UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE COMUNICAÇÃO E EXPRESSÃO
DEPARTAMENTO DE LÍNGUA E LITERATURA ESTRANGEIRAS
CURSO DE LETRAS-INGLÊS

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Assessment of Declarative and Procedural Memory in SLA Research: A Scoping Review

Florianópolis
2023

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Trabalho de Conclusão de Curso submetido ao curso de Letras-Inglês do Centro de Comunicação e Expressão da Universidade Federal de Santa Catarina como requisito parcial para a obtenção do título de Bacharel em Letras-Inglês.

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Florianópolis
2023

Bin, Pedro Ricardo
Assessment of Declarative and Procedural Memory in SLA Research : A Scoping Review / Pedro Ricardo Bin ; orientadora, Mailce Borges Mota, coorientadora, Natália Pinheiro De Angeli, 2023.
45 p.

Trabalho de Conclusão de Curso (graduação) - Universidade Federal de Santa Catarina, Centro de Comunicação e Expressão, Graduação em Letras - Língua Inglesa, Florianópolis, 2023.

Inclui referências.

1. Letras - Língua Inglesa. 2. Declarative memory. 3. Second Language Acquisition. 4. Procedural memory. 5. Psycholinguistics. I. Mota, Mailce Borges. II. De Angeli, Natália Pinheiro. III. Universidade Federal de Santa Catarina. Graduação em Letras - Língua Inglesa. IV. Título.

Pedro Ricardo Bin

Assessment of Declarative and Procedural Memory in SLA Research: A Scoping Review

Este Trabalho de Conclusão de Curso foi julgado adequado para obtenção do título de Bacharel e aprovado em sua forma final pelo Curso Letras-Inglês.

Florianópolis, 7 de julho de 2023.

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To my grandmother, Leda (*in memoriam*), with love and *saudade*.

ACKNOWLEDGEMENTS

I am very grateful for concluding this important cycle in my life and completing this research. So, I would like to express my gratitude to key people that were part of this process.

My advisor, professor Mailce Borges Mota, thank you for inviting me to work with you five years ago and, since then, for kindly guiding me in my journey into the field of Psycholinguistics. More than that, thank you for encouraging me to do research on language!

My co-advisor and best friend, Natália Pinheiro De Angeli, thank you for the support while I was conducting this research and, most importantly, for the uncountable moments of joy we shared since we've met. You inspire me a lot!

The members of the committee, Prof. Dr. Bernardo Kolling Limberger and Prof. Dr. Germán Zárate-Sández, thank you for gently accepting to read and evaluate my work.

Danielle dos Santos Wisintainer, Pietra Cassol Rigatti and João Luiz Coelho, thank you for your always serene advices and cups of coffee in our mornings at the Lab. In your names I would like to express my gratitude to all members of LabLing.

Isadora, I remember the day we met, while we were waiting for our class to start in front of room 201. I said to you that I liked your watermelon patterned backpack very much. I did not imagine today I would be thanking you for being a good friend. Catharina, Larissa R., Tarso, Eduardo, Guilherme, Fábia, Eloysa, Larissa G., and Nicolas, thank you for showing me what friendship means and for allowing me to show you my 'true colors'. Having met you all changed my life!

Finalmente, eu gostaria de agradecer a minha família. Mauricio, muito obrigado por ser o melhor irmão que eu poderia querer. Ilda, sou muito agradecido por ter uma 'segunda' mãe como você. Desde sempre eu soube que poderia contar contigo. Mãe e pai, muito obrigado por terem me apoiado de diversas maneiras enquanto eu cursei a graduação em Letras-Inglês. Dentre tantas coisas, vocês permitiram que eu pudesse me dedicar integralmente a minha formação. Sem a presença de vocês na minha vida, eu seria muito pouco do que sou hoje. Eu amo muito vocês! Obrigado por tudo.

Uma parte de mim
é só vertigem;
outra parte,
linguagem.
(GULLAR, 2017, p. 30)

ABSTRACT

The relationship between second language acquisition and the domain-general mechanisms of declarative and procedural memory are central in psycholinguistic investigations of L2 learning. In general, studies associate linguistic skills with declarative and procedural memory abilities to understand the interplay between memory and language. However, to test these associations it is important to select valid and reliable assessments of declarative and procedural memory. Therefore, the main objective of the present undergraduate thesis is to map the instruments used to assess declarative and procedural memory in SLA research in the past three years (2020-2023), by means of a scoping review methodology. Two research questions guided the review of the literature: "Which instruments do studies that investigate the role of memory in L2 learning adopt to assess declarative memory" and "Which instruments do studies that investigate the role of memory in L2 learning adopt to assess procedural memory?". A search for the literature was carried out in the Web of Science database using the following keywords: "Declarative memory", "Explicit memory", "Procedural memory", "Implicit memory", "Second Language Acquisition", and "Second Language Learning". To be included in the review, the records found in the database should be peer-reviewed research articles, written in English or Portuguese. In addition, the records should have been published in the past three years (2020-2023) and should have investigated the role of long-term memory systems in L2 learning. Only three research articles were included in the synthesis (PILI-MOSS, 2022; SAITO *et al*., 2022; ZHANG *et al*., 2021). The results of the review show that four instruments were used to assess declarative memory in the past three years (the Rey-Osterrieth Complex Figure Task; the Logical Memory Subtest in the Wechsler memory scale; the LLAMA-B; and the CVMT) and two instruments were used to assess procedural memory (the Alternating Serial Reaction Time and the Serial Reaction Time). Except for the Logical Memory Subtest in the Wechsler memory scale, the DM and PM assessments analyzed in this synthesis are valid and reliable to be used in psycholinguistic studies of SLA. However, the research articles included in this review lack transparency when they do not explain the rationale behind the selection of the neuropsychological tests used in their studies.

Keywords: Declarative memory; Procedural memory; Scoping review; Second Language Acquisition; Psycholinguistics.

