity of the individual to act purposefully,

to think rationally and to deal effectively with his environment" (p.3). H. Gardner (1993a) defined intelligence as "a set of skills of problem solving-enabling the individual to resolve genuine problems or difficulties that he or she encounters and, when appropriate, to create an effective product" (p.13). Besides, the individual must have the potential to find or create problems, thereby laying the groundwork for new knowledge acquisition (H. Gardner, 1993a). Meanwhile, Gottfredson (1997) presumed intelligence as "a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience" (p.13). Also, there do exist several other aspects of intelligence. The term 'intelligence' is used to denote the performance on certain types of tests assessing linguistic or nonlinguistic abilities (H. Brown, 2000). Under the view of Dörnyei (2005), intelligence is "a general source of aptitude not limited to a specific performance area but is transferable to many sorts of performance" (p.32). This idea might be supported by Ellis (2008) assuming intelligence to be "the general set of cognitive abilities involved in performing a wide range of learning tasks" (p.649).

Several types of intelligence that can be listed are verbal intelligence, non-verbal intelligence (NVI), concrete reasoning, abstract/non-verbal reasoning, etc. The various types of intelligence are proposed to differentiate individuals, i.e., different people have different talents and skills (H. Gardner, 1983, 1999), so further theories developed are concerned with not only the variety but also the complexity of intelligence. Specifically, H. Gardner (1983) listed eight different kinds of abilities that underlie intelligence including linguistic, spatial, logical-mathematical, musical, bodily-kinesthetic, naturalistic, interpersonal, and intrapersonal intelligence. Intelligence, in the common sense, comes in many forms (e.g., intelligence in math, art, music, reading and comprehension, emotions, etc.), and the ability to reason is assumed to be a form of intelligence. Hence, it is understandable that 'intelligence'/ 'non-verbal intelligence' and 'reasoning'/ 'non-verbal reasoning' might cause some confusing perceptions. The definition of NVR and NVI will be scrutinized in section 2.2.

2.1.1.2 Aptitude in FLL

In connection with general intelligence, aptitude is considered to be a crucial predictor in SLA. According to R. Snow (1992), aptitude is made of different personal traits dealing with the learning process. Meanwhile, Robinson (2005) suggested that aptitude is a synthesis of both cognitive abilities and performance at different stages. Within the area of SLA, the term 'language aptitude' carries various meanings. Carroll (1962) stated that "language aptitude is

a relatively invariant characteristic of the individual, not subject to easy modification by learning, [...] and is a relatively stable personal characteristic, one which is made up of various component skills or abilities" (p.122). An individual with an ability to "learn a foreign language in a given amount of time and under given conditions" is a case of language aptitude (Carroll & Sapon, 2002, p.23). Language aptitude is also defined as "language learning ability" (Dörnyei, 2005, p.32), or "a specific talent for learning a foreign or a second language" and a "componential concept" including a set of "cognitive abilities" (Carroll, 1981, 1993; Skehan, 1998, 2002; Sparks et al., 2011; cited in Wen et al, 2017, p.1,2).

There have been a significant number of studies conducted on the role of aptitude in SLA (e.g., Harley & Hart, 1997; Kiss & Nikolov, 2005; Kormos & Sáfár, 2008, etc.). Language aptitude, as claimed by Skehan (1989), is the most consistent predictor of learners' success in SLA. Findings from an investigation on the relationship between language aptitude components and L2 outcomes among learners whose intensive L2 exposure began at different ages supported this claim, i.e., the results showed a positive relationship between L2 outcomes and an analytical dimension of language aptitude in the late immersion group (starting in adolescence), and a positive correlation between L2 achievement and memory ability in the early immersion group (starting in grade 1) (Harley & Hart, 1997). Language aptitude obviously affected language performance in both groups of learners. In another study of the role of aptitude for young learners, data collected from English proficiency tests, aptitude tests, and learners' motivation also showed a strong relationship between participants' scores on the aptitude test and the English language proficiency test, proving aptitude to be the best predictor of the outcomes, followed by motivation with moderate correlations; furthermore, the association between aptitude, grades, and school subjects indicated a tendency that learners with better results scored higher on the aptitude tests than learners with lower results (Kiss & Nikolov, 2005).

Although language aptitude is a strong predictor of FL proficiency, some other studies show a connection between aptitude and other factors, which means that basic linguistic aptitude is not the only factor to influence learning an FL (Yoshihiro, 1988). Accordingly, the learner's low aptitude can be recompensed by more learning time, greater motivation, well-prepared materials and treatment, or experienced teachers that best fit the learner's needs. In another study exploring the role of aptitude in students in language courses at a university as well as the relationship between aptitude and course scores, the results indicated that aptitude did not seem to play a significant role in the course scores gotten by the first-year students

because they felt more anxious and less motivated than the second-year students whose aptitude was mostly correlated with course scores (Sureda, 2015). That is to say, motivation, anxiety, and learning strategies, considered as "mediating factors" in the influence of aptitude on FLL, play a crucial role in the success of this learning process (Sureda, 2015, p.2). On the whole, it cannot be denied that aptitude takes an important role in FLL, but attitude, motivation, and other individual differences also need to be taken into account.

2.1.2 Non-cognitive factors in FLL

2.1.2.1 Attitude and Motivation in FLL

Unlike intelligence and aptitude which are inborn, attitude and motivation can be developed or cultivated throughout the learning process (Titone, 1990; Ellis, 2004). According to Lambert (1967; cited in Macnamara, 1973), attitude is divided into two types: integrative and instrumental, i.e., an integrative attitude refers to "a desire to know and become friendly with speakers of a language", while an instrumental attitude denotes a tendency to "better oneself materially by means of the language"; the first one is more likely to lead to success than the latter one (p.37). Attitude is also defined as "an evaluative reaction to some referent or attitude object, inferred on the basis of the individual's beliefs or opinions about the referent" (R. Gardner, 1985, p.9). Together with attitude, motivation is an important factor that is regarded as the learners' orientation to the goal of learning an L2, and it occurs in the discussion of the L2 rather than the L1 learning (Wilkins, 1972). Motivation, like attitude, is divided into two types: integrative and instrumental. Integrative motivation indicates learners' purposes in learning a language that they might be interested in the people or culture of the target language, and instrumental motivation implies learners' functional goals for learning an L2 (R. Gardner & Lambert, 1972). The positive relationship between attitude, motivation, and FL proficiency has been observed in a considerable number of studies (e.g., Lambert, 1963; R. Gardner, 1979; R. Gardner et al., 1985; Dörnyei, 2001; Bain et al, 2010, etc.).

According to Lambert (1963; cited in R. Gardner, 1979), "The learner's ethnocentric tendencies and his attitudes towards the other group are believed to determine his success in learning the new language. His motivation to learn is thought to be determined by his attitudes and by his orientation toward learning a second language" (p.194). In an investigation on the role of language aptitude and attitudinal/motivational attributes on the rate of learning French vocabulary, the results showed that participants high on integrative motivation learned faster than those who were low and that learners' perceptions of their effort and interest on each test

were influenced by their level of integrative motivation (R. Gardner et al., 1985). These findings suggest a correlation between attitude/ motivation and FL performance. Dörnyei (2001) also stated that a high level of motivation impacts successful learners and helps them deal with difficulties of learning conditions as well as possible problems in the learning process, while the lack of learning attitude and motivation has negative effects on unsuccessful learners. To investigate this assumption, Bain et al. (2010) conducted a study on the differences in the aptitude, attitude, and achievement of postsecondary Spanish students who were identified as gifted and non-gifted. Accordingly, in the same attributions for ability, effort, or context, gifted students who got higher scores than non-gifted students on the aptitude scale also displayed a more positive attitude toward FLL. These results imply that positive attitudes relate to higher performance, and attitudes toward learning play a motivating role in the learners' success. In fact, the learners who want to learn and have positive attitudes toward language learning achieve more than those who do not. In a recent study carried out on 200 participants to explore the influence of affective factors on L2 learners' ability, the results consolidate the findings from previous studies, i.e., the affective factors that include attitude and motivation directly affect the speed and effectiveness of FLL as well as the learners' overall development and long-term development of SLA (Wang & Wu, 2020). The relationship between attitude/ motivation and FLL leads to effective strategies/ suggestions for FL teachers or instructors to improve L2 learners' motivation and to create positive attitudes among them towards language learning.

2.1.2.2 Learning strategies in FLL

Learning strategies are defined as "steps or actions taken by language learners to enhance any aspect of their learning: accession, storage, retrieval, and use of information" (Rigney, 1978; Oxford, 1990; cited in Stansfield, 1990, p.70). In simple words, learning strategies are the tools/ techniques learners use consciously to facilitate their learning process, as claimed by Oxford (1990) "Learning strategies are specific actions taken by the learner to make learning easier, faster, more enjoyable, more self-directed, more effective, and more transferable to new situations" (p.8). A case study conducted by O'Malley and Chamot (1990) suggested a classification of learning strategies including cognitive, metacognitive, and social-affective strategies. Meanwhile, Oxford (1990) classified language learning strategies into six coherent groups, i.e., Memory-related Strategies (that transfer information to long-term memory and recall it for communication, e.g., learning/retrieving lexical items by images, sounds, repetition, etc.), Cognitive Strategies (that manipulate the material in a direct way, e.g., summarizing main points, making predictions from the context, etc.), Compensation Strategies

(that enable learners to overcome difficulties obstructing communication by making logical guesses from the context in speaking, listening, or using body language, etc.), Metacognitive Strategies (that help learners to plan, organize, and evaluate their own learning preferences, e.g., creating a timetable, organizing learning materials, etc.), Affective Strategies (that help learners to control their mood, attitude/ motivation related to learning, e.g., encouraging or rewarding oneself, sharing feelings with others, etc.), and Social Strategies (that allow learners to interact with others, especially helpful in oral communication, e.g., ask someone to correct their mistakes, using L2 to talk with native speakers, etc.). This classification is considered to be "the most comprehensive, practical, and theoretically grounded one" (Stansfield, 1990, p.71). Among these groups, the first three directly involve the target language (as a subject matter), and the last three indirectly involve the subject matter, but they are essential to language learning (Stansfield, 1990).

Going beyond the previous definitions, Oxford et al. (1989) gave a more focused definition of language learning strategies as "actions, behaviors, steps, or techniques - such as seeking out target language conversation partners, or giving oneself encouragement to tackle a difficult language task - used by learners to enhance learning" (p.29). Meanwhile, O'Malley and Chamot (1990) defined language learning strategies as "techniques and devices used by second language learners for remembering and organizing samples of the second language", "one of the ways learners become actively involved in controlling their own learning", and "the thoughts and behaviors that learners use to help them comprehend, learn, or retain information" (p.43). The definition of language learning strategies was then further developed by Chamot (2004) who considered language learning strategies as "the conscious thoughts and actions that learners take in order to achieve a learning goal" (p.14). Language learning strategies are assumed to affect the development of learners' communicative competence (Lessard-Clouston, 1997) and improve learners' language skills in a better way (Fedderholdt, 1997). Such assumptions show that learning strategies can be used as a training tool for L2 learners because they contribute to L2 success (Dörnyei & Skehan, 2003), and their roles in language learning are undeniable. When language learners intentionally choose suitable strategies for their learning style, these strategies will become "a useful toolkit for active, conscious, and purposeful self-regulation of learning" (Oxford, 2003, p.2). In a study investigating the effects of language learning strategies on learning Turkish (as an FL) vocabulary, the findings indicated that the students used metacognitive strategies most and there was a significant correlation between the students' level of strategy use and the achievement in vocabulary

knowledge (Bolukbas, 2013). In another recent study examining the use of language learning strategies in connection with FL attitude, proficiency, and school achievement among 868 students in years 5 and 8 in Hungary, the results showed that the metacognitive, social, and memory strategies primarily influenced FL attitudes and marks in year 5; the metacognitive strategies had a dominant effect in year 8 and influenced FL marks (Habók & Magyar, 2018). These results demonstrate a certain role of learning strategies in FLL.

2.1.2.3 Age in FLL

Age is one of the factors that influence FLL, and it has been a long-held common belief that children can acquire language faster than adults. However, whether children are more successful L2 learners than adults or not has been controversial among researchers. The issue of age in SLA has been a matter of linguistic studies for a long time. The initial research was triggered by the Critical Period Hypothesis (CPH) (Lenneberg, 1967) which proposes that language learning competence can only be gained at particular times or 'critical' periods during a lifetime. Specifically, according to the CPH, LA must occur during a critical period (CP), before the age of puberty (before the completion of cerebral lateralization), so that language can be learned fully and correctly. The CPH originally refers to FLA, and under this view, language, like other biological systems, will be seriously impaired if it is not acquired before a certain age. While nowadays it is widely accepted that there is a CP in FLA (i.e., if humans are not exposed to language in the early years of life, they will lose the ability to learn a language, especially the grammatical system) (Qing-xin, 2012), the CP in SLA has continuously been a fierce debate among linguists, psychologists and neuroscientists.

Evidence for the CPH from various sources demonstrates that age is an important predictor for SLA and language learning capacity gets poorer with age. After the CP, SLA can still occur, but the native-like competence might not be attained to the same extent (Scovel, 1969; Krashen et al., 1979; Patkowski, 1980; Long, 1990, etc.). The CPH also gives an implication that the processes involved in SLA will be fast, successful, and relatively similar to those in FLA if they take place before the age of puberty. In relation to phonology in SLA, Scovel (1969) assumed that the CP for learning phonology occurs earlier than for syntax, and the ability to master the sound patterns of a language depends on neurological-muscular development. Results from another study conducted on 46 native Korean and Chinese speakers who arrived in the US between the ages of 3 and 39 and who had lived there for between 3 and 26 years also showed that participants who began acquiring English in the US at an earlier age

obtained higher scores on the test than those who began later (Johnson & Newport, 1989). This implies a strong relationship between the age of arrival in the US and English performance, which supports the CPH. In agreement with the CPH, Long (1990) presumed that some CPs control the different aspects of both FLA and SLA. Accordingly, in terms of phonology, the degradation may begin as early as six and a native-like accent is almost impossible to be attained after 12 years old; meanwhile, native-like morphology and syntax are impossible after 15. To put it differently, the ability to achieve native-like accent declines first and the sign of this reduction is described by "a sharp drop in imitation abilities" (Long, 1990, p.266). Then, other linguistic abilities diminish during various CPs, so the loss in these abilities is not considered as a one-time event (cited by Abu-Rabia et al., 2004).

On the other hand, there is a lot of evidence supporting the fact that we can learn languages at any age and nativelikeness can be still achievable up to a certain point (adolescence) in SLA (e.g., C. Snow & Hoefnagel-Hohle, 1977, 1978; Singleton & Lengyel, 1995; White & Genesee, 1996, etc.), which is opposed to the CPH. In a study testing English speakers of different ages on their naturalistic acquisition of Dutch during their first year in Holland (C. Snow & Hoefnagel-Hohle, 1977, 1978), the results showed that individuals in the age group 12-15 and adults made the fastest progress in learning Dutch during the first few months. At the end of the first year, the group 8-10 and 12-15 achieved the best control of Dutch. Subjects from the age group 3-5 scored lowest on all the tests. As a result, it can be concluded that the CP (2-12) did not apply to these findings, which does not support the CPH for SLA. When it comes to vocabulary, Singleton and Lengyel (1995) do not believe that there is a CP for learning vocabulary in SLA since vocabulary acquisition is probably also in relation to memory. The CPH on learning vocabulary was additionally taken into account by Harley and Wang (1997) suggesting that Lenneberg "seems to have viewed vocabulary learning as exempt from maturational constraints, or at least, that his primary concern was with syntax and phonology" (p.24). In another study using a test of grammaticality judgment on three groups (including near-native speakers of English as an L2, non-native speakers of English as an L2, and native English speakers), the findings demonstrated no significant differences between native speakers and near-native speakers of English; this means adult L2 learners can still achieve native-like competence, at least in the grammatical domain (White & Genesee, 1996). The issue of the CPH in SLA was further discussed by Bialystok (1997) believing that adult language learners can achieve the same success as children if they are motivated and can make

time and space for learning. In other words, there are outside factors that affect the success of adult L2 learns other than age.

Based on the various approaches to the CPH, we can conclude that different aspects of L2 can be differentially influenced by critical periods (i.e., phonology and the native-like competence do not seem to be acquired after a certain age, but others such as vocabulary or grammar processing can be improved at any age) and the deterioration in the learners' ability to acquire languages after a certain period in life might be not only under influences of biological factors but also other social aspects.

2.1.2.4 Input in FLL

Another non-cognitive factor that impacts the success of FLL is input. According to Corder (1967), language input is defined as what is available to be used by language learners for SLA. It is different from language intake which is a part of the input "that has been apperceived and further processed" (Gass, 1997, p.23). As with most theoretical ideas and concepts within an academic field, the occurrence of total consensus is uncommon. This is also the case for input. It gives the learner the necessary knowledge to decode certain aspects of the target language, such as sounds (phonetics ad phonology), words (morphology), phrases and sentences (syntax), and meaning (semantics and pragmatics). Knowledge of these concepts is certainly not only acquired through input, as other factors also come into consideration, but it is a necessity since various theoretical approaches of language learning emphasize the need for input (e.g., Krashen, 1981, 1982, 1985, 1989; Long, 1982; Gass, 1997; Van Patten & Williams, 2007, Mackey & Gass, 2015, etc.). The roles of input in SLA are examined in the view of Nativism (Chomsky, 1959, 1965, 1980), the Input Hypothesis (Krashen S., 1981, 1982, 1985, 1989), and the Input-Interaction-Output Hypothesis (Gass, 1991, 1994, 1997).

The Nativist theory is built upon Chomsky's claims about language being an innate faculty; this innateness refers to the idea that humans are born with a set of pre-wired rules of language in their minds, called Universal Grammar (UG) (Chomsky, 1959, 1965). According to Chomsky (1959), language is a complex system independent from general thinking skills, and the fact that children everywhere acquire language (without much effort) in a similar way supports the view that humans' brains are equipped with an innate capacity to learn a language. It is also accompanied with UG that input comes into play. Under Nativism, despite being needed for SLA, input is merely considered to trigger the L2 learner into recognizing what language he/ she is dealing with. As one of the primary theories supporting the claims of

linguistics nativism, UG forms the basis of all the possible human languages, and the Poverty of the Stimulus (POS) (Chomsky, 1965, 1980) is used as evidence to consolidate the theory of UG suggesting that all languages have common tenets (or same structural principles). The POS argument assumes that the language input children receive is insufficient to explain their detailed knowledge (the rich and fast development of the L1) or to acquire every feature of the language, so humans must be born with 'innateness' to learn a language. Later, many researchers have drawn implications to SLA from these arguments, i.e., the insufficiency of input in FLA also accounts for SLA (e.g., White, 1989, 2003; Pullum & Scholz, 2002; Hawkins, 2008, etc.). Therefore, learners must rely on the knowledge they are equipped with when learning L1 and rely on the L1 when learning an L2 (Ipek, 2009).

Krashen's Input Hypothesis (1981) highlighted the importance of language input and the necessity of learners' exposure to comprehensible language input in SLA. Accordingly, comprehensible language input is identified as "the only causative variable in SLA" (Krashen, 1981, p.57), and L2 input must be beyond the L2 learners' competence for SLA to occur. Later, the Input Hypothesis 'Monitor Model' (Krashen, 1982) was developed. The model starts off with the exposure of Comprehensible Input which has to pass through the Affective Filter. This filter is basically the idea that the learner's state of mind will decide whether the input is processed or not. Then, the input that passes through the filter will be converted by the Language Acquisition Device into Acquired Knowledge. Krashen does not specify how this 'device' functions, but it may be understood as UG. In the actual production of speech, Krashen (1982) claimed that only the Acquired Knowledge can produce spontaneous utterances, while the Learnt Knowledge that the learner acquired by other means is used to scan for errors of the sentence that is spoken as output (i.e., monitor this process). Krashen (1985, 1989) further suggested the crucial roles of comprehensible input and the nature of language L2 learners receive in a successful acquisition. He also argued that input should not be repetitive to facilitate SLA because both "insufficient quantity of input" and "inappropriate quality of input" possibly cause fossilization (Krashen, 1985, p.44).