RESUMO

A relação entre a aquisição de segunda língua e os mecanismos de domínio geral de memória declarativa e memória procedural é central nas investigações psicolinguísticas da aprendizagem de segunda língua (L2). Em geral, estudos associam habilidades linguísticas com habilidades de aprendizado declarativo e procedural para compreender a relação entre memória e linguagem. Porém, para testar essas associações é importante selecionar testes de memória válidos e confiáveis. Por isso, o principal objetivo desse trabalho de conclusão de curso é mapear os instrumentos utilizados para avaliar as memórias declarativa e procedural na área de Aquisição de Segunda Língua (ASL) nos últimos três anos (2020-2023) através da metodologia empregada em revisões de escopo. Duas perguntas de pesquisa guiaram esse estudo: "Quais instrumentos foram utilizados para testar a memória declarativa nos estudos da ASL?" e "Quais instrumentos foram utilizados para testar a memória procedural nos estudos da ASL?". A busca pela literatura foi feita na base de dados *Web of Science* usando as seguintes palavras-chave: "*Declarative memory*", "*Explicit memory*", "*Procedural memory*", "*Implicit memory*", "*Second Language Acquisition*", e "*Second Language Learning*". Para serem incluídos na revisão, os artigos deveriam reportar um estudo inédito, serem revisados por pares e escritos em inglês ou português. Ainda, deveriam ser publicados nos últimos três anos (2020-2023) e terem investigado o papel dos sistemas de memória de longo prazo no aprendizado de L2. Apenas três artigos foram incluídos na síntese (PILI-MOSS, 2022; SAITO *et al*., 2022; ZHANG *et al*., 2021). Os resultados da revisão mostram que quatro testes foram utilizados para testar a memória declarativa nos últimos três anos (Rey-Osterrieth Complex Figure Task; Logical Memory Subtest in the Wechsler memory scale; LLAMA-B; and CVMT) e dois testes foram utilizados para testar a memória procedural (Alternating Serial Reaction Time and Serial Reaction Time). Com exceção do Logical Memory Subtest in the Wechsler memory scale, os testes de memória declarativa e procedural analisados nessa síntese são válidos e confiáveis para serem usados em estudos de ASL. Porém, os artigos incluídos nessa revisão não apresentam uma justificativa transparente para a escolha dos testes utilizados nos estudos.

Palavras-chave: Memória declarativa; Memória procedural; Revisão de escopo; Aquisição de Segunda Língua; Psicolinguística.

LIST OF FIGURES

LIST OF ABBREVIATIONS

CNPq	Conselho Nacional de Desenvolvimento Científico e Tecnológico
DM	Declarative memory
L1	First language
L2	Second Language
PM	Procedural Memory
SLA	Second Language Acquisition

SUMMARY

1 INTRODUCTION

Acquiring a language is an inherently human venture. Language has provided our species with a rich and complex symbolic system that allows us to communicate with our peers in our mother tongue or in the other languages we may know (HAGOORT, 2019; ORTEGA, 2009). Although we are language-ready, when learning a second language (L2) we may not undertake the same path as in our first language (L1).[1] [2] Differences in the acquisition patterns of an L2 are the subject of a dense body of empirical research in the second language acquisition (SLA) field since its dawning (COOK, 1969; ELLIS, 1994). Also, these differences motivated the development of distinct hypotheses to explain how L1 acquisition diverges from L2 learning (e.g., Natural Order Hypothesis, Full Transfer Full Access Hypothesis, The Critical Period Hypothesis, etc.). A main question in this line of research is related to the learning mechanisms that may be available when one is acquiring an additional language. Learning mechanisms, in turn, are related to memory systems and processes. Together, the mechanisms of learning and memory are central to the investigation of how we acquire an L2.

There are different memory systems in the human brain (EICHENBAUM, 2012; IZQUIERDO, 2018; SQUIRE, 1992). Each of these systems encodes different types of information and operates during language acquisition and processing. For instance, working memory temporarily process information needed for complex cognitive processes such as language (BADDELEY, 2003; CAPLAN, 2016). Declarative memory (DM) is argued to subserve the acquisition and storage of vocabulary and semantic information (PARADIS, 2009). Moreover, procedural memory (PM) is claimed to be related to grammatical knowledge and the on-line manipulations and computations performed during linguistic processing (ULLMAN, 2001). In light of these arguments, cognitive-based research in SLA focuses on investigating the mechanisms of L2 learning.

There has been extensive research on the role of attention, awareness, and working memory in L2 acquisition (DÖRNYEI, 2006). These factors influence L2 learning. However, they are not considered learning mechanisms in themselves (SQUIRE; DEDE, 2015). More recently, though, there has been an increasing interest in the relationship between L2 acquisition

[1] The term "language-ready" refers to the idea that our brain is wired for language because it evolved to help us to communicate. This term is related to the body of literature on the Mirror System Hypothesis (ARBIB, 2017).

[2] In this undergraduate thesis the terms acquisition and learning are used interchangeably unless explicitly stated otherwise. However, it is important to highlight that both terms can refer to different concepts, specifically in research on L2 (PARADIS, 2009). Likewise, the terms second language and additional language, as well as learner and user are used interchangeably unless explicitly stated otherwise.

and the domain-general mechanisms of declarative and procedural memory (MORGAN-SHORT *et al*., 2014).[3] At least three influential theories in the field of SLA rely on the argument that declarative and procedural memory systems have an important role in language learning: DeKeyser's Skill Acquisition Theory; Paradis' Neurolinguistic Theory of Bilingualism; and Ullman's Declarative/Procedural Memory Model (DEKEYSER, 2007; PARADIS, 2004; ULLMAN, 2001).

In general, studies associate linguistic abilities with declarative and procedural memory abilities to understand the interplay between memory and language (ANTONIOU; ETTLINGER; WONG, 2016; HAMRICK; LUM; ULLMAN, 2018; SUZUKI, 2018). When designing these studies, it is necessary to decide which declarative and/or procedural memory test(s) should be used to examine possible associations between linguistic skills and memory abilities. The methodological decisions involved in the assessment need to take into consideration, among other factors, if the task is valid and reliable to probe learning in the desired memory system (BUFFINGTON; DEMOS; MORGAN-SHORT, 2021; MORGAN-SHORT; HAMRICK; ULLMAN, 2022). Therefore, the main objective of the present undergraduate thesis is to map the instruments that have been used to assess declarative and procedural memory in SLA research published in the past three years (2020-2023). This short time frame of three years was chosen because of the scope of the present work, which is an undergraduate thesis, and schedule limitations to finish the research.

The general topic of this undergraduate thesis - assessment of declarative and procedural memory - is also related to the research I carried out with a grant from *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq/Brazil), within the *Iniciação Científica* Program, between September 2022 and February 2023, when I was responsible for the work plan "*Avaliação da memória declarativa e da memória procedural de adultos não alfabetizados*" (Process number: 144890/2022-4), devised by Professor Mailce Mota as part of her project "*Adaptações neurocognitivas associadas à alfabetização de crianças e adultos: efeitos nos sistemas de memória, controle atencional e processamento da linguagem*" (CNPq-PQ/Process number: 311632/2019-0 | SIGPEX 202105900).