In addition to Krashen's Input Hypothesis, the Input-Interaction-Output Hypothesis (Gass, 1991, 1994, 1997) not only supports the role of language input but also further emphasizes the significance of interaction and output in SLA. According to Gass and Selinker (1994), the conversion of input into output involves five levels, i.e., apperceive input (the L2 learner notices new L2 information thanks to some particular features such as frequency, prior knowledge, affect, and attention), comprehended input (the learner comprehends or recognizes

the language input which is apperceived), intake (the input is comprehended and internalized), integration (the intake integrates with the prior knowledge), and output (the input is transformed into the output in the form of written or spoken language). As claimed by Gass (1997), the Input-Interaction-Output is a model of the major components in SLA, explaining that the language input learners receive is supported by the manipulation of the input through the "form of negotiation and native-speaker modification, that is, interaction" which establishes a basis for SLA to take place (Gass, 1997, p.34). Interaction, which refers to the conversation or context learners participate in, is important because during interaction learners may notice limitations in their competence[1]. In SLA, it can be stated that input plays a crucial role as the first beginning for the learners to acquire their target language, and output, as the result of input, takes an important part to check L2 learners' ability in target language production and language development.

On the whole, despite differing in the amount of input exposure that is necessary for acquiring a language, no theory or approach to SLA denies the importance of input, showing its crucial role in understanding the process of SLA, as claimed that "Input is without a doubt the sine qua non of acquisition" (Gass, 2010, p.19).

Having gone through some cognitive and non-cognitive factors as individual differences in FLL has given us a brief overview of various approaches to SLA, it is now appropriate to discuss the theoretical background of Non-verbal Reasoning and Short-term Memory in FLL that are also the two key elements of focus in the present study.

2.2 Non-verbal Reasoning (NVR)

2.2.1 What is Non-verbal Reasoning?

NVR (or abstract reasoning) is normally assessed as a part of intelligence testing (Kuschner, 2013), and is known as fluid intelligence or analytic intelligence (Cattell, 1963; cited in Drager, 2014). Analytic intelligence is defined as "the ability to reason and solve problems involving new information, without relying extensively on an explicit base of declarative knowledge derived from either schooling or previous experience" (Carpenter et al., 1990, p.404); while the term 'fluid intelligence' denotes the "reasoning ability in its most abstract and purest form", "the ability to analyze novel problems, identify the patterns and

[1] This approach was simplified by Dahl, Anne. *Second language acquisition*. Lectures at NTNU, 2019.

relationships that underpin these problems and extrapolate from these using logic", and "the central ability to all logical problem solving and is crucial for solving scientific, technical and mathematical problems" (ART Technical Manual, 2006, p.5). This can explain the reason why NVR is generally understood as a logical skill. Here, there is another term called 'non-verbal intelligence' (NVI) which refers to thinking and problem-solving skills that do not essentially require verbal language production and comprehension; it instead relates to processing, manipulating, or problem-solving about visual information and requires internalized, abstract or conceptual reasoning to complete a task (Kuschner, 2013). The common point learned from the definitions of fluid intelligence, analytic intelligence, and NVI is the ability to think or reason abstractly, use logic, and solve problems. Therefore, concerning the above-mentioned (part 2.1.1/ intelligence in FLL) about the concept of NVR and NVI, we assume that NVR is also NVI, and these terms are used interchangeably in this study.

2.2.2 Non-verbal Reasoning in LA

A significant number of studies have been conducted on the role of NVR in FLL. Studies on Finnish students aged 10 - 11 in elementary schools (Patjas, 1976; Koivumttki, 1979, 1980) showed that NVR was the best predictor of grades not only in FLs but also in some other subjects (cited by Kristiansen, 1990). In another study of NVI and English ability in deaf children, Watson et al. (1982) demonstrated the correlation between NVI and English learning, suggesting that NVI (and visual memory skills) could explain the reason why some hearing-impaired children succeeded in acquiring English, but others failed. The connection between NVR and FLL was further supported by results from a study of the relationship between FLL and four variables (including NVI, conceptual level, mother language, and mathematics) carried out on Finnish and Indian students aged 12-13 (Kristiansen, 1990). The results indicated that varying levels (low, medium, high) of non-verbal ability differed considerably on comprehension and production, suggesting a positive correlation between NVR and FLL under normal school conditions, disregarding mother language, the language taught, or cultural background (Kristiansen, 1990). More studies have been carried out on the role of reasoning (in general) and NVR (in particular) in solving reading comprehension tasks. Accordingly, NVR, as measured by the Raven Progressive Colored Matrices, was found to be a significant predictor of reading comprehension in typically developing children between 6 and 12 years old (Asbell et al., 2010). Despite different measures of reasoning used, not only verbal but also NVR is associated with reading comprehension. This supports the hypothesis that NVR plays an essential role in the inferential process (suggested by Tzuriel & George, 2009). In other

research, it was also found that NVI (as measured by the Culture Fair Test) predicted Russian grammar learning as an L2 (Brooks et al., 2006; Kempe & Brooks, 2008; Kempe et al., 2010) and that NVI (together with auditory sequence learning ability) could predict metalinguistic awareness as well as contribute to obvious awareness of underlying rules in adult learners (Brooks et al., 2013). Furthermore, in a recent study of early predictors of learning an FL in pre-school in Poland, the findings showed that NVI (together with emerging literacy and phonological awareness in L1) was related to the achievements in learning EFL in Polish pre-school children (Lockiewics et al., 2018). Children's nonverbal IQ was also correlated positively and moderately with English oral receptive and active skills, which is consistent with reports of the influence of non-verbal IQ on L2 learning aptitude (Grigorenko et al., 2000; Brooks et al., 2017, cited in Lockiewics et al., 2018).

2.2.3 Non-verbal Reasoning Assessment

There are several types of non-verbal tests, such as abstract reasoning, inductive reasoning, spatial reasoning, diagrammatic reasoning, or non-verbal analogy, etc. Among various NVR tests, the Raven's Progressive Matrices was used in this study since it is regarded as a good measure of 'fluid' intelligence (Sternberg, 1995; Carpenter et al., 1990) and a reliable estimate of intellectual ability (Brody, 1992; Raven, Raven & Court, 1991). This test will be discussed more as a method to collect data in Chapter 3.

2.3 Short-term Memory (STM)

2.3.1 What is Short-term Memory?

The other main cognitive factor investigated in this study is STM. To begin with, the theoretical concept of Working Memory (WM) and STM should be discussed. Some approaches see WM as a recent term and refinement of STM - an older concept which was called to distinguish it from long-term memory (LTM) (Gray, 2007), or WM is a theoretical conception of STM (Nairne & Neath, 2013). Generally, both WM and STM are defined as a group of brain systems that temporarily hold a limited amount of information we can actively work with (Cowan, 2016). However, there remain some differences between WM and STM.

According to Baddeley (1992), WM is the maintenance and controlled manipulation of a limited amount of information before the recall, or the mental ability to store and manipulate information relevant to a task (Baddely et al., 1998; Baddely, 2003). This term was first proposed through the homonymic model of Baddeley and Hitch (1974) and defined as the

temporary storage for incoming information, where this information could connect to something already in LTM (e.g., for language comprehension) and then be transferred to long-term storage. This model is comprised of the central executive (CE), the phonological loop (PL), and the visuospatial sketchpad (VSSP). These components have informational limits that are variable between individuals.

The CE functions as a control center or a master system that is responsible for coordinating and managing information within two subordinate systems - the PL and the VSSP. Gathercole (1999) also proposed that the CE involves attentional control that directs the flow of information through the system and planning (cited in Kormos & Sáfás, 2008).

Considered as the most widely researched component of WM, the PL temporarily stores phonological/ auditory information (i.e., the sound of language) and refreshes its decaying information in a rehearsal loop. Because of that, the system is also known as Phonological Short-term Memory (PSTM). This process, for example, can maintain a telephone number for as long as one keeps repeating the number to oneself again and again. The function of the PL is assumed to support language learning, including vocabulary development (Baddeley et al., 1998; Baddeley, 2003). The PL is often measured by an immediate serial recall of numbers (i.e., Digit Span test) or words/ non-words (i.e., Non-word Repetition test) (Baddeley, 2003). This type of STM will be critically discussed in 2.3.2.

The other subordinate system is the VSSP which stores visual and spatial information for manipulation (Gluck et al., 2008). This is how we visualize images in our minds. The VSSP is responsible for holding the visual and spatial information over short periods of time (Baddeley et al., 2009), i.e., it is believed that a person can only store 7 plus or minus 2 items in a very short time, and if these items cannot be transferred into LTM within a few minutes, the information is lost. Thanks to this momentary memory, we can temporarily create and revisit an image (which can be controlled in complicated tasks of spatial orientation) in our mind.

Later, a new component, called episodic buffer (EB), was added to the WM model (Baddeley, 2000). Its function is to integrate information from LTM.

When it comes to STM, it is hypothesized that an average individual can hold around seven (Miller, 1956) or four (Cowan, 2001) chunks of information in STM. This means that when given a number of items, we can remember around seven items for a brief period. STM

is defined as a cognitive system that takes charge of containing sensory events, movements, and cognitive information (e.g., words, digits, names, or other items) for a short time (Kolb & Whishaw, 2009; cited in Aben et al., 2012). The concept of STM as the intellectual capacity to store information temporarily over periods of seconds is also supported by other researchers (e.g., Neath et al., 2005; Klingberg, 2010; cited in Aben et al., 2012).

Briefly, WM can be understood as a theoretical framework that denotes structures and processes employed for storing and manipulating information temporarily; while STM generally refers to the short-term storage of information that does not include manipulating or organizing the information in memory. In other words, STM which reflects the ability to remember information over a short period is merely the storage component of WM without the CE or EB. Although the coexistence of both WM and STM is assumed by many scholars (e.g., Gathercole & Alloway, 2006; Nadel & Hardt, 2011; etc.), some other investigators (e.g., Davidson et al., 2006; Jensen et al., 2007; etc.) point out that there is no clear distinction between WM (i.e., maintenance and manipulation) and STM (i.e., only maintenance) (cited in Aben et al, 2012). Moreover, experimental research tends to focus merely on the maintenance component of WM (reviewed by D'Esposito, 2007), and both notions express the same cognitive process (Unsworth and Engle, 2007). Therefore, the concept of WM today is used to replace or involve the concept of STM with a strong emphasis on the idea of information manipulation rather than only maintenance. In this study, 'STM' is used as an interchangeable term with 'WM'.

2.3.2 Phonological Short-term Memory in LA

As mentioned above, the PSTM is the most widely researched component of WM because of its role in language learning, especially vocabulary acquisition. PSTM is a significant predictor of vocabulary acquisition in children, adolescents, and adults (e.g., Gathercole & Adams, 1993, 1994; Gathercole et al., 1997, 1999; etc.). The link between PSTM and lexical performance has been shown in many studies. Accordingly, some authors (e.g., Gathercole et al., 1992; Gathercole et al., 1997, 1999; etc.) demonstrate that children's performance on the NWR task as well as on the digit-span task predicts their performance on vocabulary tests concurrently and longitudinally. Regarding word learning, children's performance on the NWR task could predict their capacity to learn new words in their L1 (Gathercole & Baddeley, 1990) as well as in an L2 (Service, 1992; Service & Kohonen, 1995). Studies have revealed a close relationship between native vocabulary learning and the PSTM.

In a study of vocabulary development in the native language of young children, Gathercole and Baddeley (1989) found that children's capability to repeat unfamiliar non-words at the age of 4 could predict their vocabulary at 5. In another study, children with good PSTM skills for their age were found to learn previously unfamiliar names of toy animals better and faster (Gathercole & Baddeley, 1990). Research evidence also shows that words are easier to recall than non-words (Hulme et al., 1991), and non-words that conform to the phonotactic rules of the participants' L1 are easier to recall than non-words which are less "wordlike" (Gathercole, 1995), which indicates that long-term knowledge influences processing in PSTM (Gathercole et al., 1997). According to Cheung (1996), there was an interaction between PSTM and long-term phonological knowledge about the L2, which explains that in the case of high-vocabulary participants their long-term knowledge supported the learning of new words. Papagno and Vallar (1995) showed that STM and word-learning abilities were related among adults as well. In a study with university students, Speciale et al. (2004) found that both phonological sequence learning and PSTM capacity contributed to vocabulary learning. Besides vocabulary learning, studies also indicate a strong relationship between WM and reading comprehension in children, whether WM is measured with tasks requiring the processing and storage of words (De Beni et al., 1998), sentences (Seigneuric et al., 2000), or numbers (Yuill et al., 1989) since these tasks demand linguistic skills (cited in Cain et al., 2004).

The relationship between PSTM and new word learning is also extended to the learning of foreign languages. Accordingly, it was found that children's accuracy in repeating unfamiliar non-words was the best predictor of English learning success at school (Service, 1992), and the association of NWR with FL proficiency was stronger than with other aspects of FLL (Service & Kohomen, 1995). The importance of PSTM in L2 vocabulary learning was specifically indicated on a neuropsychological patient having a selectively damaged phonological loop (Baddeley et al., 1988; Papagno et al., 1991). This patient had no difficulty learning native language words but was considerably impaired in her ability to learn FL words. Papagno and his colleagues (1991) also supported the importance of the PL by suggesting that normal learners could not acquire FL words under articulatory suppression, an interference treatment that selectively affects PSTM, especially when the words differed from those of their L1. In other words, PL capacity promotes learning phonological patterns of new words, and stored knowledge of the phonological structure of the language supplements the loop. This also matches previous study evidence (Baddeley, 1986) which showed the crucial role of the PL in

vocabulary acquisition by storing unfamiliar sound patterns while long-term representations are built.

Some researchers claim that PSTM plays a more general role in SLA than just supporting vocabulary acquisition. Ellis (1996) argued that language learning is mainly sequence learning, and since STM is responsible for remembering sequential information, its role in language learning is far greater than previously supposed (cited in Kormos & Safar, 2008). Ellis and Sinclair (1996) showed experimental evidence that participants encouraged to rehearse FL utterances are better than those prevented from rehearsal by articulatory suppression at both comprehending and learning FL material, metalinguistic knowledge of grammar, accuracy in pronunciation as well as productive grammatical fluency and accuracy (cited in Kormos and Safar, 2008). STM, as a major part of sequence learning, allows short-term maintenance of sequence information, and short-term rehearsal of sequences promotes the consolidation of LTM of language sequences (Ellis & Sinclair, 1996). The connection between phonological memory and oral production skills is also supported by results from an investigation into the role of phonological memory in L2 speech production by English-speaking participants who were learning Spanish, i.e., phonological memory was found to contribute significantly to the development of L2 narrative skills and the achievement in the correct use of function words for both less proficient participants and more proficient participants, suggesting the essential role of phonological memory in narrative development at earlier stages of L2 learning and in the grammatical acquisition at later stages (O'Brien et al., 2006).

2.3.3 Short-term Memory Assessment

To assess participants' PSTM capacity, there are some measurements such as Non-word Span tests (referring to the highest number of syllables the participants could repeat in at least half of the cases), Alphabet Span tests (i.e., participants mentally reordering the words from a given list in correct alphabetical order) (Craik, 1986), or Digit Span tests (in which participants will listen to a series of numbers and will be asked to repeat them in the same order (forward span) or in reverse order (backward span) compared to what the speaker says), etc., (Botwinickand Storandt, 1974). However, one of the most widely used tests of PSTM capacity is NWR tests, which involve the presentation, memorization, and recall of non-words, i.e., to ask participants to repeat non-words of differing lengths. Non-words denote words that do not exist in the given language (or words are not lexically valid) but adhere to its phonotactic rules

(or phonologically valid). These non-words must be phonologically processed, stored, and then repeated, so the test does require both the storage and processing component. Although it is not always the case that NWR abilities are directly measuring WM and the PL due to other possible cognitive processes underlying this causing the variance in ability, NWR tests are assumingly good at measuring the capacity of WM for SLA since it is less affected by language knowledge/ experience than other assessments. Besides, recall of non-words has indicated a strong and consistent link to L2 outcomes in both children and adults (Baddeley et al., 1998; Masoura & Gathercole, 1999; O'Brien et al., 2007; Hummel, 2009).

In NWR tests, participants are asked to repeat items that they have not heard or learned before, implying that participants cannot make use of stored knowledge of the target items, and they also cannot be influenced by limited exposure to the target language or limited knowledge of words in that language (Chiat, 2015). This can be demonstrated in some studies that language experience does not affect NWR performance. For instance, in a study examining the English NWR accuracy of three groups of 7-year-old bilingual children (including L1 Korean, L1 Chinese, and L1 Spanish) with different length of exposure to English as L2, the results showed that children in these groups achieved higher overall accuracy on the English NWR test compared to that of monolingual English-speaking children (Lee & Gorman, 2012). Lee et al. (2013) also investigated performance on Korean (as L1) NWR in Korean monolingual children and Korean-English bilingual children (with L1 Korean) from 3 to 5 years old, and found no significant differences between these two groups. These two examples show that NWR tests in L1 and L2 have similar results, i.e., NWR performance is not influenced by language experience. However, other approaches suggest that children with more experience of the language tested can repeat non-words better than children with less experience. Specifically, Messer et al. (2010) conducted a study on monolingual Dutch and bilingual Turkish-Dutch 4-year-old children, and the results showed differences in these two groups, i.e., the Turkish-Dutch children had higher scores on the Turkish (as their L1) NWR test compared with Dutch children, but had lower scores on the Dutch NWR test. Sharp and Gathercole (2013) further supported the influence of language knowledge on NWR tests by comparing the performance on a Welsh NWR test of Welsh-English bilingual children with varying levels of exposure to Welsh in the home (Only Welsh at home, Only English at home, or Welsh and English at home), and they found that children's performance on sounds unique to Welsh was affected by the level of exposure to this language. The findings from these two studies show that the level of language exposure and experience of the language tested has a certain influence on NWR

performance, suggesting that the use of the NWR tests should be adopted with caution (Sharp & Gathercole, 2013).

2.4 The present study

We have just gone through several studies on the role of STM in LA that specifically show the relationship between STM and vocabulary acquisition in both L1 and L2 among children and adults (i.e., performance in NWR tests can predict vocabulary proficiency), the connection between phonological memory and oral production skills, the major part of STM in sequence learning, and the relationship between STM and reading comprehension.

The research on the role of NVR in LA also shows the link between NVR and FLL (i.e., NVR is the best predictor of achievement in FL), the connection between NVR and L2 grammar learning, the association of non-verbal IQ with oral receptive skills, and the correlation between NVR and reading comprehension - playing an essential role in the inferential process.

The present study continues to investigate the roles of NRV and STM in English grammar and vocabulary as well as further examine the stronger predictor among these two factors in FLL. Additionally, in this study, all the subjects were Vietnamese, and (besides the English NWR test) the Vietnamese NWR test was used to measure STM capacity, so it is necessary to have a brief discussion about the Vietnamese language as well as language situation in Vietnam.

Vietnamese is the national and official language in Vietnam. As classified in the early linguistic work more than 150 years ago, Vietnamese belongs to the Austroasiatic language family which also includes the Khmer language spoken in Cambodia and various smaller/ regional languages spoken in other places (SEAlang Projects, 2006; Diffloth, 2011). Besides, Vietnamese is a part of the Vietic language family which additionally consists of many minority languages used in northern and central Vietnam as well as in the Lao border areas (Hayes, 1992; SEAlang Projects, 2006). Vietnamese makes use of the Latin alphabet, so some of the same letters can be found in English (e.g., a, b, c, d, e, g, h, etc.); and the alphabetical order is, as claimed by Thompson (1965), basically similar to the order of Roman alphabet (as in English) (cited in Tai, 2013). However, compared to English which has 21 consonants and 5 vowels, the Vietnamese sound system is more complicated. Vietnamese has 17 consonant letters together with 11 compounds producing 23 consonant sounds altogether, and 8 final

consonants (including 6 consonants and 2 semi-consonants). When it comes to vowels, Vietnamese has a large number of single and compound vowel sounds including 11 monads, 29 diphthongs, and 12 triphthongs (Tran, 2010).