In order to fulfill the objective of the present study, it is important to lay down the main constructs that are part of the theoretical and empirical literature supporting the investigation.

[3] Memory and learning are closely related concepts, although the relation between these two terms is not always specified (KAZDIN, 2000). However, depending on how each term is conceptualized, they may convey different meanings. In the present manuscript, both concepts are used interchangeably unless explicitly stated otherwise. See Kazdin (2000) for definitions of each term.

Section 2, Review of Literature, explores concepts such as declarative and procedural memory and their relation to the field of SLA, as well as neuropsychological assessments and measures.

2 REVIEW OF LITERATURE

This section is divided into four subsections. The first subsection, "Human memory and its systems: a brief overview", introduces the concept of memory adopted in the present work and briefly describes the human memory systems. The second subsection, "Cognitive-based theories of second language acquisition", exhibits three theoretical accounts that posit long-term memory systems as core components of their proposals on language learning and processing. The third subsection, "Assessing declarative and procedural memory abilities: some considerations", explores the general characteristics of a neuropsychological test and the importance of valid memory assessments in cognitive-based SLA research. Finally, the fourth subsection, "Scoping reviews and their importance", provides a definition of this type of study as well as discusses its importance for scientific inquiry.

2.1 Human memory and its systems: a brief overview

Memory has been the subject of extensive philosophical elaborations and scientific experimental investigations. The dawning of the experimental study of memory dates back to Herman Ebbinghaus' work (LEVELT, 2013). In 1885, the German philosopher published his monograph entitled *Über das Gedächtnis. Untersuchungen zur experimentellen Psychologie* (*On memory. Studies in experimental psychology*). In this work, he reported, for the first time, measures of memory as a higher mental process. He investigated the formation of new memory associations using a corpus of 2300 possible nonsense syllables in German. His findings showed two main characteristics of memory: (i) information can be retained for different periods of time, varying from seconds until months; and (ii) repetition and retention are related processes, since the more repetitions are done, the more information is held in memory (MOTA, 2015). Ebbinghaus' pioneering work is considered a cornerstone of research on memory and language (LEVELT, 2013).

Since the 19th century, the study of human memory has been a fruitful field of inquiry in cognitive psychology. However, as pointed out by Mota (2015), defining memory is not trivial. The term conveys different ideas and, according to Tulving (2000, p. 36), can designate six concepts in cognitive psychology: (1) memory as the capacity to encode, store and retrieve

information; (2) memory as the repository in which information is maintained; (3) memory as the information in the repository; (4) memory as some property of that information; (5) memory as a retrieval process of that information; (6) memory as an individual's phenomenal awareness of remembering something. That is, the term memory can be considered a capacity, a system, a process, a type of information, and conscious phenomena (MOTA, 2015). In the present work, memory is defined as a cognitive capacity that enables humans to acquire and encode information, store this information for a specified period of time, and retrieve this information when it is needed (SQUIRE, 2004; SCHACTER; WAGNER, 2014; TULVING, 2000; ZOLA-MORGAN; SQUIRE, 1993).

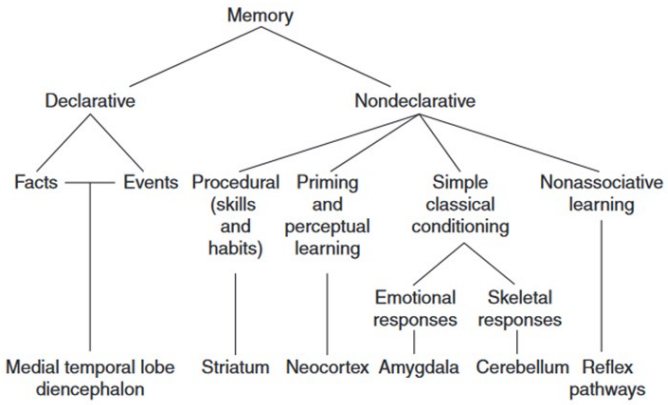
In addition to the complexities in terminology, it is also difficult to determine how many types of memory exist and how they should be classified. In 1960, one of the main debates was related to the controversy between the unitary system view *versus* multiple systems view on memory (TULVING, 1985; 1999). The unitary system view considers memory an indivisible complex entity. This view posits that there is only one representational system in which knowledge is consolidated. According to Tulving (1999), this idea has its roots in the assumption that in all languages there is only one word for "memory". Although it is easy to question this idea, the concept of memory was seldom discussed or challenged for more than hundred years (TULVING, 1999). However, experimental evidence of double dissociation from patients who suffered memory impairment (e.g., patient H. M.) and advancements in hemodynamic and electrophysiological methodologies established the first discussions on the multiple systems view (SCOVILLE; MILNER, 1957; SQUIRE, 2009; TULVING, 1985).[4] For instance, researchers noticed that different regions in the brain were activated when distinct types of information were being retrieved (TULVING, 1999). Since then, the multiple systems view has become widely accepted (IZQUIERDO, 2018; SQUIRE, 2004).

As a consequence of adopting the multiple system view, some taxonomies have been developed regarding the brain organization of memory (SQUIRE, 1992; 2004; TULVING, 1985). On that note, memory systems can be classified in terms of the distinct types of information they encode and the underlying brain structures and principles by which they operate (SQUIRE; DEDE, 2015). Considering the several possibilities and dichotomies to

[4] Henry Molaison, (i.e., patient H. M.) is one of the most famous cases in the field of neuroscience. He had a severe memory impairment after an experimental neurosurgery conducted to control seizures. His memory deficits were initially studied by Brenda Milner in 1975 (SCOVILLE; MILNER, 1957). Patient H. M. continued to be the subject of investigations until his death in December 2008. His case documented for the first time in the literature a double dissociation between declarative and procedural memory; for instance, he was able to acquire visuo-motor skills, through a ten-trials mirror-drawing task, even though he had no recollection of having done the task before. To read more about the legacy of patient H. M., see Squire (2009).

describe the human memory systems (i.e., declarative *versus* procedural, explicit *versus* implicit, episodic *versus* semantic, conscious *versus* unconscious, etc.), the taxonomy proposed by Squire (1992; 2004) is adopted in the present undergraduate thesis to exemplify a possible organization of memory (Figure 1).

Figure 1 - Larry Squire's organization of the human memory systems

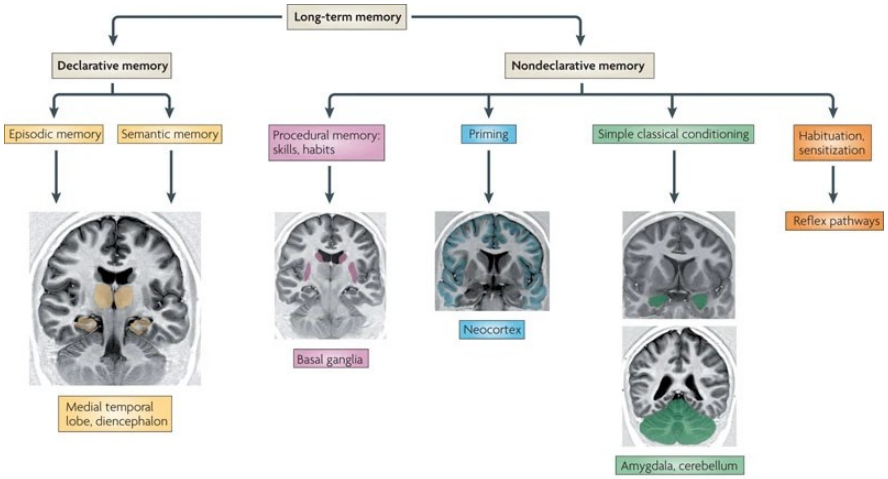


Source: Squire and Dede (2015, p. 3).

According to Squire (1992; 2004) one first distinction can be made between two major systems: working memory and long-term memory. On one hand, working memory is a system that temporarily processes information needed for complex cognitive processes such as language (BADDELEY, 2003). In Squire's proposal (1992; 2004), the term working memory is preferred when conceptualizing the short-term system. However, this distinction is controversial in the literature. On the other hand, long-term memory can be divided into declarative memory and nondeclarative forms of memory that include procedural, priming and perceptual learning, simple forms of conditioning, and nonassociative learning (SQUIRE; DEDE, 2015).[5] Figure 2 presents the basic brain regions hypothesized to subserve the memory systems organization proposed by Squire.

[5] In the literature, there are different conceptualizations of memory systems and learning mechanisms. However, these distinct proposals will not be accounted for in the present manuscript due to the scope of the discussion. See Eichenbaum (2012) and Izquierdo (2018) for in depth discussions of memory and learning.

Figure 2 - Brain regions subserving memory systems

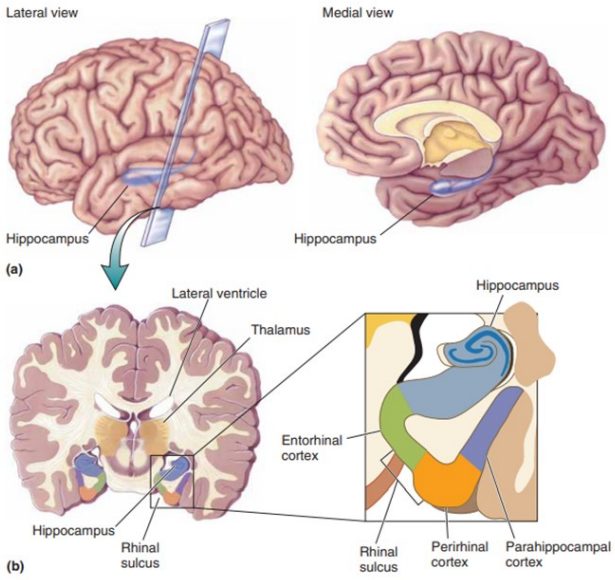


Source: Henke (2010, p. 524).

Declarative memory (DM), sometimes termed explicit memory (SCHACTER, 1992), has two major components or subsystems: semantic memory and episodic memory (SQUIRE, 1992; 2004). The first component is related to the facts we know about the world (BEAR; CONNORS; PARADISO, 2016b), such as that *Don Quijote* was written by Miguel de Cervantes. The second component is related to the experiences we have lived in our lives (BEAR; CONNORS; PARADISO, 2016b), such as the last birthday party we celebrated.[6] The brain regions supporting declarative memory system are the hippocampus and the adjacent entorhinal, perirhinal, and parahippocampal cortices (SQUIRE; KNOWLTON; MUSEN, 1993). Figure 3 illustrates the brain structures subserving DM in more detail. Information in this system is consciously learned, it is available for recollection or verbalization, it is flexible and used in controlled manner (PARADIS, 2004). Explicit memory has been systematically investigated and we understand its functioning more deeply than nondeclarative memory (SCHACTER; CHIU; OCHSNER, 1993).

[6] Declarative memory is the kind of memory we typically have in mind when we use the term memory in everyday conversations.

Figure 3 - Brain structures subserving declarative memory



Note: (a) Lateral and medial views of the hippocampus in the temporal lobe; (b) Coronal section of the hippocampus and other medial temporal lobe structures.
Source: Bear, Connors and Paradiso (2016b, p. 838).

The nondeclarative memory system is essential to our lives (SQUIRE; DEDE, 2015). The concept of nondeclarative memory is an umbrella term that refers to multiple forms of memory which are not declarative (SQUIRE; DEDE, 2015). The nondeclarative memory system is paramount to our unconscious responses to the world, even though we do not have access to its operations (SQUIRE; DEDE, 2015). It is also from nondeclarative memory that habits and preferences are created (SQUIRE; DEDE, 2015). Then, these created unconscious habits and preferences influence our mental lives (SQUIRE; DEDE, 2015). Moreover, nondeclarative memory is dispositional. That is, it is expressed through performance rather than recollection (SQUIRE, 2004). In Squire's (1992; 2004) taxonomy, nondeclarative memory, sometimes termed implicit memory, refers to procedural memory, priming and perceptual learning, simple forms of conditioning, and nonassociative learning. According to Squire and Dede (2015), procedural memory is related to habits formation and skills acquisition; priming can be defined as improved access to representations that have been recently encountered and perceptual learning can be defined as improved ability to detect visual stimuli with practice; simple forms of conditioning are related to a behavior acquired in a chain of stimulus-response; finally, nonassociative learning is a type of learning that does not depend on chains of stimuli-

responses to take place and is commonly referred to habituation and sensitization (HENKE, 2010).