Among many differences between English and Vietnamese in all aspects of language, some important differences will be mentioned here since these discrepancies cause a lot of difficulties to Vietnamese learners of English. Firstly, Vietnamese has three types of phonemes, i.e., tones, consonants, and vowels; notably English does not have lexical tones (Giang, 2007). Six different tones in Vietnamese (added on the vowels) can make a lexical word change its meaning (e.g., *ma* - ghost, *má* - mother, *mà* - but, *mả* - grave, *mã* - code) and make sounds in Vietnamese different from sounds in English. Secondly, there are some sounds existing in English but not in Vietnamese, such as /tʃ/, /dʒ/, /θ/, /ð/, etc., and vice versa, sounds of Vietnamese letters containing additional diacritics (i.e., ă, â, đ, ô, ơ, ê, ư) do not exist in English. Thirdly, the number of codas available in Vietnamese is limited to a certain point, i.e., only six consonants and two semi-vowels can stand in word-final position; among the six final consonants, there are three nasal sounds (i.e., /m/, /n/, /ŋ/) and three unaspirated voiceless plosives (i.e., /p/, /t/, /k/) (see Nguyen, 2007). This can explain why many people believe that Vietnamese does not have 'ending sounds'. Also, only one final consonant can stand at a time in Vietnamese but there can be up to four final consonants (to form consonant clusters) in English, which is a challenge to Vietnamese people in English pronunciation. Fourthly, Vietnamese is an isolating language (Kim, 1936; Emeneau, 1951; Cadière, 1958; etc.) because of the absence of morphological affixes. Having no inflectional morphology means that verbs are not inflected in Vietnamese; meanwhile, English is a typical example of inflectional morphemes expressing tense and aspect by using suffixation (-ing, -ed, -en) attached to the verb or analytic use of the auxiliary 'have'. Vietnamese, instead, uses contextual or time elements (Hlavatá & Slavická, 2003) to mark such following distinctions:

(1) a. **Hôm qua** tôi chơi piano.
Yesterday I play piano.
(*I played the piano yesterday*)

b. **Ngày mai** tôi chơi piano.
Tomorrow I play piano.
(*I will play the piano tomorrow*)

As can be seen from (1a) and (1b), the verb *chơi* (play) does not change its form in the past tense and future tense in Vietnamese; however, in English, the tense morpheme *-ed* is attached to the end of the verb *play*, namely *played* to illustrate the past event in (1a) and the modal verb *will* is added before the main verb *play* to denote the future event in (1b).

In terms of grammar, one typical structure showing the difference between Vietnamese and English grammar is *wh*-questions. Vietnamese is a *Wh*-in-situ language (Trinh, 2005; Bruening & Tran, 2006), meaning that *wh*-phrases stay at the same position corresponding to non-*wh*-words, as shown below:

(2) a. Lan chơi **gì**?
Lan play what?
(*What does Lan play*?)

b.* **gì** Lan chơi?
What Lan play?
(*What does Lan play*?)

In (2a), the *wh*-word (what) *gì* stays in-situ where its corresponding non-*wh*-word is. If the question particle *gì* (what) is moved to in front of the subject *Lan*, the sentence becomes ungrammatical as shown in (2b).

In Vietnam, besides Vietnamese as the official language, many foreign languages (e.g., English, French, Chinese, Korean, etc.) are taught and learned in the Vietnamese educational system. Among them, English plays a dominant role. Since Đổi mới (Renovation) in 1986, English has become the most important and popular FL being taught, learned, and used nationally (Van, 2020). Despite not being used in daily communication as much as Vietnamese, English is "considerably visible in the linguistic space of Vietnam and prevalent in education and even some aspects of popular culture" (Van, 2020, p.1, 2). Regarding popular culture in Vietnam, specifically in TV/ movies, there are various TV programs/ movies in many FLs, and English is predominant among them. However, it is hard to conclude that English TV programs/ movies are most dominant since (young) Vietnamese people are much closer to Asian culture (e.g., Korean, Chinese, Japanese, etc.) than English-language culture.

CHAPTER 3: METHODOLOGY IN THE STUDY

This chapter describes the methodology of the study to measure the participants' NVR, their STM, and their English proficiency level. The background information part will outline the research hypothesis; meanwhile, the participants, the research design with instruments for data collection, the methods of analysis, and the ethical considerations will be discussed in the other sections.

3.1 Background information

To begin with, the following research questions were investigated to meet the purposes of the study:

- Do scores on the NVR tests (as measured on the Raven's Matrices) predict scores on the English vocabulary tests and English grammar tests?
- Does STM capacity impact the acquisition of vocabulary (based on the results on the NWR tests and English vocabulary tests)?
- Which is the stronger predictor of English learning outcomes (as shown on the English proficiency tests), NVR or STM?

In view of the literature on NVR, STM, and FLL, and considering the research questions mentioned above, the present study attempted to examine the following hypotheses:

- Scores on the English vocabulary tests and English grammar tests can be predicted from scores on the NVR tests (as measured on the Raven's Matrices). This hypothesis is formed based on the connection between NVR and FLL (e.g., grammar learning, reading comprehension, etc.) (Kristiansen, 1990; Brooks et al., 2006; Asbell et al., 2010; etc.).
- STM capacity has a positive influence on the acquisition of English vocabulary. This hypothesis is supported by the evidence that there is a connection between the ability to repeat non-words and vocabulary size (Baddeley et al., 1988; Papagno et al., 1991; Gathercole et al., 1992, 1997 1999; etc.), such that individuals with larger vocabularies perform better on NWR tests.

- STM is a stronger predictor of English proficiency as compared to NVR due to the relationship between phonological processing, STM, and vocabulary learning (e.g., Gathercole & Baddeley, 1990; Gathercole et al., 1992, 1997, 1999; Gathercole & Adams, 1993, 1994, Service, 1992; Service & Kohonen, 1995; etc.), and the important role of STM in sequence learning (Ellis & Sinclair, 1996).

3.2 Participants and settings

The participants of this study were 30 Vietnamese students from three public high schools in a central coastal city (with a population of around 1 million) in Vietnam. They were of both sexes including 15 males and 15 females in the 16 to 18 age range. The mean age of the full samples was 16.6 years, and the division of gender was made to assure the equality and generality of gender differences. Their native language was Vietnamese, and they had learned EFL at their schools. English was just a foreign-language subject, not a language of communication in school. Also, all the participating students did not have any impaired awareness or learning.

3.3 Research design

In this study, the results of all the tests were derived and analyzed in numerical data. Therefore, the study is categorized as a quantitative approach.

3.3.1 Research instruments for data collection

Multiple-choice tests were used to measure the participants' NVR skills and their proficiency in English. The NWR test, which is a PSTM test, was carried out as a predictor for vocabulary size. A background information questionnaire was also applied to enhance the insights gained from the study.

3.3.1.1 Multiple-choice tests

Multiple-choice tests require participants to choose the best answer to a question from some given options. By doing this kind of test, participants just focus on the content without formulating an answer, which consumes less processing time. The multiple-choice tests which are mentioned below were online tests. Results were automatically assessed at the end of each test, supporting the researcher in analyzing the data faster.

Raven's Progressive Matrices Test

The NVR test used in this study was the online version of Raven's Progressive Matrices test, developed by John C. Raven in 1936. The test was chosen for this study because of its popularity and reliability. This kind of test, which is used to measure fluid intelligence (Sternberg, 1995) and general cognitive/ intellectual ability (Brody, 1992; Raven, & Court, 1991), enables participants to analyze and solve complicated issues without relying upon verbal (language) skills. The test included 60 visual questions created by logical matrices. The questions were mostly to find out the missing parts of the figures or diagrams from the given options. The participants were expected to choose the correct answer among them. The questions were made in sequences from easy to difficult, and the logic of the questions was increasingly complex and difficult to distinguish. The test was taken from a source on the web[2].

English Proficiency Test of Vocabulary - LexTALE

To measure the participants' English vocabulary, the researcher administered online the LexTALE (developed by Meara and colleagues, 1996; cited by Lemhöfer & Dijkstra, 2012) - a quick, validated, and standardized test of vocabulary knowledge for medium to highly proficient speakers of English as an L2. Not only is it evaluated as a measure of English vocabulary knowledge and a good indicator of general English proficiency, but the LexTALE scores have been found to correlate well with experimental word recognition data (from lexical decision and progressive demasking experiments; Lemhöfer & Dijkstra, 2004, 2008). That is why this test, considered to meet the needs of cognitive researchers, was used in the study. The test (as a simple un-speeded visual lexical decision task) consisted of 62 trials, in each of which the participants would see a string of letters. Their task was to decide whether that was an existing English word or not. This test was also taken from a source on the web[3].

English Proficiency Test of Grammar - Cambridge Assessment English (For schools)

Like the other tests, the English proficiency test on grammar was administered online. This test, which is specially made for students at schools, was taken from Cambridge Assessment English - a website with free online practice tests for people studying for an English language exam[4]. As a part of the University of Cambridge, this site is a reliable source to take the tests from. The test included 25 questions covering a wide range of English grammar, such as tense, preposition, use of words, phrasal verbs, etc. At the end of the test, the

[2] https://brainapps.io/raven
[3] http://www.lextale.com/takethetest.html
[4] https://www.cambridgeenglish.org/test-your-english/for-schools/

participants' English level would be assessed at a CEF level (A2 to C2), which made it different from other tests spreading on social networks. By showing the number of correct answers, the test made the data analysis less time-consuming.

3.3.1.2 Non-word Repetition Test (Pseudo generator)

NWR tests are widely used to measure phonological working memory capacity as well as other language processes (i.e., speech perception, phonological encoding, phonological memory, phonological assembly, and articulation) that can describe LA in many populations (Coady & Evans, 2008). The tests are considered to be unbiased by sociocultural factors and prior knowledge because "non-words are unfamiliar and have zero frequency, so there should be no lexical support for their repetition" (cited by Coady & Evans, 2008, p.7). Some studies have also shown a connection between NWR and vocabulary size as well as new word learning (e.g., Gathercole & Baddely, 1989; Gathercole et al., 1997; Gathercole et al., 1999; etc.,). Consequently, the NWR tests were carried out to assess the participants' PSTM in the present study. The non-words were generated by Pseudo - a reliable pseudo-word generator written by Walter van Heuven[5]. The participants were presented with 16 non-words that follow English phonology (as L2) in one test and 16 non-words that follow Vietnamese phonology (as L1) in the other test. These non-words were spoken and pre-recorded by a native English speaker and a native Vietnamese speaker. The participants were asked to repeat a series of non-words of varying syllable length (1 - 4 syllables) and complex combinations of sounds. Their performance on these tests was assessed by the number of correct repetitions with no omission, substitution, or addition of sound. The list of the non-words could be found in **Appendix A**.

3.3.1.3 Questionnaire

A questionnaire with 11 alternative multiple-choice questions in English was set up to investigate factors beyond non-verbal intellectual abilities. Accordingly, the questionnaire was designed to gain information about the following factors: the average age to start learning English formally, the volume of exposure to English, or attitude/ motivation in learning English, etc. Together with the results from the tests, the information from the questionnaire gathered essential insights for the study. The questionnaire could be found in **Appendix B**.

[5] https://waltervanheuven.net/pseudo/index.html

3.3.2 Procedure

The web-based questionnaire and language tests were administered online via a reliable video conferencing software application called Zoom. This cloud platform enabled the researcher and participants to make video calls, share content, and exchange information about the study. For personal security issues, the researcher used Zoom through NTNU and followed their guidelines to secure the meeting. Zoom was only used to share the links and give instructions, i.e. no data were collected through Zoom. 30 students participated in the study, and the researcher divided those students into different groups. The division was made based on the participants' free time, and it also helped the researcher to collect data more easily thanks to a small number of participants at a time. This division did not affect the fact that all the individuals performed the same tasks. Accordingly, the tests (including the NVR test and the English proficiency tests) together with the questionnaire were administered during one session for each group. In terms of the NWR test, since the participants' repetition of non-words had to be recorded, this test was done individually, so the other participants would not be able to hear this.

The study was conducted in five parts. Limited time was set for every part, and the participants were not allowed to finish their tests and questionnaire after the allotted time. All parts of the test and questionnaire were set up in Nettskjema which is administered by the University of Oslo and NTNU by mutual agreement[6]. This ensures safe transmission of data, i.e. the results of the tests that were automatically assessed on the websites were sent and stored through this environment, not in the online tests themselves. The researcher sent invitation emails to the participants so that they could access the tests and questionnaire in Nettskjema, instructed them how to do the tests, explained all the items in the tests to the participants clearly to prevent any misunderstandings, and set the time for them.

In the first part, the participants were asked to finish the Raven's Progressive Matrices NVR test in 20 minutes. The second part and the third part of the study measured the students' competence in English with the English proficiency test on vocabulary - LexTALE, as well as the English proficiency test on grammar taken from Cambridge Assessment English, respectively. Each of these tests took 10 minutes. For the NVR test and the English proficiency tests, the participants were required to upload their test results to Nettskjema by taking screenshots of the results that show the relevant assessment. In the fourth part, the participants

[6] https://nettskjema.no/user/index.html

had 10 minutes to answer 11 questions about personal information in the questionnaire through Nettskjema. As the final part, the NWR test took place around 5 - 10 minutes, and when it was done, the participants had to upload their recordings to Nettskjema.

3.3.3 Methods of analysis

After being collected, the data were statistically analyzed with Microsoft Excel and SPSS. The scores obtained by the 30 participants in the tests were compiled by tables and column diagrams. Since the results of the English vocabulary tests were presented in percent form, the scores from the other tests were also converted from the number of the correct answers into the percentage to keep the data well-structured.

Unlike the data from the NVR test and the English proficiency test of vocabulary and grammar that were automatically assessed in the tests themselves, the data from the NWR test were processed manually by the researcher together with one non-disabled English native speaker and one non-disabled Vietnamese native speaker. Accordingly, each phoneme, vowel, or consonant, was scored as correct or incorrect regarding target phonemes. Phoneme substitutions, omissions, and additions were counted as incorrect, while phoneme distortions were counted as correct. The number of phonemes repeated correctly was divided by the total number of target phonemes. The scores of the NWR tests were then compared with the English vocabulary scores.

To evaluate the data from the questionnaire which relates to the non-cognitive factors in FLL, the answers were reviewed and classified into categories. The categories being the average age to start learning English formally, the volume of exposure to English, or attitude/ motivation in learning English, etc. The percentage of participants who chose a given response to each question was then calculated.

After the data were processed, the interrelationship between the data was assessed by using the Pearson Correlation Coefficient. Correlation explains the relationship between the variables regarding numerical values, so it was chosen to evaluate the connection between NVR, STM, and English proficiency. The correlation between the scores of the NVR test and the English proficiency tests was calculated first. After that, the correlation between the scores of the NWR test and the English proficiency tests was computed. Then, the correlation between the scores of the NVR test and the NWR test was reckoned.

In terms of the correlation analysis, the Pearson correlation coefficient (*r*) is measured on a scale varying from -1 through 0 to +1, i.e. a value of -1 refers to a complete negative correlation with all data points lying on a line for which one variable increases when the other decreases or vice versa; a value of 0 means a complete absence of linear correlation between the variables; and a value of +1 denotes a perfectly positive relationship between two variables with all data points lying on a line for which one variable increases as the other increases (Introductory Business Statistics: The Correlation Coefficient r, 2020, p. 68; Hornberger et al., 1997). The strength of the relationship can be assessed by the values of *r*, i.e., a weak correlation has values from 0.1 to 0.3, a moderate correlation has values from 0.3 to 0.5, and values higher than 0.5 denote a strong correlation (SPSS tutorials: Pearson Correlation, Kent State University Libraries, 2021). Hence, it can be perceived that the nearer the value is to zero, the weaker the relationship is. Together with the value of *r*, *p*-value (or statistical significance) is important to check "the probability of finding a given deviation from the null hypothesis (0) - or a more extreme one - in a sample" (SPSS tutorials). In other words, the *p*-value examines whether the correlation coefficient *r* (which is not zero) has statistical significance or not. A small *p*-value (≤ 0.05) means that the null hypothesis can be rejected and the correlation coefficient is statistically significant, meanwhile, a high *p*-value (> 0.05) does not ensure the correlation between the variables (SPSS tutorials).

Together with the Pearson Correlation Coefficient as a parametric test, the Mann-Whitney U test and the Kruskal-Wallis H test were used as non-parametric tests to investigate the relationship between background factors (as non-cognitive factors) and English proficiency measures since the background data of the present study was not scaled. The Kruskal-Wallis test is a distribution-free test used to compare two or more (groups of) independent variables of equal or different sample sizes. The Kruskal-Wallis test is considered as an alternative for a one-way ANOVA if the assumptions required by the latter are not met by the data, and also an extension of the Mann-Whitney test which is used for the comparison of only two independent groups. The Mann-Whitney, known as the Wilcoxon test for independent samples, is an alternative for the independent samples t-test when the assumptions required by the latter are violated. *P*-value is crucial to determine if there is any significant difference between independent groups; specifically, if the *p*-value is smaller than 0.05, the hypothesis that the difference is due to random sampling can be rejected and the samples can be concluded to have different distributions, but if the *p*-value is greater than 0.05, it cannot be concluded that the distributions differ, or there is no significant difference between the groups (SPSS tutorials).

3.4 Ethical considerations

The project was registered with and recommended by NSD - The Norwegian Centre for Research Data AS. Accordingly, the processing of personal data in this project was in accordance with data protection legislation. Participation in the project was voluntary and the participants consented themselves to participate in the whole test session of the research project with their personal data processed until the end date of the project. All information about the participants was made anonymous. The participants were allowed to withdraw from the study during the test session with no need to give the researcher a reason. Their participation in the study or withdrawal from the study would not influence their grades or relationship with the teacher in any way, nor would their performance in the tests.

The source of data did not include special categories of personal data. We processed the participants' personal data confidentially and under data protection legislation (the General Data Protection Regulation and Personal Data Act). Their responses were completely anonymous. All the files and data collected were stored safely in Nettskjema and according to NTNU's guidelines. No personal data (e.g., email addresses, names, etc.) was stored together with test scores. The data would not be stored after the end of the project, and the data subjects would not be identifiable in the thesis/ publications from the project. The informed consent letter could be found in **Appendix C**.

CHAPTER 4: DATA ANALYSIS

This chapter presents the data collected from the tests and the questionnaire, together with the data analysis. Besides, all the test scores are converted into percentages in the graphs, and percentages are used consistently throughout the chapter.

4.1 Data presentation

In this part, all the data collected from the NVR tests, the NWR tests, and the English proficiency tests, are summarized in the table of descriptive statistics. Meanwhile, the data from the questionnaire are presented in the graphs.

4.1.1 Descriptive statistics of NVR, STM, and English proficiency

In terms of the test measurement, the NVR test was carried out online and assessed automatically. It was marked out of 60 and each question carried 1 mark. The English proficiency tests include the English vocabulary test and the English grammar test. 62 trials in the English vocabulary test and 25 questions in the English grammar test were also done online and assessed automatically. For the NWR tests, participants were presented with non-words that follow Vietnamese phonology as L1 (i.e., the Vietnamese NWR test) and non-words that follow English phonology as L2 (i.e., the English NWR test). Each of the tests included 16 non-words varying from 1 to 4 syllables. The NWR tests were evaluated based on the number of phonemes repeated correctly regarding the target ones. The results from all these tests are shown in percentage (see **Appendix D** for individual results).

These descriptive results, as represented in the following table (Table 1), were used to examine the variables under consideration in the present study.

Table 1: *Descriptive statistics of NVR, STM, and English proficiency (n=30) (measured in %)*

Research variables	N	Min	Max	Mean	SD
NVR	30	51.6	88.3	73.7	10.0
STM (measured by English NWR)	30	63.7	98.9	87.5	6.4
STM (measured by Vietnamese NWR)	30	88.9	99.1	95.1	3.0

English grammar proficiency	30	20	84	49.7	15.8
English vocabulary proficiency	30	45	97.5	64.8	14.6

The results show the range of each variable based on the minimum and maximum values, the mean referring to the average of the variables' scores, and the standard deviation denoting the variation of the data (i.e., measures how far the variables' scores are from the mean).

4.1.2 Descriptive statistics for the Questionnaire data

Besides the assessment of STM and NVR as the two main concerns in this study, the evaluation of the data from the questionnaire is needed. To begin with, the average age of the participants was 16.6 years, and their average age to start learning English formally was 7.4 years. All the participants had Vietnamese as their L1, and 23.3% of them knew other languages (i.e., Chinese, Korean, French, and German) besides English and Vietnamese. 53.3% of the participants were exposed to English before school, and the charts below (Figure 1 & Figure 2) show the frequency and the ways these participants (that count 53.3% out of total) got exposure to English (as an L2) before they went to school.