The regions supporting nondeclarative memory are distributed in the brain - see Figure 2 to have a general overview of the system distribution. For example, procedural memory (PM) relies upon the striatum, priming and perceptual learning rely on the neocortex - a complex structure with intricate connections that is regarded to be the newest part of the cerebral cortex in an evolutionary scale (RAKIC, 2009) -, simple forms of conditioning are related to the amygdala and the cerebellum, and nonassociative learning depends upon the reflex pathways - that consists of a chain of neurons, for instance, from the receptor organ to the cerebral cortex (BEAR; CONNORS; PARADISO, 2016a).

Considering the different forms of nondeclarative memory, in the present manuscript, procedural memory is of special interest. According to Paradis (2004), information in this system is acquired incidentally and stored implicitly. It is also inflexible and used automatically (PARADIS, 2004). It is noteworthy that PM precedes DM phylogenetically and ontogenetically (LOCKHART, 1984). For instance, children possess only implicit memory during the first 12 months of life (PARADIS, 2004). Explicit memory emerges later and continues to develop throughout life, while implicit memory tends to decay (SCHACTER; MOSCOVITCH, 1984; PARKIN, 1989).

Having in mind the different features that characterize DM and PM and the distinct neuroanatomical structures that underlie each system, explicit knowledge has been conceptualized in the literature as *knowing that*, while implicit knowledge has been described as *knowing how* (COHEN; SQUIRE, 1980). These dissimilarities have implications for how information is consolidated in each form of memory. Therefore, as learning in each of these two systems are qualitatively different, declarative and procedural memory play distinct roles in L2 acquisition. To better explore how the memory systems are related to L2 learning, the next subsection exhibits three influential theories of SLA that predict specific roles for declarative and procedural learning mechanisms.

2.2 Cognitive-based theories of second language acquisition

A major concern in SLA has been the establishment of well-grounded theories to explain L2 learning. Within the field, there are distinct and sometimes contrasting proposals to account for the complexities of L2 acquisition (ELLIS, 1994; DOUGHTY; LONG, 2003;

ORTEGA, 2009).[7] In the present undergraduate thesis, I take a psycholinguistic stance on second language learning (GODFROID; HOPP, 2023). In other words, considering psycholinguistics has as its main aim to describe and explain how linguistic knowledge is acquired, represented, and processed in the human brain (FERNÁNDEZ; CAIRNS, 2010; WARREN, 2013), the present study focuses on how linguistic learning abilities are conceived in theories of L2 acquisition. Accordingly, theories and models are indispensable in this perspective because only through them it is possible to propose explanations about how language phenomena are instantiated in the human brain.

Some theoretical accounts in SLA are rooted in information processing theories that arose in the field of psychology in the 1970s as well as in perspectives of learning and memory that emerged in the 1980s and 1990s in the field of cognitive neuroscience (ANDERSON, 1983; EICHENBAUM; OTTO; COHEN, 1994). For instance, three prominent theories in SLA make the same basic assumption that domain-general learning and long-term memory mechanisms underlie L2 acquisition. Although these three proposals advocate declarative and procedural memory to be intimately related to L2 learning, they diverge in their theoretical foundations.

The first is Robert DeKeyser's Skill Acquisition Theory (2007), which emerged from the notion of cognitive architecture developed in psychology in the 1970s. Based on an information processing perspective, DeKeyser's theory relies specifically on the influential ACT-R architecture (ANDERSON, 1983; 2007). In this conceptualization, acquiring a second language is not different from learning skills such as geometry or programming. Independently of what you are learning, this theory accounts for initial learning to advanced proficiency. On that note, three stages of skill acquisition are proposed; in each stage, the knowledge is qualitatively different from the others. In the first stage, people acquire knowledge about the skill they are learning. For instance, someone can be explicitly taught a morphosyntactic rule in a specific language to form the plural of nouns. Then, in the second stage, the learner acts upon this knowledge, turning *knowledge that* into *knowledge how* - or, in more technical terms, transforming declarative knowledge into procedural knowledge. This process is called proceduralization and it occurs rapidly if the requirements for procedural learning are fulfilled (DEKEYSER, 1997). For example, after learning the morphosyntactic rule, a person may start using it in very controlled conditions, such as classroom oral production exercises. Once procedural knowledge is acquired, it needs to be fine-tuned. Therefore, the third stage, automatization, takes place through the practice of the skill recently learned. A great amount of

[7] See VanPatten, Keating and Wulff (2020) for an introduction to theories of SLA.

practice is needed to decrease task execution time and the percentage of errors. In the case of the example above, the morphosyntactic rule, available in someone's linguistic repertoire, can be practiced during natural dialogues.

It is important to note that DeKeyser's perspective considers transformation of declarative knowledge into procedural knowledge. However, not all cognitive-based theories in SLA agree upon this matter. For instance, Paradis' Neurolinguistic Theory of Bilingualism (2004; 2009), which is rooted in the literature of the cognitive neuroscience of memory, clearly differentiates declarative from procedural knowledge. More specifically, Paradis distinguishes metalinguistic knowledge (the conscious knowledge of a language) from implicit competence (the grammatical functions of a natural language). He proposed that metalinguistic knowledge relies on declarative memory, which is hippocampus-based, subject to conscious recollection, and flexibly used. On the other hand, implicit competence is believed to rely on procedural memory, which is independent of the hippocampus, not available to conscious recall, expressed implicitly through performance, and used inflexibly. Paradis argues that metalinguistic knowledge includes form-meaning patterns of vocabulary while implicit competence comprises phonology, morphology, and syntax as well as the grammatical properties of lexical items. For L2, this theory proposes that learning of vocabulary and grammatical functions initially depends upon the declarative memory system. Then, as learning progresses, grammatical functions may gradually start to rely on procedural memory. This does not mean that one type of knowledge is transformed into another; it means that both declarative and procedural learning mechanisms take place in parallel. Then, with exposure to language, linguistic competence starts to be subserved only by procedural memory, for instance.

A similar proposal is Michael Ullman's Declarative/Procedural Model (2001; 2016). Ullmann advocates that in language acquisition and use, the distinction between the mental lexicon and grammar relies on the distinction between the declarative and procedural memory systems. On that note, declarative memory supports acquisition and use of semantic and episodic knowledge. This system is central for learning arbitrary relations, such as explicit known rules of the language (ULLMAN, 2001). The brain regions subserving this component of the model are the same that support declarative memory: hippocampus and the adjacent entorhinal, perirhinal, and parahippocampal cortices. The procedural memory system supports acquisition and control of cognitive and motor abilities. This system is central to the manipulation of symbolic information; for instance, the manipulation that takes place during syntactic processing. The brain regions subserving this component of the model are the same that support procedural memory: frontal/basal-ganglia structures, premotor area and Broca

region. Subcortical structures, such as the thalamus and cerebellum may also be part of this system (ULLMAN, 2001; 2016).