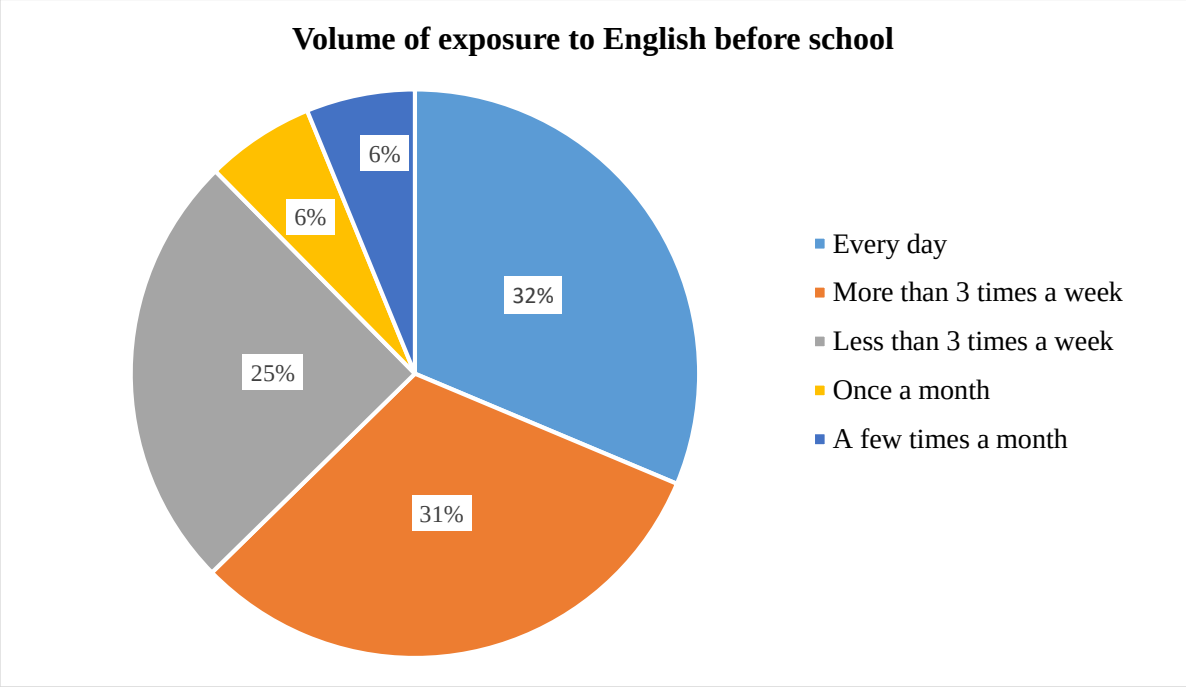

Figure 1: *Participants' volume of exposure to English before school (53.3% out of total)*

The above pie chart (Figure 1) shows the volume of exposure to English before school for 53.3% of the participants who had such exposure. As we can see from the chart, only 12%

of these students were exposed to English less than a few times a month, which means that the number of the students in this group who were exposed to English on at least a weekly basis before they were sent to school counts up to 88% (of 53.3%), approximately 46.9% out of the total number of 30 participants.

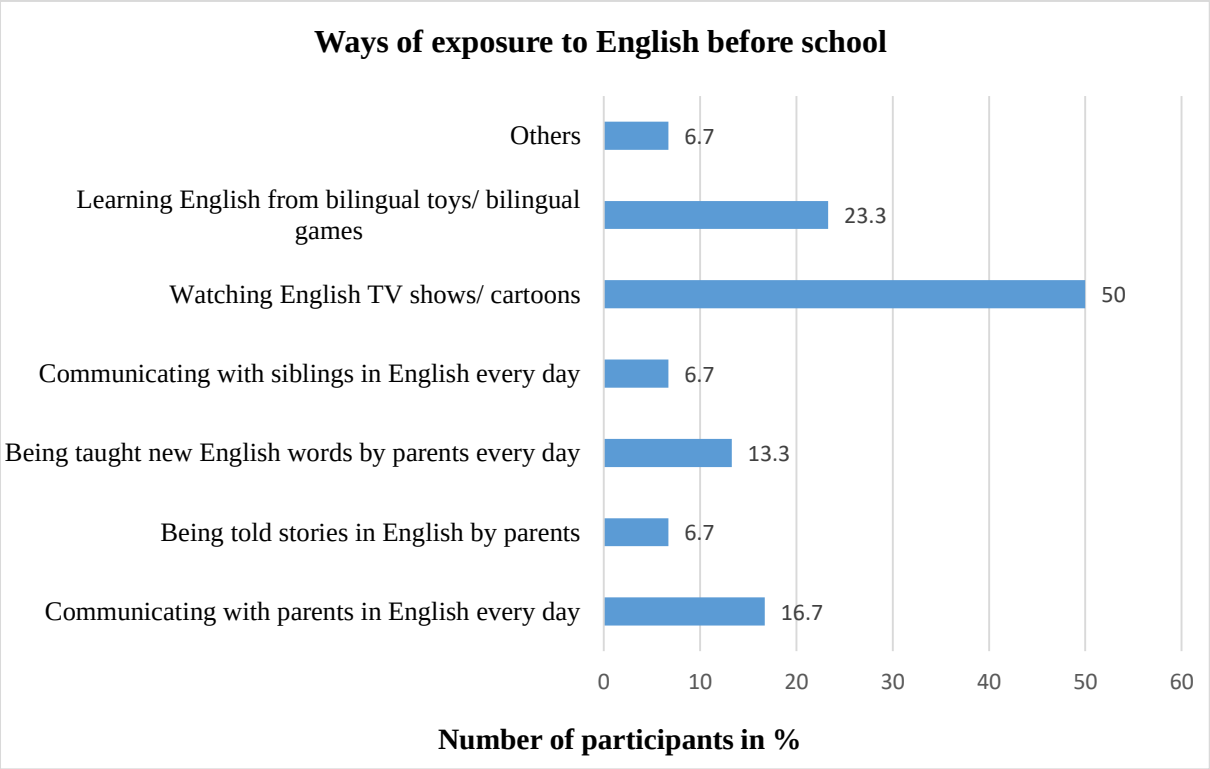

Figure 2: *Participants' ways of exposure to English before school (53.3% out of total)*

The column chart (Figure 2) above shows the various ways the participants (that count 53.3% of the total number of participants) were exposed to English prior to starting school. As calculated from the chart, 73.3% of these participants had their primary exposure to English before school from popular culture (i.e., movies, TV shows, video games, etc.), meanwhile, 43.4% of the participating students had their primary early exposure to English from their parents or family.

The following pie chart (Figure 3) illustrates the time all the participants spend learning English inside the classroom per day. From here on, figures will show data for all the participants (i.e., 30).

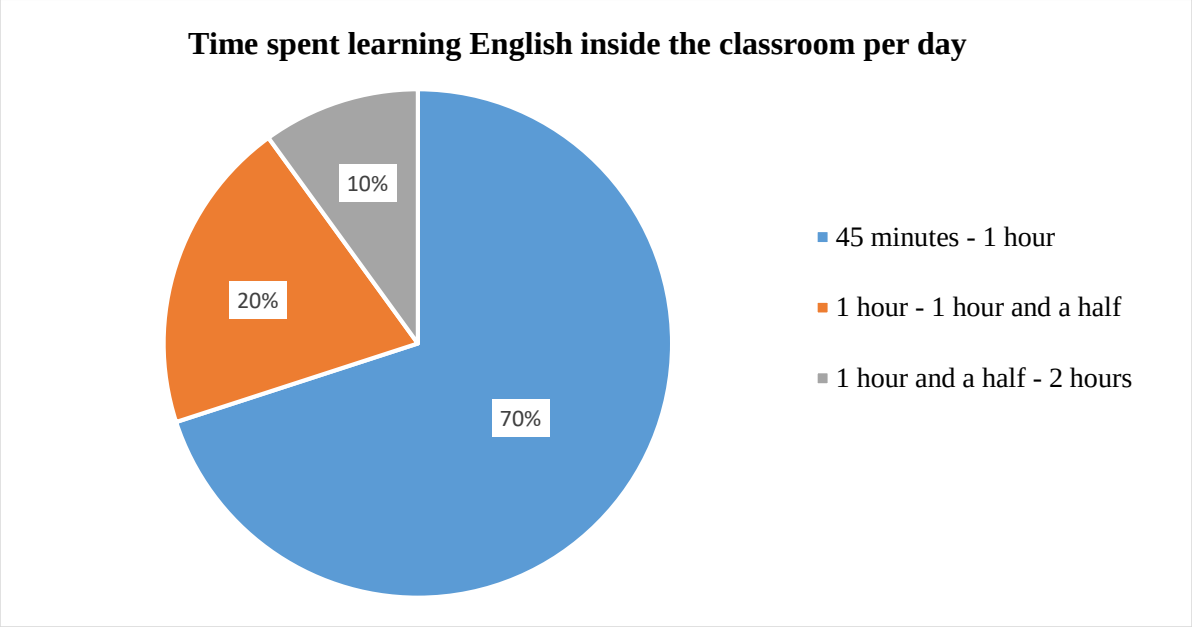

Figure 3: *Participants' time spent learning English inside the classroom per day*

As shown in Figure 3, 30% of the students spend more than one hour per day learning English inside the classroom, while up to 70% of the subjects have lessons lasting from 45 minutes to one hour, showing the average number of hours the students spend learning English at the class. Following this, the clustered column chart (Figure 4) shows the amount of time the participating students spend learning English outside the classroom setting and which activities they spend their time on in an average day.

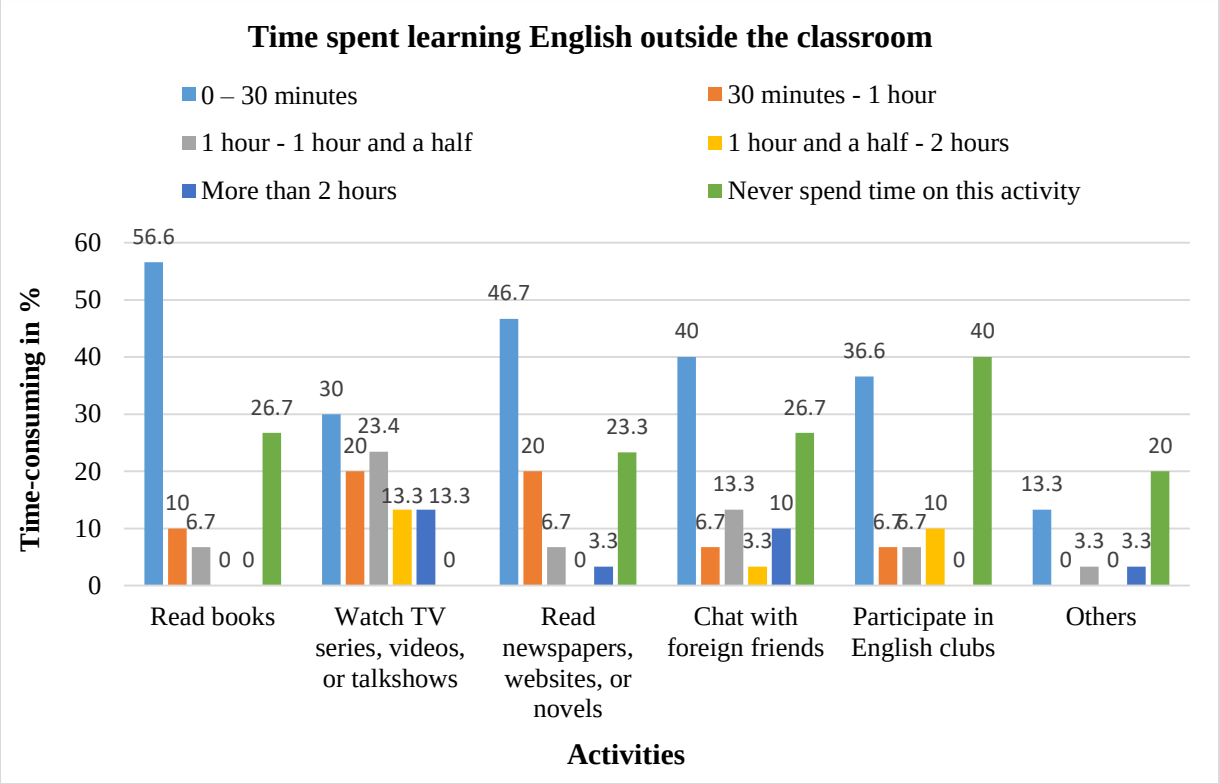

Figure 4: *Participants' time spent learning English outside the classroom per day*

As we can see from the chart (Figure 4), the option of '0-30 minutes a day' is the most frequently chosen response in all the categories, showing a tendency that the participants spend 30 minutes or less a day learning English through activities outside the classroom. Besides, 30 minutes is the maximum amount of time most of the participants spend on reading activities (e.g., read books, newspapers, novels, etc.), while the answers are more varying in the other categories. Specifically, in the 'Watch TV series, videos, or talk shows' category, the subjects have more different responses and with more subjects watching English TV programs more than an hour a day (compared to the other groups). This is also the only category of activities that all the participants spend their time on with no student reporting that they never engaged in them, which further underlines the findings in Figure 2 about popular culture (i.e., movies, TV shows, video games, etc.) being the primary exposure to English for the subjects both before and while in school.

Finally, the places where the participants learn English besides school are shown in the bar chart (Figure 5) and the reasons motivating them to learn English are represented in the clustered bar chart (Figure 6) as below:

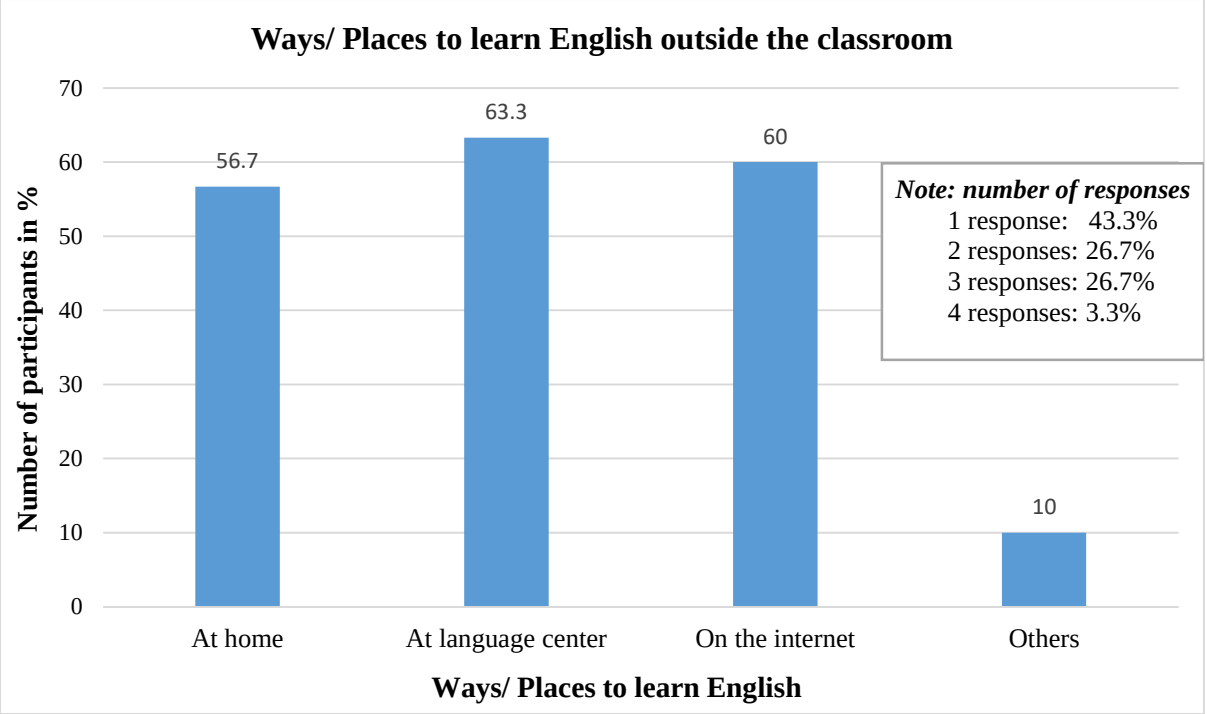

Figure 5: *Participants' ways/ places to learn English outside the classroom*

In the above column chart (Figure 5), we can see that all three of the named options for answers score very high (above 50%) since this is a multiple-response question and some of the participants must have chosen multiple responses. Specifically, 43.3% of the students chose only one response, meanwhile, the remaining which counts 56.7% of the participants chose two or more responses. In other words, more than half of the participating students have spent time learning English in two or more of the extra-curricular activities. It can be also observed that the option 'on the internet' is compatible with all other options because the internet can be used as a tool to learn English at home, at a language center, or almost anywhere else.

The following column chart (Figure 6) shows us some popular reasons the participants want to learn English.

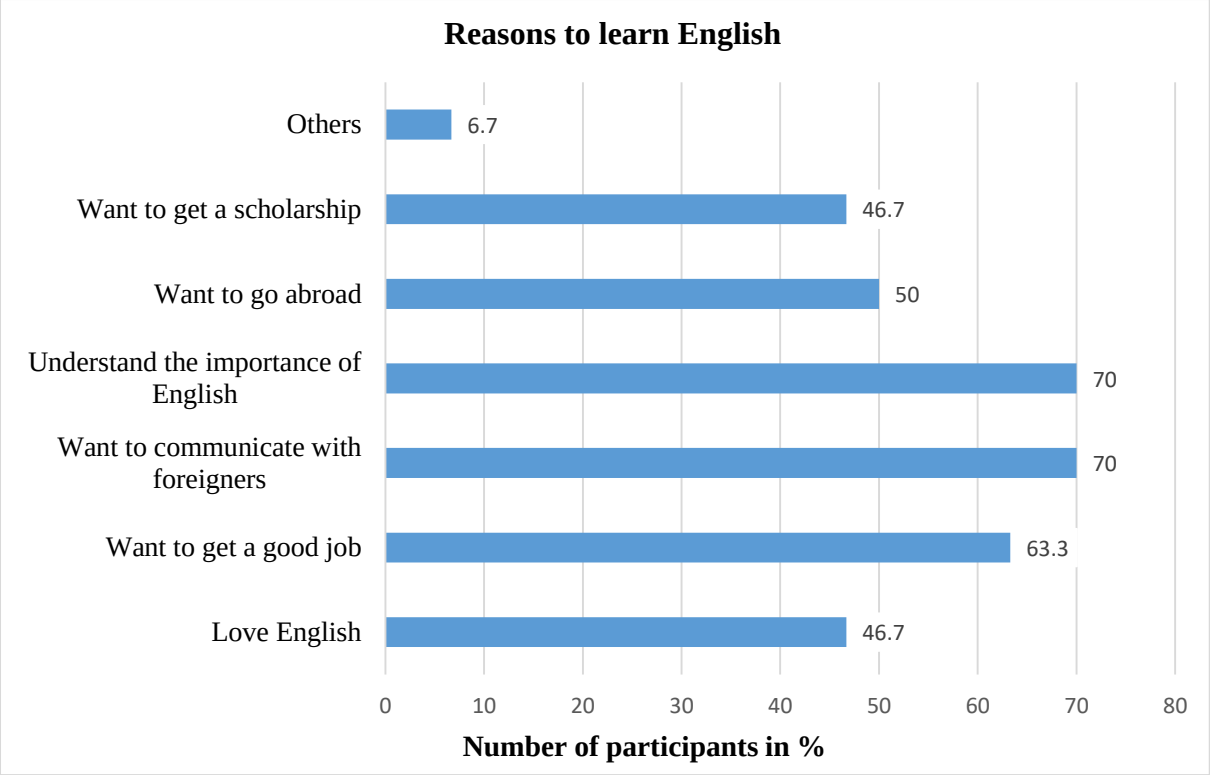

Figure 6: *Participants' reasons to learn English*

As we can see from the three top answers, the importance of being bilingual today is clear to the participants who want to learn English to communicate with foreigners and to get better job possibilities. This is also a multiple-response question and all the suggested motivations have a high percentage of responses, so we can assume that the majority of participating subjects had two or more motivations for learning English.

In short, the questionnaire data gave some main findings: (1) 53.3% of the participating students were exposed to English before school; (2) the majority of the participants spend up to an hour a day learning English at school and they mostly do not spend more than an hour a day learning English through activities outside the classroom; (3) besides school, they learn English at home and language centers, and the internet is used as a popular tool as well; (4) different activities support their English learning, but popular culture (e.g., movies, TV shows, video games, etc.) is the English source that they report spending more time on; (5) despite the various reasons to motivate their learning, the participants mainly learn English because they understand its importance in the modern life and want to communicate with foreigners as well as have better career opportunities in the future. As a result, we can see the group was heterogeneous in terms of background measures. The background (or non-cognitive) factors are also expected to have certain effects on learners' English proficiency. The relationship

between these background factors (together with cognitive factors) and English proficiency measures will be investigated in the following section.

4.2 Correlation analysis

In this section, the correlation between the scores of the tests (i.e., NVR tests, NWR tests, and the English proficiency tests) is analyzed to see the influence of the two cognitive factors (i.e., NVR and STM) on English proficiency. The correlation between these factors is illustrated by scatter diagrams with trend lines. As mentioned in chapter 3, the Pearson Correlation Coefficient is used as a parametric measure of the linear correlation of variables. Besides that, the relationship between the background factors from the questionnaire and the English proficiency is examined by the Mann-Whitney U test (used to accommodate two groups of an independent variable) and the Kruskal-Wallis H test (used to accommodate three or more groups of an independent variable) as non-parametric measures.

4.2.1 Correlation between NVR and English proficiency

Correlation between NVR and English vocabulary proficiency

Figure 7 below represents the correlation between NVR and English vocabulary proficiency based on the NVR test scores and the English vocabulary test scores.

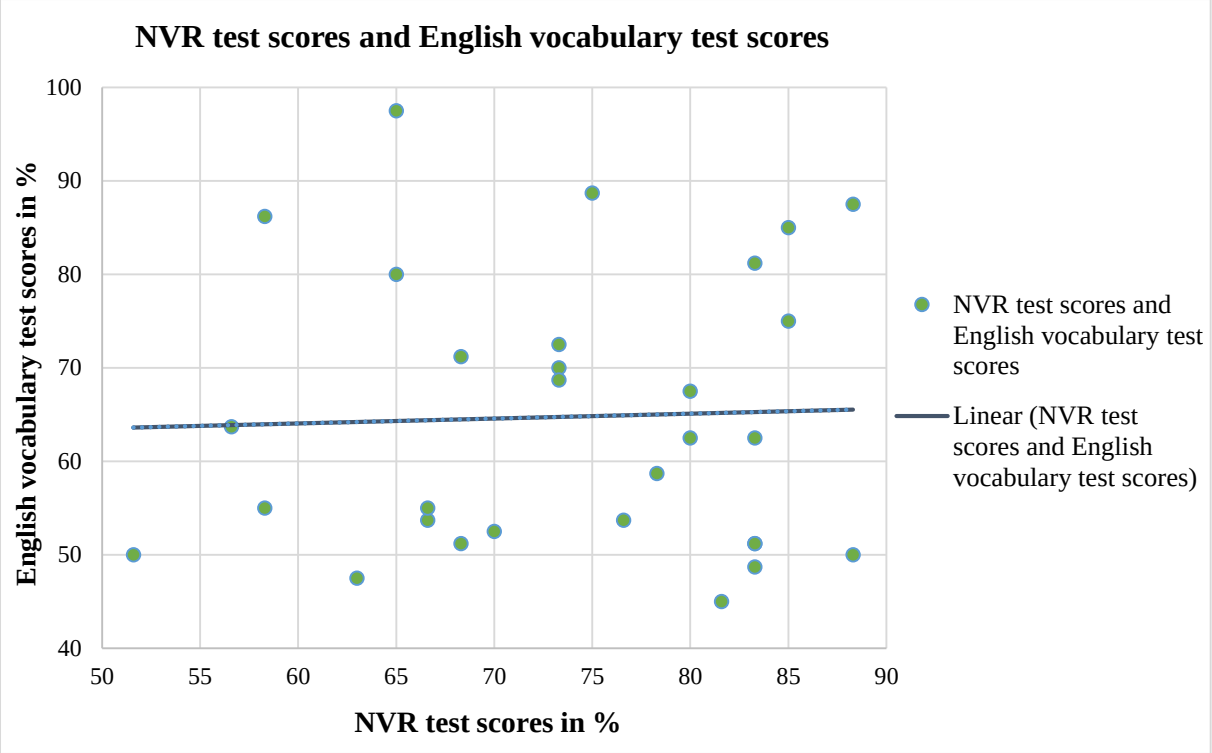

Figure 7: *Correlation between NVR and English vocabulary proficiency*

The correlation between the NVR test scores and English vocabulary test scores is shown clearly in the scatter diagram above (Figure 7). As we can see, the data points/ dots are spread out in the graph and the linear is almost a horizontal line without going up or down, showing no trend to the data. In terms of the correlation coefficient, NVR and English vocabulary proficiency were found to be uncorrelated with r (30) = 0.03, p = 0.85. The result is not significant at $p \leq 0.05$. As a result, it can be said that there is no relationship between the participants' NVR and their English vocabulary proficiency. That is to say, high or low NVR does not have a significant impact on learners' proficiency in acquiring English vocabulary.

Correlation between NVR and English grammar proficiency

Figure 8 illustrates the correlation between NVR and English grammar proficiency based on the NVR test scores and the English grammar test scores.

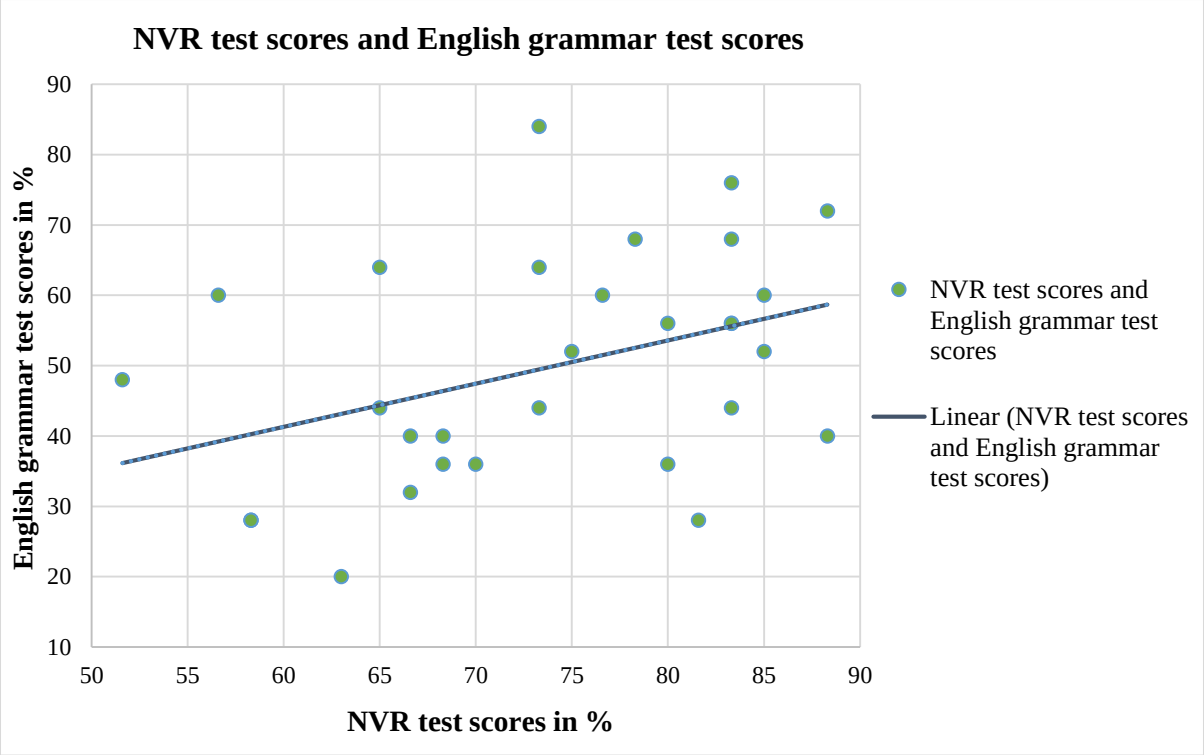

Figure 8: *Correlation between NVR and English grammar proficiency*

From the scatter diagram above (Figure 8), we can see that the data points come closer to form the trend line which also goes up steadily. This shows a certain connection between the participants' NVR and their possibility to acquire English grammar. NVR and English grammar proficiency were found to be moderately positively correlated, $r\,(30) = 0.39$, $p = 0.03$. The result is significant at $p \leq 0.05$. A moderate correlation coefficient shows a relationship between the variables. This implies that learners with higher NVR are more accurate on English grammar than ones with lower NVR.

4.2.2 Correlation between STM and English proficiency

Correlation between STM and English vocabulary proficiency

The relationship between STM and English vocabulary proficiency based on the English NWR test scores and the English vocabulary test scores are illustrated in Figure 9 below.

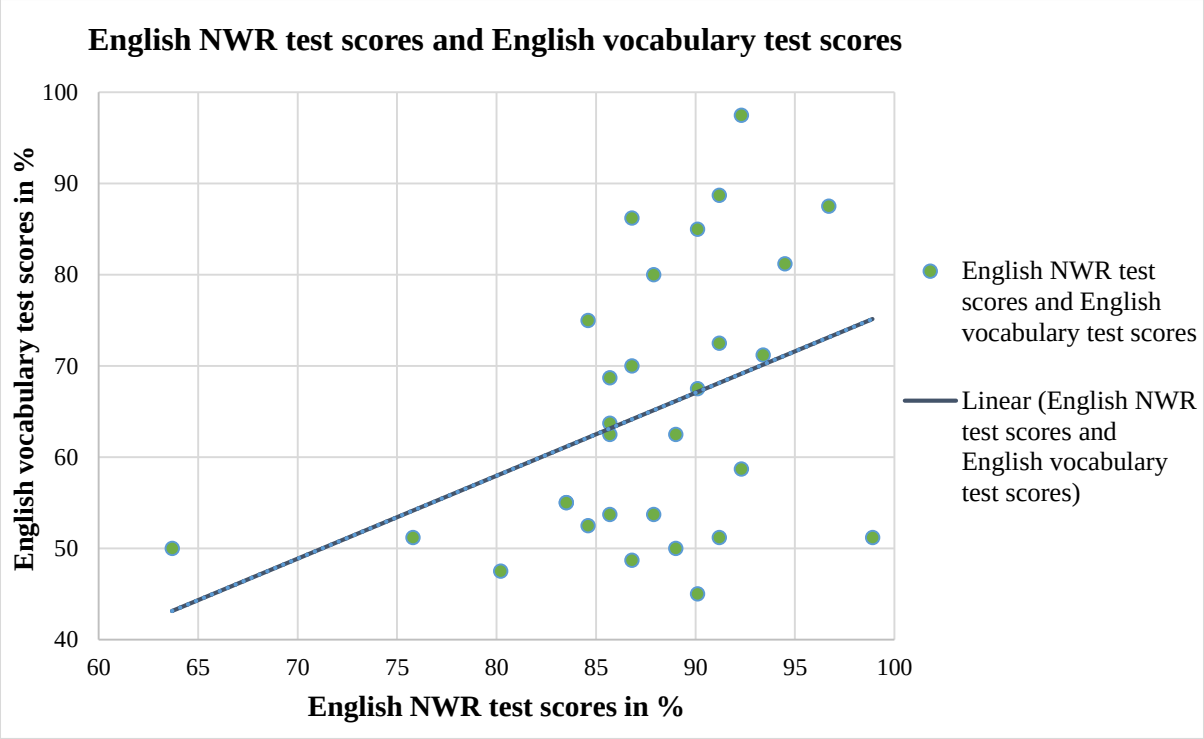

Figure 9: *Correlation between STM (as measured by the English NWR test) and English vocabulary proficiency*

As shown by Figure 9, the data points lie close together to make the trend line, implying a tendency that the participants with higher scores in the English NWR test got higher scores in the English vocabulary test and the participants with lower scores in the English NWR test got lower scores in the English vocabulary test. STM, as measured by the English NWR test, and English vocabulary proficiency were found to be moderately positively correlated, r (30) = 0.40[7], p = 0.02. The result is significant at $p \leq 0.05$. A glance at the trend line which goes up firmly, and the moderate positive value of r make it clear that STM, as measured by the English NWR test, and English vocabulary proficiency are correlated, or learners with better STM have larger English vocabulary.

On the other hand, the Vietnamese NWR test result did not support this relationship, as shown in the graph (Figure 10) below:

[7] r (30) = 0.399 ≈ 0.40

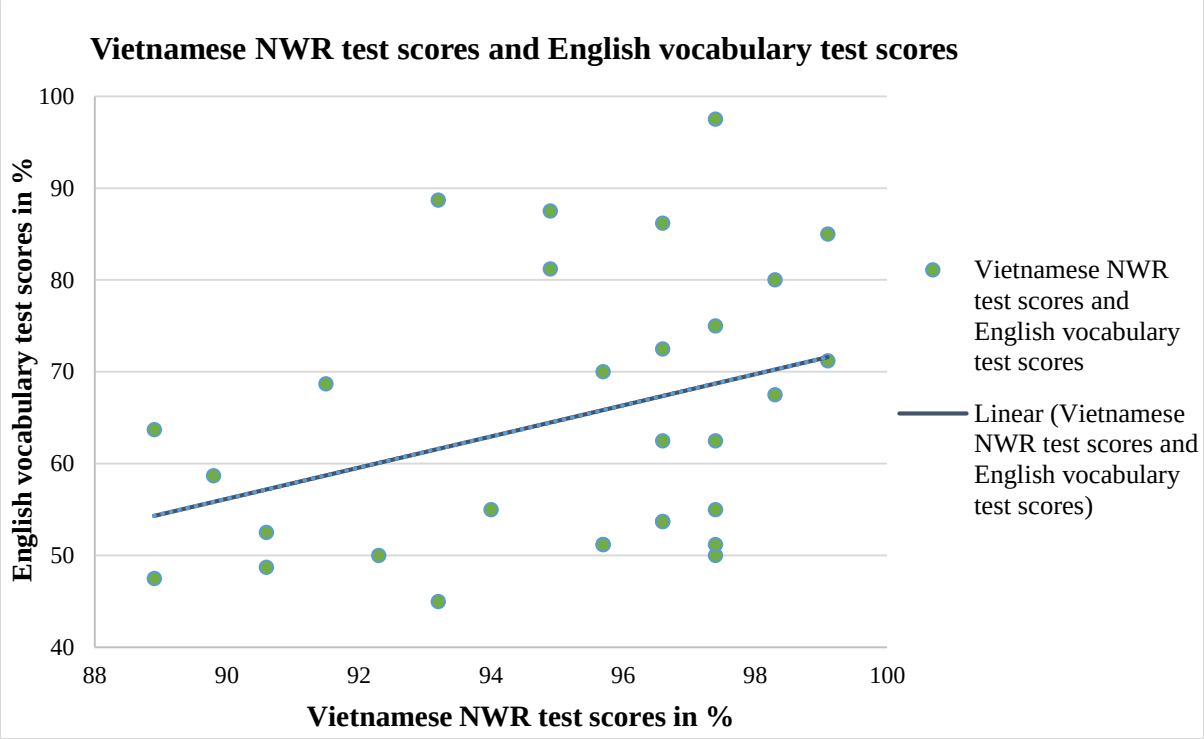

Figure 10: *Correlation between STM (as measured by the Vietnamese NWR test) and English vocabulary proficiency*

Although there is a trend in the data, STM, as measured by the Vietnamese NWR, and English vocabulary proficiency were found to be uncorrelated, r (30) = 0.34, p = 0.06[8]. The result is not significant at $p \leq 0.05$. As a result, it can be said that there is no significant correlation between STM, assessed by the Vietnamese NWR test, and proficiency in acquiring English vocabulary.

Correlation between STM and English grammar proficiency

When it comes to the correlation of STM and English grammar proficiency, data from the English NWR test and Vietnamese NWR test in comparison with the English grammar test showed zero correlation between these variables, as shown by the graphs below (Figure 11 & Figure 12).

[8] $p = 0.0579 \approx 0.06$

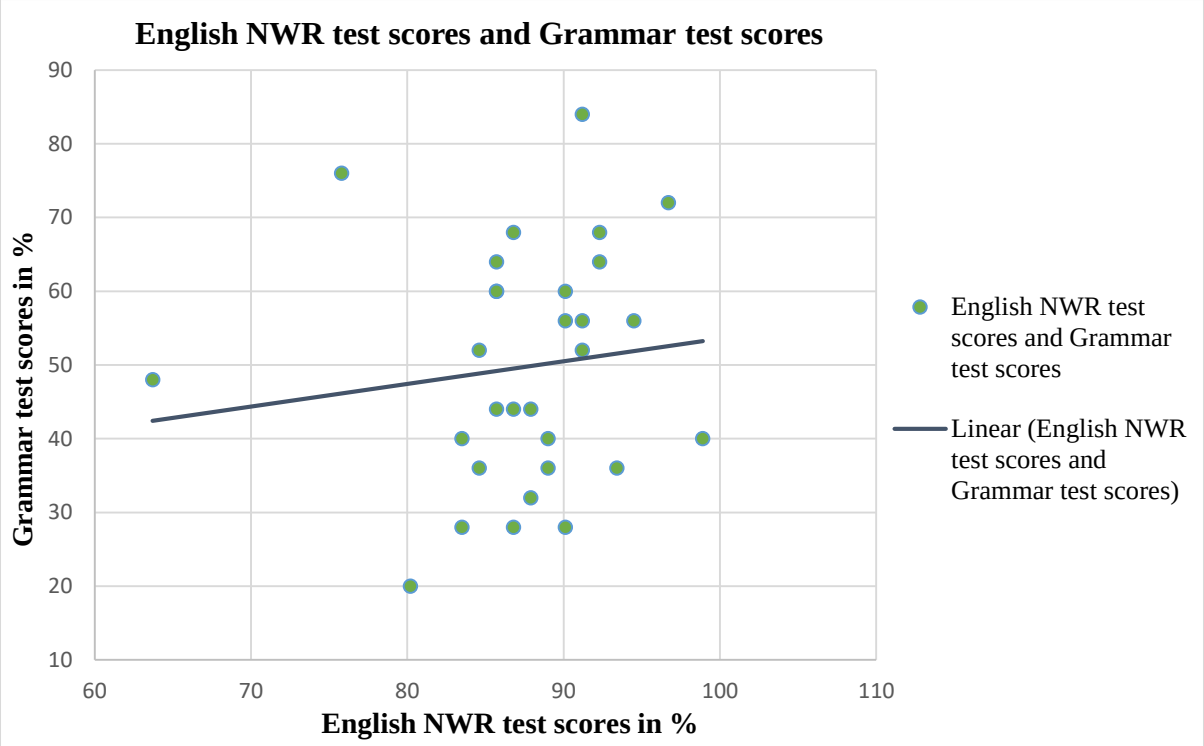

Figure 11: *Correlation between STM (as measured by the English NWR test) and English grammar proficiency*

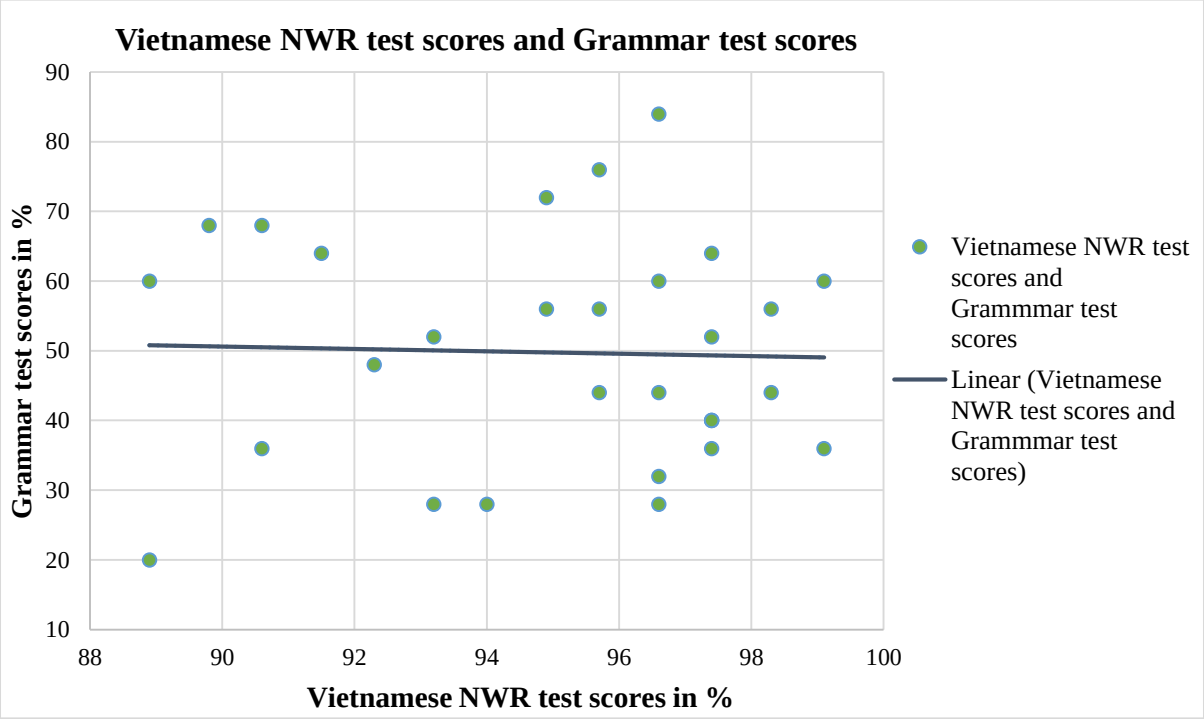

Figure 12*: Correlation between STM (as measured by the Vietnamese NWR test) and English grammar proficiency*

In these graphs, the data points are spread out even more, showing no correlation between the variables. Accordingly, STM, as measured by the English NWR test, and English grammar proficiency were found to be insignificantly correlated, r (30) = 0.12, p = 0.51. The result is not significant at $p \leq 0.05$. Meanwhile, the r-value of STM, as measured by the Vietnamese NWR test, and English grammar proficiency was in fact negative, r (30) = -0.03, indicating a possible negative relationship. However, the result is not significant at $p \leq 0.05$ with p = 0.86, so the correlation was not significant. Thus, based on these results, we can conclude that there is no connection between learners' STM capacity and their grammatical proficiency.