Although Ullman (2006, p. 100) claims the Declarative/Procedural model "differs from Paradis' perspective" (i.e., Neurolinguistic Theory of Bilingualism), Paradis himself states that his theory is also based on the distinction between declarative and procedural memory systems (PARADIS, 2009, p. 12). Ullman also distinguishes his conceptual foundations from the ones adopted by Paradis. He affirms that his model is based on "contemporary research" in cognitive neuroscience while Paradis' theory is based in the 1980s and 1990s perspectives in the field (MORGAN-SHORT; ULLMAN, 2023, pp. 223-224). In the present undergraduate thesis, I acknowledge that both authors rely on the same conceptual distinction, but they put forward different hypotheses of how declarative and procedural memory systems account for L2 learning.[8]

Understanding how these domain-general learning and long-term memory mechanisms operate during L2 acquisition is critical to inform theoretical perspectives in SLA. However, gathering data to inform these theories is far from being an easy task. One of the difficulties relies on making sure that learning in a specific linguistic ability (e.g., vocabulary, morphosyntax, syntax, etc.) is the same kind of learning in a memory system (e.g., declarative or explicit *versus* procedural or implicit). Therefore, the assessment of declarative and procedural memory is essential to associate measures in language attainment with measures of memory mechanisms. Regarding this topic, some methodological considerations should be made. In the following subsection, some of the tenets of measuring memory during L2 studies are discussed.

2.3 Assessing declarative and procedural memory abilities: some considerations

Measurement is a central feature in quantitative research. Its centrality relies upon the fact research involves defining, controlling, and quantifying variables. On that note, measurement can be defined as the process of systematically assigning a quantitative description (i.e., numbers) to people's attributes with the aim of numerically representing these attributes in objective categories (NUNNALLY; BERNSTEIN, 1994). Inside this definition of measurement, there are two fundamental concepts: (i) scaling, which is the quantitative

[8] Presenting these divergent hypotheses is not in the scope of the present study.

description mentioned above, and (ii) classification, which is the assignment of a quantitative description to a specific category (NUNNALLY; BERNSTEIN, 1994). Research on the interface between memory and language demands, for instance, accurate measures of memory performance to assure the study internal validity (BUFFINGTON; DEMOS; MORGAN-SHORT, 2021). These measures can be gathered through a variety of psychological tests.

Psychological tests can be defined as standardized procedures used to acquire a sample of behavior from a person and describe it in scores (GREGORY, 2016; PRICE, 2017). According to Gregory (2016), psychological tests can be conveniently divided into eight categories: intelligence tests, aptitude tests, achievement tests, creativity tests, personality tests, interest inventories, behavioral procedures, and neuropsychological tests. Considering that the primary goal of psychological measurement is to describe individuals' psychological attributes (PRICE, 2017) and the objective of the present work is to identify assessments of declarative and procedural memory, neuropsychological tests will be mapped in this scoping review. This type of test assesses cognitive, sensory, perceptual, and motor performance. Moreover, these tests can be used to determine the extent, locus, and behavioral consequences of brain damage (GREGORY, 2016).

(Neuro)Psychological tests are systematically developed instruments. The developing process can be divided into 10 nonexhaustive phases: (i) identifying the purpose of a test; (ii) selecting the attributes reflective of the construct under testing; (iii) identifying the examinee population; (iv) delineating the content of the testing items; (v) writing the items; (vi) developing the test administration procedures; (vii) conducting the pilot test with a representative sample; (viii) conducting the item and factor analysis; (ix) developing the norms or interpretative scores; and (x) writing the test manual (PRICE, 2017).[9] All these phases are necessary to warrant the accuracy in assessments of neuropsychological instruments. Although these instruments tend to be carefully designed, their accuracy sometimes is not perfect (STRAUSS; SHERMAN; SPREEN, 2006). Therefore, studies interested in investigating the validity and reliability of tests are of keen importance to the establishment of trustful results. Validity can be defined as the degree to which an instrument measures what it is intended to measure (NUNNALLY; BERNSTEIN, 1994; STRAUSS; SHERMAN; SPREEN, 2006). Reliability can be defined as the degree to which an instrument is free from errors (STRAUSS; SHERMAN; SPREEN, 2006).

[9] See Price (2017) for a detailed description of the mentioned phases.

Instrument validity and reliability are essential features of neuropsychological tests. Consequently, these features also influence the results of a study that uses neuropsychological measures. That is, if a study aims to assess declarative or procedural memory abilities using a test that lacks validity and reliability, the conclusions that can be drawn from this study would be weak. This concern has been raised in SLA research, for instance (BUFFINGTON; DEMOS; MORGAN-SHORT, 2021). To avoid problems in the assessment of DM and PM, Morgan-Short, Hamrick and Ullman (2022) present four criteria that are paramount to the achievement of high instrument validity.[10]

When selecting a test, a first criterion to take into consideration is that tasks need to be selected only if they have been independently shown to reflect learning that depends on the underlying brain structures of each system. For instance, DM relies on the medial temporal lobe while PM relies on the basal ganglia circuitry. The second, third and fourth criteria are related to process-purity of the tasks. Accordingly, assessments should reflect learning only in one system; should rely only in one memory system; and should be nonverbal to avoid contamination from the systems, specifically DM. In a nutshell, according to Morgan-Short and colleagues (2022, p. 71), valid tasks should: "1) have been tied to the relevant neural circuit, 2) be process-pure, 3) rely on only one of the two systems, and 4) be nonverbal".

In line with the constructs of reliability and validity, another consideration regards the issue on how neuropsychological measures vary according to culture, geographic localization, and socioeconomic status (FERNÁNDEZ; MARCOPULOS, 2019). One example of this issue is the debate on WEIRD populations (HENRICH; HEINE; NORENZAYAN, 2010). WEIRD is an acronym for Western, Educated, Industrialized, Rich, and Democratic societies. In a nutshell, this discussion problematizes scientists' attitudes when they promote broad claims about human psychology and behavior based on a very specific and distinct sample: highly educated members of western countries. These people compose the convenient sample size in the majority of published studies, but they are not representative of the world's population. However, the problem with these generalizations has to do not only with the populations under investigation, but also with the instruments used to assess cognitive abilities (FERNÁNDEZ; MARCOPULOS, 2019). Most normalized instruments are designed and tested with WEIRD populations (SHOU *et al*., 2022). As a consequence, the outcomes of these instruments can be biased towards measuring a specific population and may generate a floor effect if tested with

[10] In their criteria, Morgan-Short, Hamrick and Ullman (2022) emphasize validity instead of reliability because if a task is not valid, thus, its reliability does not matter.

different samples. This is why possible cultural, geographical and societal variability needs to be taken in consideration when selecting the instrument to assess a specific sample if the researcher decides to use a test developed for a WEIRD population.