4.2.3 Correlation between NVR and STM

This part analyzes the relationship between NVR and STM based on the NVR test scores and the NWR test scores. The relationship between STM, as measured by the English NWR test, and NVR is illustrated in Figure 13 below.

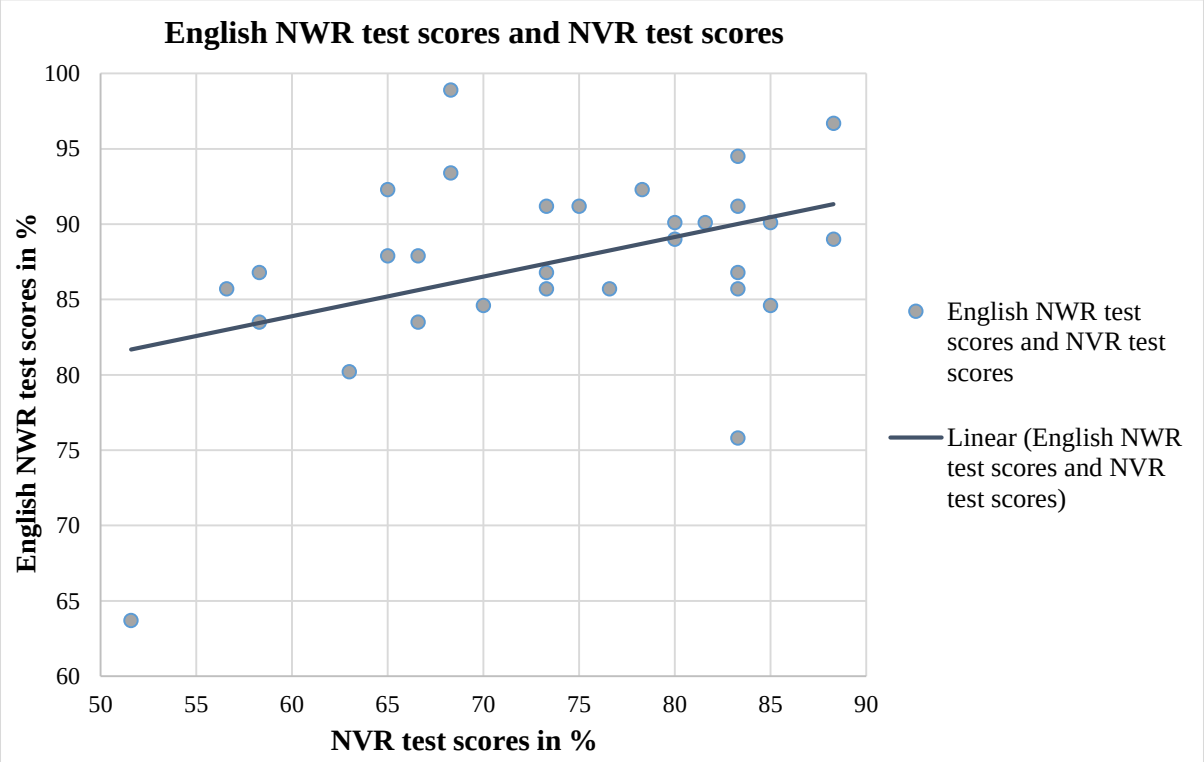

Figure 13: *Correlation between STM (as measured by the English NWR test) and NVR*

As can be seen from the scatter diagram above (Figure 13), the data points quite closely follow the linear pattern, indicating a trend to the data. Accordingly, STM, as measured by the English NWR test, and NVR were found to be moderately positively correlated, r (30) = 0.41, p = 0.02. The result is significant at $p \leq 0.05$. This result indicates a correlation between STM and NVR,

i.e., learners with higher NVR have better STM capacity and vice versa. Nevertheless, there is no correlation between STM, as assessed by the Vietnamese NWR test, and NVR, as represented in Figure 14 below.

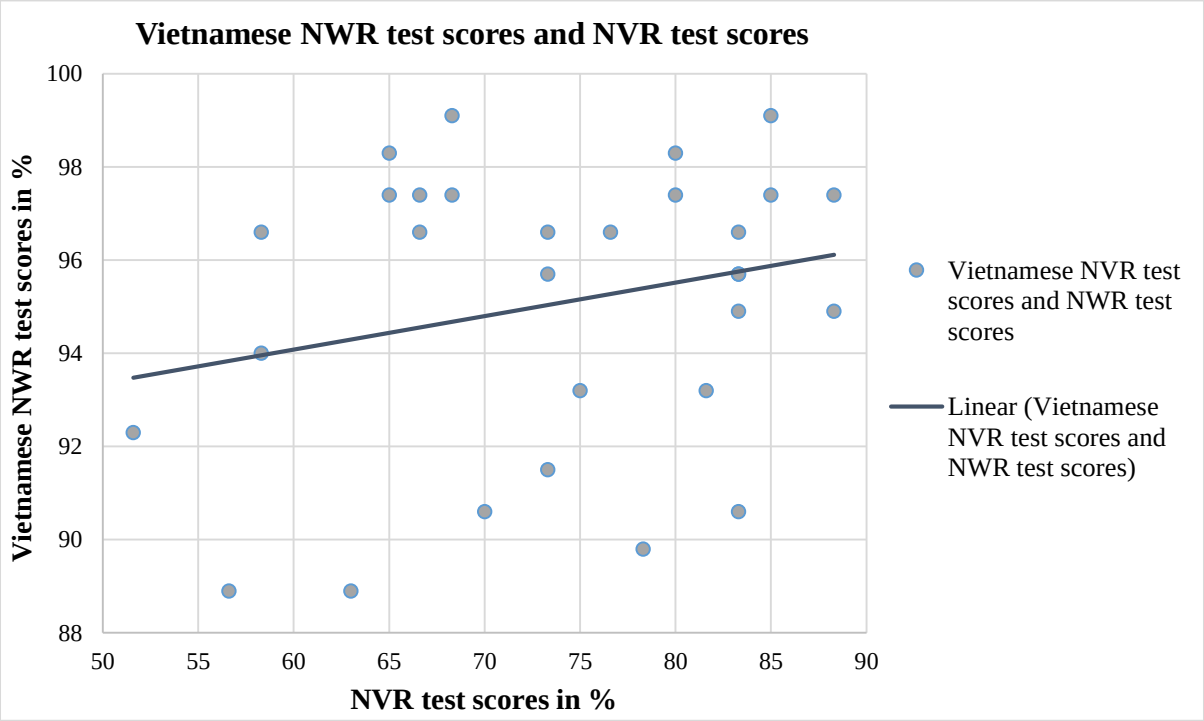

Figure 14: *Correlation between STM (as measured by the Vietnamese NWR test) and NVR*

As shown in the scatterplot above (Figure 14), there does not appear to be an obvious trend to the data points that are just spread out all over the place. Even though the *r*-value of STM, as measured by the Vietnamese NWR test, and NVR was found to be (weakly) positive, $r\ (30) = 0.23$, the result is not significant at $p \leq 0.05$ (i.e., $p = 0.20$), showing a zero correlation between these two variables.

4.2.4 Background factors in connection with English proficiency

The influence of the background factors (i.e., age, gender, exposure to English before school, time spent learning English inside the classroom, time spent learning English through activities outside the classroom, number of reasons to learn English, and possibility to know other languages) on the participants' English proficiency is shown by the tables below that summarize data from the questionnaire and the English proficiency tests. The significance level (*p*-value) is set to 0.05 in both the Kruskal-Wallis test and the Mann-Whitney test.

Table 2: *Descriptive statistics and Kruskal-Wallis analysis results for English proficiency scores (measured in %) using age as the grouping variable (n=30)*

Ranks			
	Age	N	Mean Rank
Vocabulary	16	15	18.40
	17	11	11.27
	18	4	16.25
Grammar	16	15	15.53
	17	11	12.91
	18	4	22.50

Test Statistics[a,b]		
	Vocabulary	Grammar
Chi-Square	4.201	3.503
df	2	2
Asymp. Sig. (2-tailed)	0.122	0.174

a. Kruskal Wallis Test

b. Grouping Variable: Age

The Kruskal-Wallis test was conducted to examine the differences on the English proficiency test scores according to the participants' age. No significant differences (Vocabulary: p = 0.122; Grammar: p = 0.174; $p > 0.05$) were found among the three age categories (i.e., 16, 17, 18), showing that age does not have a significant impact on the participants' English performance.

Table 3: *Descriptive statistics and Mann-Whitney analysis results for English proficiency scores (measured in %) using gender as the grouping variable (n=30)*

Ranks				
	Gender	N	Mean Rank	Sum of Ranks
Vocabulary	Female	15	15.13	227
	Male	15	15.87	238

Grammar	Female	15	15.83	237.5
	Male	15	15.17	227.5

Test Statistics[a]		
	Vocabulary	Grammar
Mann-Whitney U	107	107.5
Wilcoxon W	227	227.5
Z	-.228	-.208
Asymp. Sig. (2-tailed)	0.819	0.835
Exact Sig. [2*(1-tailed Sig.)]	0.838[b]	0.838[b]

a. Grouping variable: Gender

b. Not corrected for ties.

The Mann-Whitney test was used to investigate the differences on the English proficiency test scores according to the participants' gender. Here we see that the *p*-values, quoted next to Asymp. Sig. (2-tailed), are greater than 0.05 (i.e., Vocabulary: $p = 0.819$, Grammar: $p = 0.835$), which means that no statistically significant differences were found. In other words, gender is not the factor affecting the students' English proficiency.

Table 4: *Descriptive statistics and Mann-Whitney analysis results for English proficiency scores (measured in %) using exposure to English before school as the grouping variable (n=30)*

Ranks				
	Exposure to English before school	N	Mean Rank	Sum of Ranks
Vocabulary	Exposed	16	15.63	250
	Not exposed	14	15.36	215
Grammar	Exposed	16	15.13	242
	Not exposed	14	15.93	223

Test Statistics[a]		
	Vocabulary	Grammar
Mann-Whitney U	110	106
Wilcoxon W	215	242

Z	-.083	-.250
Asymp. Sig. (2-tailed)	0.934	0.802
Exact Sig. [2*(1-tailed Sig.)]	0.951[b]	0.822[b]

a. Grouping variable: Exposure to English before school

b. Not corrected for ties.

In terms of the participants' exposure to English before school, it was expected that participants who were exposed to English before school could learn English better. However, based on the Mann-Whitney test statistics, no significant differences (Vocabulary: $p = 0.934$, Grammar: $p = 0.802$; $p > 0.05$) were found among these two categories. Consequently, it can be said that English proficiency is not affected by early exposure to English.

Table 5*: Descriptive statistics and Mann-Whitney analysis results for English proficiency scores (measured in %) using time spent learning English inside the classroom as the grouping variable (n=30)*

Ranks				
	Time spent inside the classroom	N	Mean Rank	Sum of Ranks
Vocabulary	45 minutes – 1 hour	21	15.67	329
	1 hour – 2 hours	9	15.11	136
Grammar	45 minutes – 1 hour	21	15.57	327
	1 hour – 2 hours	9	15.33	138

Test Statistics[a]		
	Vocabulary	Grammar
Mann-Whitney U	91	93
Wilcoxon W	136	138
Z	-.159	-.068
Asymp. Sig. (2-tailed)	0.874	0.946
Exact Sig. [2*(1-tailed Sig.)]	0.894[b]	0.965[b]

a. Grouping variable: Time spent learning English inside the classroom

b. Not corrected for ties.

The findings from the Mann-Whitney test also indicated a zero correlation between participants' time spent learning English in class and their English performance with *p*-values > 0.05 (Vocabulary: $p = 0.874$, Grammar: $p = 0.946$).

We presume that the time the participants spend learning English through extra-curricular activities has certain effects on their English achievement. These activities are categorized into reading activities, popular culture, and interactive activities. Table 6 & 7 below show descriptive statistics and Kruskal-Wallis analysis results for English vocabulary and grammar scores using participants' time spent on reading activities (i.e., English books and newspapers, novels, etc.) as the grouping variable.

Table 6: *Descriptive statistics and Kruskal-Wallis analysis results for English proficiency scores (measured in %) using time spent reading English books as the grouping variable (n=30)*

Ranks			
	Time spent reading English books	N	Mean Rank
Vocabulary	Less than 30 minutes	17	14.18
	More than 30 minutes	5	23.00
	Never	8	13.63
Grammar	Less than 30 minutes	17	16.59
	More than 30 minutes	5	17.30
	Never	8	12.06

Test Statistics[a,b]		
	Vocabulary	Grammar
Chi-Square	4.384	1.699
df	2	2
Asymp. Sig. (2-tailed)	0.112	0.428

a. Kruskal Wallis Test

b. Grouping Variable: Time spent reading English books

The Kruskal-Wallis test was conducted to examine the differences on the English proficiency test scores according to the participants' time spent reading English books. The mean rank of the participants who spend more than 30 minutes a day reading English books is highest and

the mean rank of the participants who never spend time on reading English books is lowest for both Vocabulary and Grammar, implying a tendency that the more time students spend on reading English books, the better their English proficiency is. However, the test statistics showed no significant differences (Vocabulary: $p = 0.112$; Grammar: $p = 0.428$; $p > 0.05$) among the three categories of time spent on reading English books (i.e., less than 30 minutes, more than 30 minutes, and never).

Table 7: *Descriptive statistics and Kruskal-Wallis analysis results for English proficiency scores (measured in %) using time spent reading English newspapers, novels, etc. as the grouping variable (n=30)*

Ranks			
	Time spent reading English newspapers, novels, etc.	N	Mean Rank
Vocabulary	Less than 30 minutes	14	14.86
	More than 30 minutes	9	15.67
	Never	7	16.57
Grammar	Less than 30 minutes	14	14.54
	More than 30 minutes	9	17.06
	Never	7	15.43

Test Statistics[a,b]		
	Vocabulary	Grammar
Chi-Square	0.182	0.452
df	2	2
Asymp. Sig. (2-tailed)	0.913	0.798

a. Kruskal Wallis Test

b. Grouping Variable: Time spent reading English newspapers, novels, etc.

There were also no significant differences (Vocabulary: $p = 0.913$; Grammar: $p = 0.798$; $p > 0.05$) between time spent reading English newspapers/ novels and the English test scores, which again confirms that the level of the participants' English proficiency was not affected by the amount of time used for reading activities.

Table 8: *Descriptive statistics and Mann-Whitney analysis results for English proficiency scores (measured in %) using time spent on popular culture (e.g., watching English TV programs/ movies, etc.) as the grouping variable (n=30)*

Ranks				
	Time spent on popular culture	N	Mean Rank	Sum of Ranks
Vocabulary	Less than 1 hour	15	13.50	202.50
	More than 1 hour	15	17.50	262.50
Grammar	Less than 1 hour	15	13.03	195.50
	More than 1 hour	15	17.97	269.50
Test Statistics[a]				
			Vocabulary	Grammar
Mann-Whitney U			82.5	75.5
Wilcoxon W			202.5	195.5
Z			-1.245	-1.539
Asymp. Sig. (2-tailed)			0.213	0.124
Exact Sig. [2*(1-tailed Sig.)]			0.217[b]	0.126[b]

a. Grouping variable: Time spent on popular culture

b. Not corrected for ties.

Among activities outside the classroom, watching English TV programs or popular culture is the only category of activities that all the participants spent their time on (as mentioned in section 4.1.2, Figure 4), so it was expected to be a potential factor having impacts on English learning. As shown in table 8, the mean rank and sum of ranks of the students who spend more than one hour on popular culture are higher than the ones who spend less than one hour on this activity, which shows a trend that the more time the students spend on watching English TV programs, the better their English proficiency is. Despite that, the Mann-Whitney statistics demonstrated the opposite that there is no significant difference between the participants' time spent on learning English through popular culture and their English efficiency. Accordingly, the *p*-values of Vocabulary and Grammar were greater than 0.05, i.e., 0.213 and 0.124 respectively.

Table 9 & 10 below show descriptive statistics and Kruskal-Wallis analysis results for English vocabulary and grammar scores using time spent on interactive activities (i.e., chatting with foreigners and joining English clubs) as the grouping variable.

Table 9: *Descriptive statistics and Kruskal-Wallis analysis results for English proficiency scores (measured in %) using time spent chatting with foreigners as the grouping variable (n=30)*

Ranks			
	Time spent chatting with foreigners	N	Mean Rank
Vocabulary	Less than 30 minutes	12	14.00
	More than 30 minutes	10	17.70
	Never	8	15.00
Grammar	Less than 30 minutes	12	17.17
	More than 30 minutes	10	13.80
	Never	8	15.13
Test Statistics[a,b]			
		Vocabulary	Grammar
Chi-Square		1.000	0.822
df		2	2
Asymp. Sig. (2-tailed)		0.606	0.663

a. Kruskal Wallis Test
b. Grouping Variable: Time spent chatting with foreigners

The Kruskal-Wallis test was conducted to examine the differences on the English proficiency test scores according to the participants' time spent chatting with foreigners as an interactive activity. No significant differences were found among the three categories of time (i.e., less than 30 minutes, more than 30 minutes, and never) with *p*-values of Vocabulary and Grammar were greater than 0.05 (i.e., Vocabulary: $p = 0.606$; Grammar: $p = 0.663$). The same results from the Kruskal-Wallis test on the English proficiency test scores and the participants' time spent on English clubs are shown below:

Table 10: *Descriptive statistics and Kruskal-Wallis analysis results for English proficiency scores (measured in %) using time spent joining English clubs as the grouping variable (n=30)*

Ranks			
	Time spent joining English clubs	N	Mean Rank
Vocabulary	Less than 30 minutes	11	16.64
	More than 30 minutes	7	13.71
	Never	12	15.50
Grammar	Less than 30 minutes	11	18.55
	More than 30 minutes	7	17.14
	Never	12	11.75

Test Statistics[a,b]		
	Vocabulary	Grammar
Chi-Square	0.472	3.760
df	2	2
Asymp. Sig. (2-tailed)	0.790	0.153

a. Kruskal Wallis Test

b. Grouping Variable: Time spent joining English clubs

The *p*-values of Vocabulary and Grammar were respectively 0.790 and 0.153 that are also greater than 0.05. The findings from these two tests imply no relationship between learners' time spent on interactive activities and their English performance.

Table 11: *Descriptive statistics and Kruskal-Wallis analysis results for English proficiency scores (measured in %) using number of reasons to learn English as the grouping variable (n=30)*

Ranks			
	Number of reasons to learn English	N	Mean Rank
Vocabulary	1	8	16.31
	3	6	12.92
	4	5	11.80
	5	6	13.00

	6	5	24.00
Grammar	1	8	13.44
	3	6	10.17
	4	5	18.60
	5	6	13.33
	6	5	24.70

Test Statistics[a,b]		
	Vocabulary	Grammar
Chi-Square	6.625	9.140
df	4	4
Asymp. Sig. (2-tailed)	0.157	0.058

a. Kruskal Wallis Test

b. Grouping Variable: Number of reasons to learn English

Considered as one of the most important predictors of language acquisition, motivation was expected to have a relationship with English proficiency. The Kruskal-Wallis test was conducted to examine the differences on the English proficiency test scores according to the participants' reasons to learn English. From Table 11, we can see that participants having the most reasons to learn English get the highest scores in both English Vocabulary and Grammar tests. Nevertheless, the statistics test denied the significant differences (Vocabulary: $p = 0.157$; Grammar: $p = 0.058$; $p > 0.05$) between English test scores and the number of reasons to learn English, indicating that motivation does not influence the learners' proficiency in English.

Table 12: *Descriptive statistics and Mann-Whitney analysis results for English proficiency scores (measured in %) using possibility to know other languages as the grouping variable (n=30)*

Ranks				
	Possibility to know other languages	N	Mean Rank	Sum of Ranks
Vocabulary	Know	7	17.14	120
	Do not know	23	15.00	345
Grammar	Know	7	15.00	105
	Do not know	23	15.65	360

Test Statistics[a]		
	Vocabulary	Grammar
Mann-Whitney U	69	77
Wilcoxon W	345	105
Z	-.564	-.172
Asymp. Sig. (2-tailed)	.572	.863
Exact Sig. [2*(1-tailed Sig.)]	.598[b]	.886[b]

a. Grouping variable: Possibility to know other languages

b. Not corrected for ties.

Finally, we believed that students knowing other languages besides English and Vietnamese have better proficiency in English, but no significant differences between the possibility to know other languages and English test scores were found ((Vocabulary: $p = 0.572$; Grammar: $p = 0.863$; $p > 0.05$).

In brief, not as we expected, there was no relationship between background factors and English proficiency in the present study, giving some implications that will be mentioned in Discussion chapter.

4.2.5 Data analysis summary

The results of correlations between NVR, STM, and English proficiency are summarized in the following table (Table 13). Accordingly, the study demonstrated significant correlations between (1) NVR and English grammar, (2) STM, as measured by the English NWR test, and English vocabulary, and (3) STM, as measured by the English NWR test, and NVR.

Table 13: *Summary of correlations between NVR, STM, and English proficiency*

Correlation between (.) and (.)	Correlation efficient (*r*)	P-value	Implication
NVR and English vocabulary	0.03	0.85 (not significant at p≤.05)	Non-significant correlation

NVR and English grammar	0.39	0.03 (significant at p≤.05)	Significant correlation
STM (through English NWR test) and English vocabulary	0.40	0.02 (significant at p≤.05)	Significant correlation
STM (through Vietnamese NWR test) and English vocabulary	0.34	0.06 (not significant at p≤.05)	Non-significant correlation
STM (through English NWR test) and English grammar	0.12	0.51 (not significant at p≤.05)	Non-significant correlation
STM (through Vietnamese NWR test) and English grammar	-0.03	0.86 (not significant at p≤.05)	Non-significant correlation
STM (through English NWR test) and NVR	0.41	0.02 (significant at p≤.05)	Significant correlation
STM (through Vietnamese NWR test) and NVR	0.23	0.20 (not significant at p≤.05)	Non-significant correlation

The study also showed no connection between the background/ non-cognitive factors and English proficiency, indicating that all the correlations above are not influenced by the background factors. The next chapter will give us more insights into this matter.

CHAPTER 5: DISCUSSION OF THE RESULTS

In this present study, we aimed to examine the impact of NVR and STM capacity on English learners' competency, and thereby discover the roles of these two factors in learning EFL. The study attempted to answer the questions of (1) whether NVR scores predict scores on the English proficiency tests, (2) whether STM capacity impacts English vocabulary acquisition, and (3) which the stronger predictor of English learning outcomes is between NVR and STM.

Firstly, we hypothesized that scores on the English proficiency tests could be predicted from scores on the NVR tests due to the connection between intellectual ability and language learning (e.g., Kristiansen, 1990; Brooks et al., 2006; Asbell et al., 2010; etc.). However, the results showed that NVR did not predict English vocabulary acquisition with a non-significance of the result, but did predict English grammar performance. As a result, our hypothesis is just partially supported regarding the effect of NVR on English grammar proficiency. This analysis fits with the finding that non-verbal intelligence was found to predict Russian grammar learning (Brooks et al., 2006; Kempe & Brooks, 2008; Kempe et al., 2010), and that NVR is a significant predictor of reading comprehension (Asbell et al., 2010) since reading comprehension is also involved in the grammar test. The question here is why NVR does not correlate with language vocabulary acquisition. It can be explained by the fact that word learning is merely "the process of memorization, association, and imitation of a series of paired associates" (Bloom, 2000, p.1), which depends less on pattern recognition or reasoning ability than grammar does. In other words, doing the NVR test and the English grammar test might require a similar process of reasoning/ logical thinking or recognizing patterns, which makes scores from these two tests correlated with each other. However, Bloom (2000) also argued that "word learning is actually far from simple..., requires rich mental capacities - conceptual, social, and linguistic that interact in complicated ways" (p.1). It implies that there might be other reasons affecting this result, which deserves further investigation.

Secondly, we also hypothesized that the acquisition of English vocabulary would be positively influenced by STM capacity. In line with the hypothesis, some previous studies as mentioned in the literature (e.g., Baddeley et al., 1988; Gathercole & Baddeley, 1990; Papagno, 1991; Gathercole, 1992, 1997, 1999; etc.) have found a connection between STM and vocabulary learning, e.g., STM is a significant predictor of vocabulary acquisition in children, adolescents, and adults (e.g., Gathercole & Adams, 1993, 1994; Gathercole et al., 1997, 1999),

and children's performance on the NWR task predict their ability to learn new words in both their L1 (Gathercole & Baddeley, 1990) and L2 (Service, 1992; Service & Kohonen, 1995), or STM and word-learning abilities are related among adults (Papagno and Vallar, 1995). In the present study, the scores on the English NWR test predicted the scores on the English vocabulary test, reflecting the impact of STM capacity on English vocabulary; however, the scores on the Vietnamese NWR test did not predict the scores on the English vocabulary test. This finding will be discussed in more detail below. The results, hence, provide some support for our hypothesis. Furthermore, a non-significant correlation coefficient between STM and English grammar suggests that STM is more likely to affect the acquisition of vocabulary than grammar. This can be explained based upon the discussion about the difference between the process of acquiring grammar and vocabulary as mentioned earlier. Also, STM capacity can predict vocabulary proficiency thanks to the important role of the phonological loop which boosts learning phonological patterns of new words by storing unfamiliar sound patterns while long-term representations are built (Baddeley, 1986).

Thirdly, we presumed that STM would be the stronger predictor of English learning outcomes than NVR since a number of studies have shown the relationship between phonological processing, STM, and vocabulary learning (e.g., Gathercole & Baddeley, 1990; Service, 1992; Gathercole et al., 1992, 1997, 1999; Gathercole & Adams, 1993, 1994; Service & Kohonen, 1995, etc.), and the important role of STM in sequence learning (Ellis & Sinclair, 1996). Nevertheless, the findings of the present study indicated that NVR was moderately correlated with English grammar but insignificantly correlated with English vocabulary; on the contrary, STM affected the acquisition of English vocabulary but had no significant correlation with the acquisition of English grammar. That is to say, these two cognitive factors have a selective impact on different aspects of English, and we cannot conclude that STM is the stronger predictor of English learning outcomes than NVR. For that reason, our hypothesis is not completely supported. Here, our study has also yielded a remarkable outcome with respect to the moderately positive correlation between NVR and STM (as measured by the English NWR test), implying that learners who have better STM capacity might have greater NVR (or fluid/ analytic intelligence). This finding is expected to contribute to further research in cognitive linguistics which is "the study of language in its cognitive function, where cognitive refers to the crucial role of intermediate informational structures in our encounters with the world" (Geeraerts & Cuyckens, 2012, p.5). As discussed above, it is more likely that NVR which reflects the process of reasoning/ logical thinking facilitates grammar learning and STM

with the phonological loop which reflects the process of storing and managing phonological patterns of new words influences vocabulary learning. However, the moderate correlation between NVR and STM (as measured by the English NWR test) raises the question of whether or not the contribution of NVR to grammar learning as well as the contribution of STM to word learning is unique, or both NVR and STM are interrelated. We doubt that the non-correlation between NVR and English vocabulary might be affected by the design of the English vocabulary test used in this study. Specifically, the LexTALE vocabulary test required the participants to decide whether the items were existing English words or not, which seemingly does not need reasoning skills/ logical thinking. Assuming that we use another vocabulary test requiring them to match words to relevant paragraphs, for example, will the result reflect a correlation between NVR and vocabulary proficiency? Further research is needed to shed light on these issues.

Additionally, we examined the influence of the background factors on the participants' English performance to investigate how much NVR and STM matter relative to other individual factors. Some previous findings supported the role of non-cognitive factors (e.g., attitude, motivation, learning strategies, etc.) in FLL, i.e., both attitude/motivation and aptitude are correlative in SLA (R. Gardner. et al., 1985); the lack of learning attitude and motivation has negative effects on unsuccessful learners (Dörnyei, 2001); motivation, anxiety and learning strategies, considered as "mediating factors" in the influence of aptitude on FLL, play a crucial role in the success of this learning process (Sureda, 2015, p.2), etc. Nonetheless, the results from the questionnaire contradicted these claims. Accordingly, all the background factors did not have any significant effect on the participant's English performance, which suggests the dominant role of NVR and STM in English proficiency as well as challenges existing theories about the influence of background factors on FLL. However, a more detailed analysis of background factors was not conducted in this study since the main focus of the thesis was on NVR and STM, so the conclusions here are tentative.

Finally, our study provides an important insight into the role of STM in language proficiency and the reliability of NWR tests in assessing STM capacity. Specifically, as mentioned in the literature and methodology chapter, NWR tests are good at measuring learners' phonological awareness or word learning because they are argued to be unbiased or similar. However, the results showed that STM, as measured by the Vietnamese NWR test, in the relationship with English vocabulary proficiency, English grammar proficiency, and NVR, was non-significant. Meanwhile, STM, as measured by the English NWR test, was correlated

with English vocabulary and NVR. This implies that it is not necessarily the case that STM facilitates vocabulary learning, but on the contrary, that the participants with more experience with English and better English vocabulary were better able to repeat English non-words. The discrepancy between the English and Vietnamese NWR test related to English vocabulary possibly explains this matter. Accordingly, as discussed in section 2.4 of the theory chapter, Vietnamese is a tonal language with different tones and diacritics in lexical items as well as with the limited codas, which make considerable differences between Vietnamese and English in phonetics and phonology. These two languages are also dissimilar in grammatical structures, tense, and aspect. Hence, it might be impossible to have a connection between Vietnamese non-words and English vocabulary; that is to say, participants with better Vietnamese vocabulary cannot make use of their Vietnamese knowledge in patterning (English) non-words to (Vietnamese) words, so the scores of the Vietnamese NWR test could not predict the scores of the English vocabulary test. On the other hand, the English non-words probably share phonological features of real words in English, and participants with better English vocabulary can pattern English non-words to words they knew, so the performance in the English NWR test could predict English vocabulary proficiency. These findings also support some previous research (as mentioned in section 2.3.3 of the theory chapter) that found a correlation between language proficiency and STM as measured by repeating non-words following the phonology of the language tested. Specifically, Messer et al. (2010) found that the Turkish-Dutch children had higher scores on the Turkish (as their L1) NWR test than monolingual Dutch children, but had lower scores on the Dutch (as their L2) NWR test compared to Dutch children. This means that children with more experience of the language tested can repeat non-words better than children with less experience. In another study, Sharp and Gathercole (2013) compared the performance on a Welsh NWR test of Welsh-English bilingual children with different levels of exposure to Welsh at home (Only Welsh at home, Only English at home, or Welsh and English at home), and he also found that the level of children's exposure to this language affected their performance on sounds unique to Welsh. Consequently, we assume that linguistic knowledge (e.g., phonemes, syllable structure, etc.) might impact the participants' performance on the NWR tests in the present study. Despite that, we do not know whether there is a link between Vietnamese vocabulary and STM (as measured by the Vietnamese NWR test) since carrying out a Vietnamese vocabulary test is beyond the scope of this study, so further research is needed to investigate the impact of language experience on NWR performance.

Like other studies, ours has several limitations that need to be acknowledged. First, we only tested NVR and STM in FLL on English grammar and English vocabulary while there are many other skills that make up L2 proficiency, such as: speaking, listening, writing, etc. The lack of test variety that cannot cover all aspects of language learning must affect the general result. In a future study, it is recommended that more aspects should be included in the language proficiency tests to improve their content validity. Second, data from the questionnaire were not well suited to detailed analysis because the thesis focused on NVR and STM, and other data were collected only to check background factors, but more detailed questions about these factors would be advisable in future studies. Third, we only investigated one age group, thus looking at other age groups (e.g., younger learners) may be an avenue for further research. Also, we believe that only one L1 group tested in this study cannot generalize results on NVR and STM, so investigations on learners with different L1s and/or different L2s would be worthwhile in the future. Despite these limitations, the study was conducted carefully to ensure the validity of the results. By extension, the generalizability of the results is assured by the adequate sample size (n=30), and the diversity of the samples (i.e., the participants are from different schools), as well as the equality of gender (i.e., 50 % male & 50% female) are guaranteed. Moreover, although all the aspects of English learning were not covered in the tests, grammar and vocabulary are appropriate to answer the research questions in the scope of the study.

CHAPTER 6: CONCLUSION

In summary, this study set out to identify the role of NVR and STM in learning EFL. The questions this research investigated to answer were:

- Do scores on the Non-verbal Reasoning tests (as measured on the Raven's Matrices) predict scores on the English vocabulary tests and English grammar tests?
- Does Short-term Memory capacity impact the acquisition of vocabulary (based on the results on the non-word repetition tests and English vocabulary tests)?
- Which is the stronger predictor of English learning outcomes (as shown on the English proficiency tests), Non-verbal Reasoning or Short-term Memory?

The subjects consisted of 30 Vietnamese high-school students aged from 16 to 18 (their mean age was 16.6 years) with an equal division of gender. Their native language was Vietnamese and they had learned EFL at school. None of them had any impaired awareness or learning. The instruments used to collect the data for this study were an NVR test (i.e., Raven's Progressive Matrices Test), an NWR test (i.e., Pseudo generator), English proficiency tests of Vocabulary (i.e., the LexTALE) and Grammar (i.e., Cambridge Assessment English), and a background information questionnaire. All the test results were statistically analyzed, and the study is categorized as a quantitative approach.

Results of this study showed that NVR was a good predictor of English learning outcomes, and potentially also STM. Accordingly, there was a moderately positive correlation between (1) NVR and English grammar, and (2) STM, as measured by the English NWR test, and English vocabulary, which are in agreement with the view of the previous studies in the literature and provide partial support for our hypotheses. These results show a selective impact of NVR and STM on different aspects of English proficiency. Furthermore, both of these cognitive factors played a dominant role in English competence demonstrated by the fact that the background factors (e.g., age, gender, time spent learning English, etc.) did not affect the performance on the English proficiency tests in this study. Finally, our research yielded two main findings recommending further investigation, i.e., (1) the fact that English vocabulary proficiency was correlated with STM as measured by the English NWR test but non-correlated with STM as measured by the Vietnamese NWR test means that performance in NWR tests can be affected by previous knowledge and experience of the language tested, which suggests

that language choice in the NWR test is important and may make a difference when conducting research on STM and L2; (2) the moderately positive correlation between NVR and STM (as measured by the English NWR test) implies that these two factors might be interrelated and have influences on many aspects of L2 learning rather than contributing specifically to grammar or vocabulary.

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APPENDICES

Appendix A - List of non-words

1 Syllable	2 Syllables	3 Syllables	4 Syllables
Trann /tra:n/	Tpy /ˈtipi/	Bolite /ˈbɒli:də/	Encouraee /inˈkju:rə,i:/
Cravh /krɑ:f/	Lvan /ləˈvɑ:n/	Perwuade /pəˈwɔ:di/	Pareicular /pæ' reikjulə/
Tongk /tʌŋk/	Naren /naˈren/	Modivay /ˈməʊdəveɪ/	Eupecally /ˈju:pekəli/
Quirh /kə:rk/	Keytoard /ˈki:tɔ:rd/	Evinence /ˈevinəns/	Ebbarrassing /ˈebærəsiŋ/

Table 14: *List of English non-words*

1 Syllable	2 Syllables	3 Syllables	4 Syllables
Tứng /tɨŋ˧˥/	Nguần ngoãng /ŋʷə̆n˨˩ ŋʷaŋ˧ˀ˧/	Đuỳu Luần khuầng /dʷiw˨˩ lʷə̆n˨˩ kʷə̆ŋ˨˩/	Cam sao thất wản /kam˧ saw˧ tʰə̆t˧˥ wan˨˩/
Phằn /fă̱n˨˩/	Hyễn ương /hiən˧ˀ˧ ɨəŋ˧/	Đuy húy toa /dʷi˧ hʷi˧ tʷa˧/	Nhùng nhà thùng thằn /n̲ʊŋ˨˩ n̲a˨˩ tʰʊŋ˨˩ tʰă̱n˨˩/
Uễnh /ʷen˧ˀ˧/	Khuyu khoắc /kʷiw˧ kʷăk˧˥/	Toang đoáng xoàng /tʷaŋ˧ dʷaŋ˧˥ sʷaŋ˨˩/	Xiển rộng lênh mông HN /siən˨ roŋ˧ˀ˨ˀ leŋ˧ moŋ˧/ HCM /siən˨ zoŋ˧ˀ˨ˀ leŋ˧ moŋ˧/
Khoại /kʷaj˧ˀ˨ˀ/	Thoằng loẵng /tʰʷă̱ŋ˨˩ lʷă̱ŋ˧ˀ˧/	Triêu đoa khoa HN /tɕiəw˧ dʷa˧ kʷa˧/ HCM /ʈiəw˧ dʷa˧ kʷa˧/	Nả bí tù đù /na˨ bi˧˥ tu˨˩ du˨˩/

Table 15: *List of Vietnamese non-words*

Appendix B - Questionnaire

1. *What is your gender?*

a. Male

b. Female

2. *How old are you?*

a.16

b.17

c.18

3. *Is Vietnamese your first language?*

a. Yes

b. No

4. Is English your first language?

a. Yes

b. No

5. *Were you exposed to English before school?*

a. Yes

Please specify:

How much were you exposed to English before school?	In what way were you exposed to English before school? (You can choose more than one option)

a. Every day b. More than 3 times a week c. Less than 3 times a week d. Once a month e. A few times a month f. A couple of times a year g. Other, please specify: …… …… ……	a. Your parents communicated with you in English every day. b. Your parents told you stories in English. c. Your parents taught you new English words every day. d. Your siblings communicated with you in English every day. e. Your babysitter/ nanny spoke English. f. You watched English TV shows/ cartoons. g. You had bilingual toys/ played bilingual games, and you learned English from them. h. Other, please specify: ……. ……. …….

b. No

6. *At what age did you first start learning English formally?*

Please specify: .....

7. *How much time do you spend learning English inside the classroom on an average day?*

a. 45 minutes - 1 hour

b. 1 hour - 1 hour and a half

c. 1 hour and a half - 2 hours

d. More than 2 hours

8. *How much time do you spend learning English outside the classroom on an average day?*

(Tick ✓ the boxes of time you spend on the relevant activities)

Activities/ Time	0 - 30 minutes	30 minutes - 1 hour	1 hour - 1 hour and a half	1 hour and a half - 2 hours	More than 2 hours	Never spend time on this activity
Read English books						
Watch English TV series, videos, or talkshows						
Read English newspapers, websites, or novels						
Chat with your foreign friends						
Participate in English clubs						
Other, please specify:						

9. *Where have you learned English (besides school)?*

(You can choose more than one answer)

a. At home

b. At language center

c. On the internet

d. Other, please specify:

…….....

10. *Why do you learn English?*

(You can choose more than one answer)

a. Because I love English

b. Because I want to get a good job

c. Because I want to communicate with foreigners

d. Because I think English is important nowadays

e. Because I want to go abroad

f. Because I want to get a scholarship

g. Other, please specify:

…….

11. *Do you know any other languages besides English and Vietnamese?*

a. Yes

The language you know	Your proficiency level (Basic – Intermediate – Advanced)

b. No

<u>Appendix C</u> - Informed Consent Letter

Are you interested in taking part in the research project?

'The role of Non-verbal Reasoning and Short-term Memory in Foreign Language Learning'

This is an inquiry about participation in a research project where the main purpose is to investigate individual factors and their influence on English learning. In this letter, we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project

There are many factors affecting a successful language learner. In order to understand more about how to learn a foreign language successfully, we need to understand more about some of the individual factors that influence learning, and that is what the researcher is doing in this study.

This study is carried out for a **master's thesis**.

Who is responsible for the research project?

Norwegian University of Science and Technology (NTNU) is the institution responsible for the project.

Why are you being asked to participate?

You are being asked to participate in this study because you are in the target group of Vietnamese individuals between age 16 and 18, who are learning English.

What does participation involve for you?

You will do all tests on computers connected to the internet at an Informatics Center. The tests will be taken place at a time that suits you and will last for about 60 minutes. When you log on to the link, you will see the researcher, and she will be giving you instructions. You will also see other participants, but no one will see how you do on the tests while you do them. You are asked to complete one non-verbal test, one non-word repetition test, two English tests, and

provide some personal information in a questionnaire. In the first part, you will be asked to finish the Raven's Progressive Matrices non-verbal reasoning test consisting of 60 visual questions (created by logical matrices) in 20 minutes. The questions will be to find out the missing parts of the figures or diagrams from the given options. You are expected to choose the correct answer among them. The second part and the third part of the study will measure your competence in English with the English proficiency test on vocabulary and the English proficiency test on grammar, respectively. You will answer about 60 trials for the vocabulary test, and 25 questions for the grammar test. Each of these tests will take 10 minutes. In the fourth part, you will have 10 minutes to answer 11 questions about personal information in the questionnaire. In terms of the non-word repetition test - the final part, you will be asked to repeat words you hear during the test, and your repetition of non-words will be recorded. This test will take place in 5 - 10 minutes and will be done individually, so the other participants will not be able to hear this.