Thus, assessing DM and/or PM is a challenging task. Such a challenge is not only related to the tenets of each memory system itself, but also to the choice of instrument used to assess memory abilities. This is where lies the objective of the present study: to map declarative and procedural memory assessments used in SLA. Therefore, a scoping review was conducted to fulfill this objective. The next subsection defines scoping reviews and presents the importance of conducting this type of study.

2.4 Scoping reviews and their importance

Scientific inquiry generates knowledge about the world. The communication of this knowledge occurs mainly through academic publishing. Over the last decades, the number of published research articles has grown exponentially (FIRE; GUESTRIN, 2019). In this scenario researchers face two main difficulties: to catch up with the ever-growing number of published results, and to assess the quality of these materials. A possibility to deal with these problems is conducting literature reviews periodically. Literature reviews synthesize the knowledge of a specific field in varied ways. Therefore, there are different types of literature reviews: narrative, critical, descriptive, systematic, and scoping reviews. Each of them has its own goals, procedures, and limitations (JESSON; MATHESON; LACEY, 2011). For instance, narrative reviews provide comprehensive summaries of the current state of knowledge in a specific area (JESSON; MATHESON; LACEY, 2011). This type of review does not aim to search for articles rigorously or acknowledge limitations in the summaries provided. Scoping reviews and systematic reviews, in turn, have very well detailed procedures for searching the literature and acknowledging limitations. Consequently, they are good techniques to deal with the ever-growing number of published results, even in the language sciences (RAITSKAYA; TIKHONOVA, 2019).

According to Colquhoun and colleagues (2014), “a scoping review or scoping study is a form of knowledge synthesis that addresses an exploratory research (…) question aimed at mapping key concepts, types of evidence, and gaps in research related to a defined area or field by systematically searching, selecting, and synthesizing existing knowledge” (p. 1292-1294). The present study will use the framework developed by Arksey and O'Malley (2005) and later expanded by Levac, Colquhoun and O’Brien (2010) in order to synthesize the literature under

analysis. Moreover, this scoping review will follow the PRISMA-ScR [Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews] guidelines (TRICCO *et al*., 2018).

Due to the stages proposed in Arksey e O'Malley (2005) framework and PRISMA-ScR guidelines (TRICCO *et al*., 2018), scoping reviews are a potentially transparent and reproducible approach to synthesize the scientific evidence available in a field of inquiry. In order to improve rigor, transparency, and reproducibility, the methodological procedures of this scoping review were preregistered in the Open Science Framework (OSF).[11] Preregistration is the practice of documenting the research design of a study - for instance, its research questions, methodological procedures, and statistical analysis plan (BIN; MOTA, 2021; NOSEK *et al*., 2018; ROETTGER, 2021). This practice is commonly conducted in quantitative research. However, qualitative research and literature reviews can also be preregistered (TRICCO *et al*., 2018; HAVEN; VAN GROOTEL, 2019; HAVEN *et al*., 2020).

Having in mind the importance of literature synthesis in the area of SLA and the specific features of a scoping review, the next section presents the method of this undergraduate-level research.

3 METHOD

This section is divided into two subsections. The first subsection, “The present study”, restates the objective of this scoping review and presents its research questions. Then, a subsection entitled “Methodological procedures” describes all the stages of the information search.

3.1 The present study

The main objective of the study is to map what instruments were used to assess declarative and procedural memory in SLA research in the past three years (2020-2023). In order to fulfill this objective, the following research questions (RQ) guides the investigation:

> RQ1: Which instruments do studies that investigate the role of memory in L2 learning adopt to assess declarative memory?

[11] Link to the preregistration: https://osf.io/avmun.

RQ2: Which instruments do studies that investigate the role of memory in L2 learning adopt to assess procedural memory?

Considering this review follows a specific guideline, below I report the procedures I used for searching the literature.

3.2 Methodological procedures

The search was conducted with the advanced search option at the Web of Science database (see Figure 4). The following keywords were selected to perform the search: "Declarative memory", "Explicit memory", "Procedural memory", "Implicit memory", "Second Language Acquisition", and "Second Language Learning".[12] The keywords were chosen considering that in the SLA field all these are terms used to refer to the memory systems I am interested in. Also, I performed the search using both second language acquisition and learning as key terms in the query strings.

To be included in the synthesis the information sources should be: peer-reviewed research articles, written in English or Portuguese, and published in the past three years (2020-01-01 to 2023-01-01). Also, the studies must have objectively stated that their aim was to investigate the role of memory systems in L2 language learning; more specifically, measures of declarative and/or procedural memory need to be associated with measures of linguistic performance. Finally, if the full-text was not available online, the research article was not included in the synthesis.

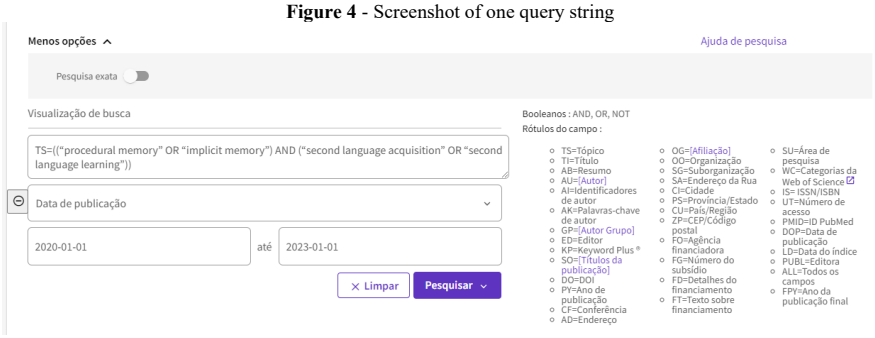
The search was conducted in two phases: (i) the pilot search and pilot screening phase, and (ii) the official search and official screening phase. Piloting is needed because adjustments in searching procedures are commonly necessary in this type of study (ARKSEY; O'MALLEY, 2005; LEVAC; COLQUHOUN; BRIEN, 2010; COLQUHOUN *et al*., 2014). Pilot search was conducted on April 28th, 2023. Pilot screening was conducted during May, 2023. A search validation procedure was done during this stage, to evaluate if the keywords elicited the accurate records (i.e., studies in the field of SLA that investigated associations between linguistic and memory performance). After I confirmed the selected keywords were retrieving articles that met inclusion criteria, I preregistered the review and conducted the official search in June, 2023.