As a participant, you are allowed to withdraw from the study during the test session, and you will not need to give the researcher a reason. Your participation in the study or withdrawal from the study does not influence your grades or relationship with the teacher in any way, nor will your performance in the tests.

Participation is voluntary

Participation in the project is voluntary. If you choose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you choose not to participate or later decide to withdraw.

Your personal privacy - how we will store and use your personal data

We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

- Only the researcher and her supervisors, in connection with the institution responsible for the project, will have access to the personal data.
- Participants' identities are fully protected. Accordingly, your responses are completely anonymous. No personal identifying information or IP addresses will be used when discussing or reporting data. All files and data collected will be safely kept in

Nettskjema, which is administered by the University of Oslo and NTNU by mutual agreement.

- Participants will not be recognizable in publications.

What will happen to your personal data at the end of the research project?

The project is scheduled to end in 15/05/2021. Once the data has been fully analyzed, it will be anonymized at the end of the project.

Your rights

So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?

We will process your personal data based on your consent.

Based on an agreement with Norwegian University of Science and Technology (NTNU), NSD - The Norwegian Centre for Research Data AS has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?

If you have questions about the project, or want to exercise your rights, contact:

- Norwegian University of Science and Technology (NTNU) via the researcher: Phan Thi Minh Dung (Email: minhdung53ta3@gmail.com), the research supervisor: Mila Vulchanova (Email: mila.vulchanova@ntnu.no), or the research co-supervisor: Anne Dahl (Email: anne.j.dahl@ntnu.no).

- Our Data Protection Officer: Thomas Helgesen (Email: thomas.helgesen@ntnu.no)
- NSD – The Norwegian Centre for Research Data AS, by email: (personverntjenester@nsd.no) or by telephone: +47 55 58 21 17.

Yours sincerely,

Project Leader
(Main supervisor/ Co-supervisor) (Researcher)
Mila Vulchanova/ Anne Dahl Phan Thi Minh Dung

CONSENT FORM

I have received and understood information about the project '*The role of non-verbal reasoning and short-term memory in foreign language learning'* and have been given the opportunity to ask questions.

I give consent to participate in the whole test session of the research project and that my personal data can be processed until the end date of the project, approx 15/05/2021.

Place and Date Participant's name and signature

Appendix D - Individual test results

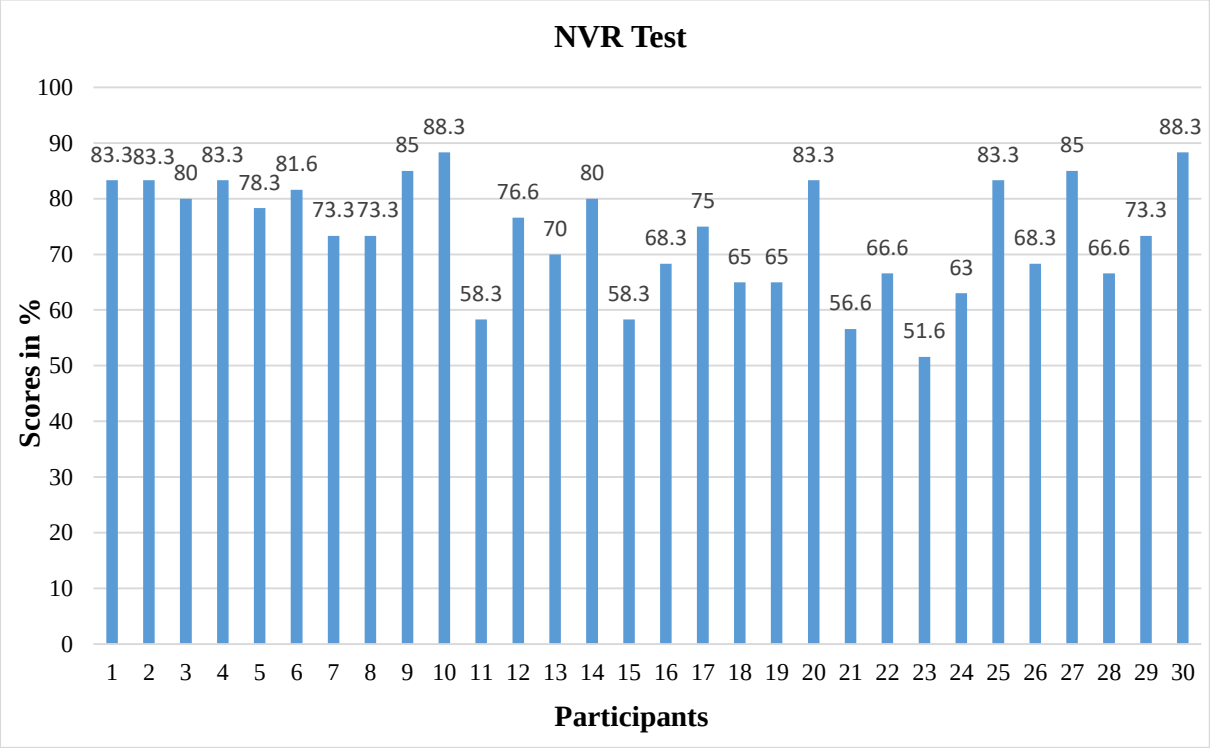


Figure 15: *NVR test scores (in %)*

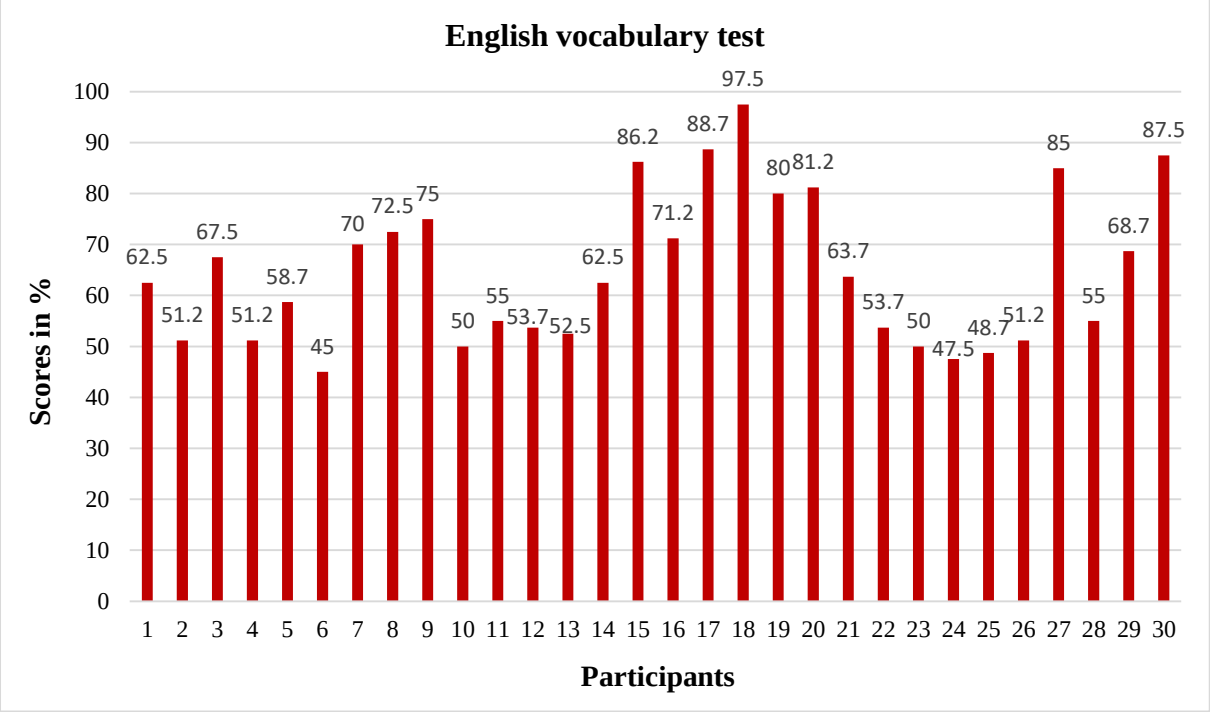


Figure 16: *English vocabulary test scores (in %)*

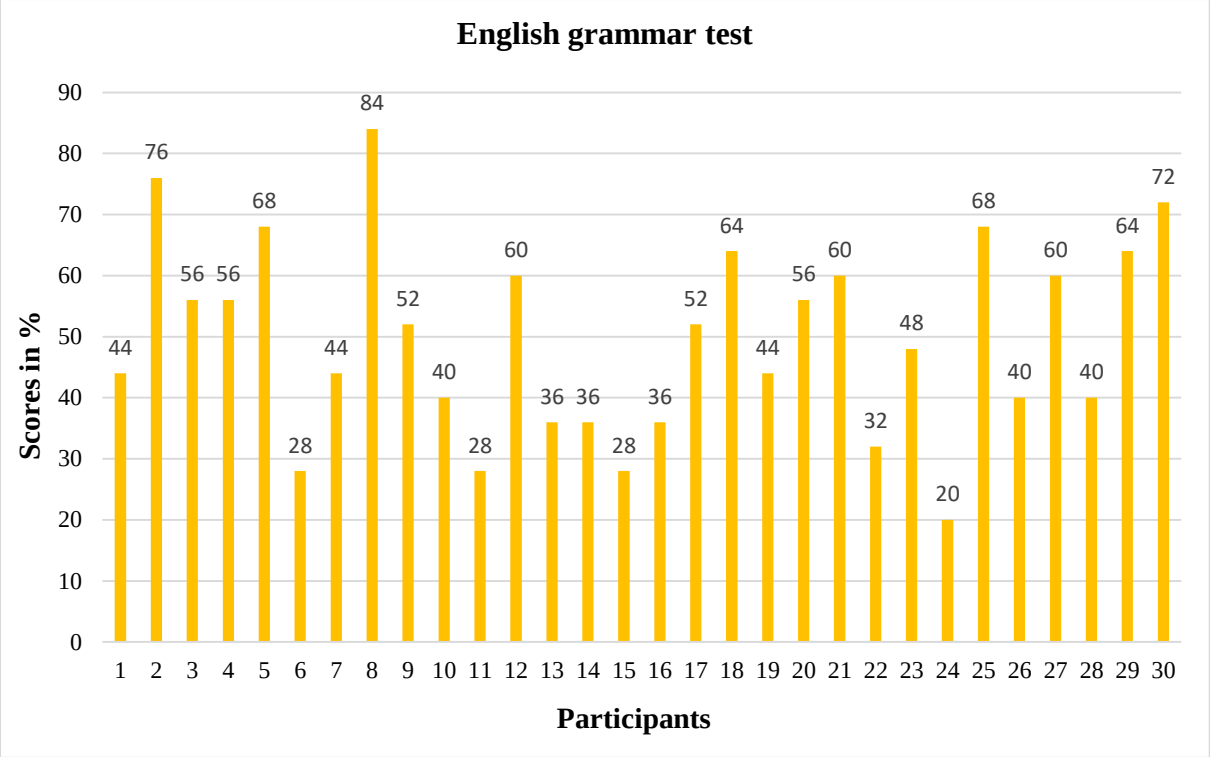


Figure 17: *English grammar test scores (in %)*

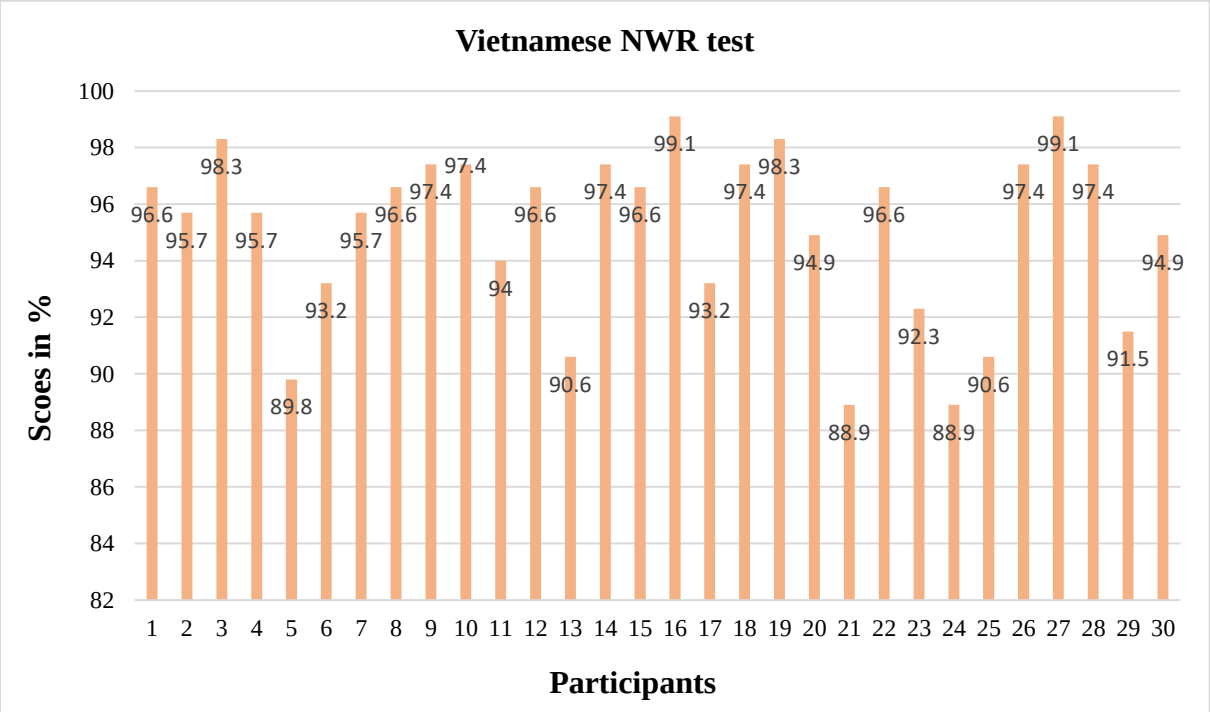


Figure 18: *Vietnamese NWR test scores (in %)*

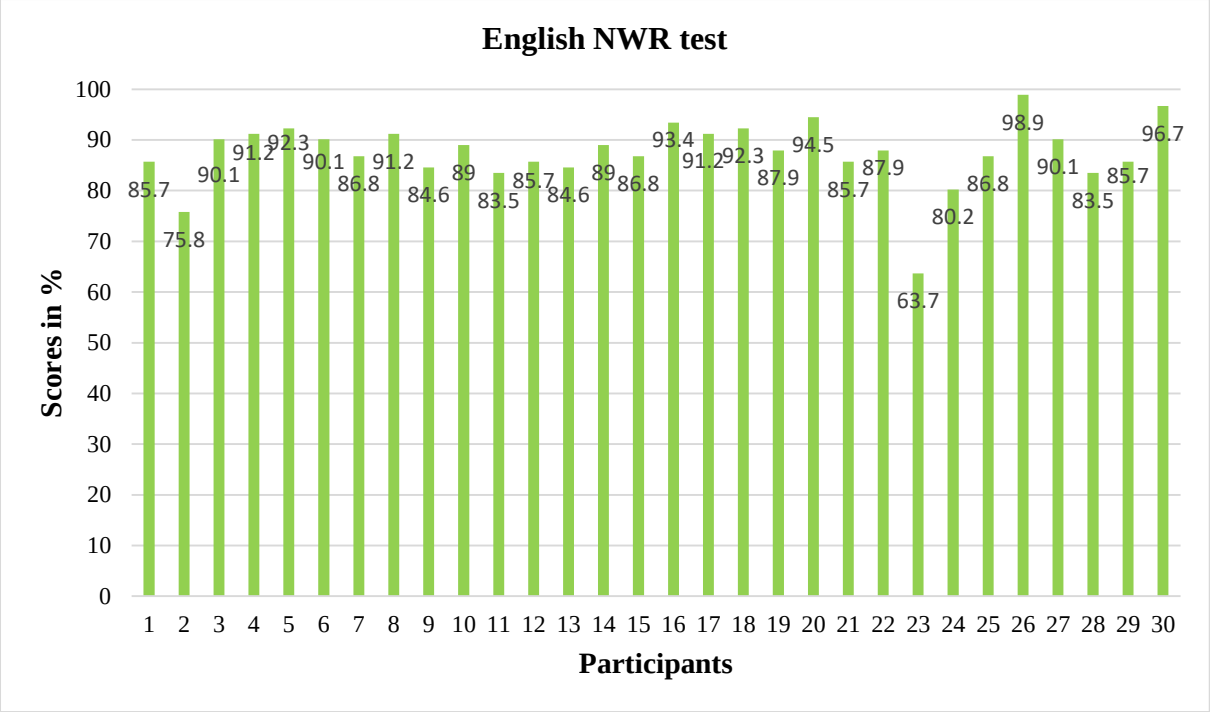
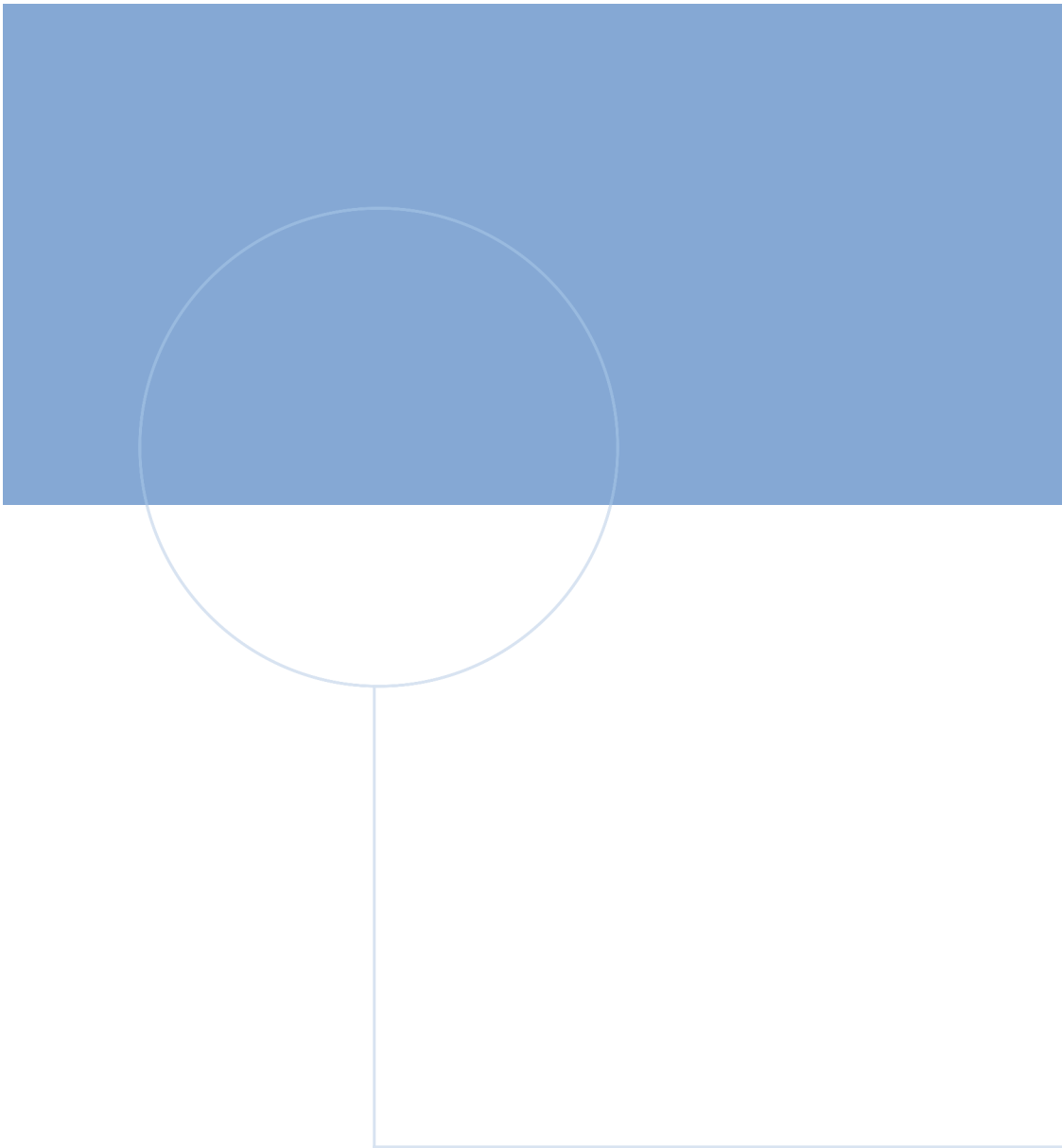


Figure 19*: English NWR test scores (in %)*



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