[12] The Web of Science search mechanism does not discriminate between capital letters.

The following two query strings (QS) were used, in a three-year interval (2020-01-01 | 2023-01-01):

QS1: TS=((“declarative memory” OR “explicit memory”) AND (“second language acquisition” OR “second language learning”))
QS2: TS=((“procedural memory” OR “implicit memory”) AND (“second language acquisition” OR “second language learning”))

Figure 4 - Screenshot of one query string



Source: Web of Science

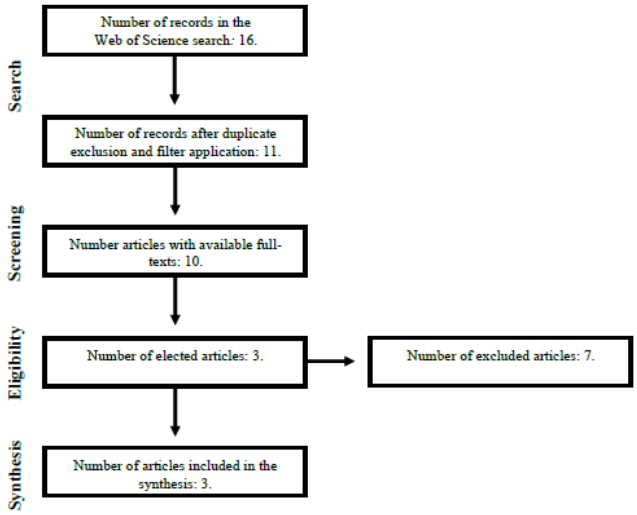
I combined the results from the two sets (QS1 and QS2) using the OR operator in order to exclude the duplicate articles. Also, I applied a filter to include only research articles in the sample. I found 6 articles using QS1 and 10 articles using QS2. After the exclusion of the duplicates and the application of the filter, only 11 articles remained in the sample.[13]

After searching, it is important to screen the literature. Thus, screening the articles was divided into two stages: in the first stage, I screened the titles and abstracts of the articles. In the second stage, I screened the full-texts. In this phase, I applied the inclusion criteria and found that one of the 11 articles did not have its full-text available. So, this article was excluded (MURPHY; MILLER; HAMRICK, 2021). Based on the screening, 7 more articles were excluded from the sample (RASTELLI, 2023; MENKS *et al*., 2022; GODFROID; KIM, 2021; BUFFINGTON; DEMOS; MORGAN-SHORT, 2021; THOMPSON *et al*., 2021; SENGOTTUVEL *et al*., 2020; MILLER; GODFROID, 2020) because they did not meet the inclusion criteria of the review. The individual justification for each excluded article is in

[13] Search history and all information about the records found in the searches as well as any other material used in this review are available in an OSF project: https://osf.io/qu5xb/.

Appendix A. Thus, only 3 articles were eligible for the synthesis. Figure 1 presents the flowchart of the research.

Figure 5 - Flowchart of the review



Note: the justification for the excluded articles can be found in Appendix A.
Source: Own authorship.

The process of data extraction consisted of identifying the name of the instruments used to assess declarative and procedural memory in each source included in the review. Additionally, complementary information was also extracted from each source: population and number of participants, languages investigated, L2 domain examined (e.g., syntax, vocabulary, etc.), the context in which the L2 was learned (e.g., classroom, naturalistic, etc.), the L2 task used in the study, and information regarding a possible rationale for the choice of the instruments. The data extracted from the research articles was organized in Table 1.

The next section presents the results of this review.

4 RESULTS

In this section, I present the data that was extracted from the articles considered eligible for the synthesis. Table 1 provides an overview of the information extracted from the studies. I

Table 1 - Data extracted from the studies

Reference	Participants	L2	Level of L2	L2 Domain	Context in which L2 was learned	Task probing learning L2	Task probing DM	Task probing PM	Provided a rationale
Pili-Moss (2022)	36 participants	L2: BrocantoJ (miniature artificial language)	Early stages of learning	Vocabulary and syntax	Online gaming	Gaming task	Rey-Osterrieth Complex Figure Task + Logical Memory Subtest in the Wechsler memory scale	ASRT task	No
Saito *et al*. (2022)	70 participants	L2: English	Different levels of proficiency	L2 Speech	Instructional settings	Identification task	LLAMA-B test	SRT task	No
Zhang *et al*. (2021)	38 participants	L2: English	High intermediate to advanced proficiency	Vocabulary	It is not informed	VLT	CVMT	It is not applicable	No

Note: L1 = First language; L2 = Second language; DM = Declarative memory; PM = Procedural memory; Rey-Osterrieth Complex Figure Task (OSTERRIETH, 1944); Logical Memory Subtest in the Wechsler memory scale (RYAN; MORRIS; YAFFA; PETERSON, 1981); ASRT = Alternating Serial Reaction Time (HOWARD, J. H.; HOWARD, D. V, 1997); LLAMA-B = paired associates test of the LLAMA aptitude test battery (MEARA, 2005); VLT = Vocabulary Levels Test (NATION, 1990); CVMT = Continuous Visual Memory Task (TRAHAN; LARRABEE, 1988); SRT = Serial Reaction Time (NISSEN; BULLEMER, 1987).

Source: Own authorship.

also present summaries for each individual study inserted in the final sample. In addition to what instruments were used in studies, I extracted population and number of participants, languages investigated, L2 domain examined (e.g., syntax, vocabulary, etc.), the context in which the L2 was learned (e.g., classroom, naturalistic, etc.), and L2 task used in the research. Finally, I checked if the authors provided a rationale for using a specific memory test in their studies.

The exploratory study reported in Pili-Moss (2022) aimed at investigating how declarative and procedural learning abilities support adult L2 learning. Pili-Moss (2022) was particularly interested in probing the possible different contributions of PM and DM in two different scenarios. In scenario 1, participants had to fully process form-meaning relationships in order to reach an accurate interpretation, whereas in scenario 2, optimal interpretation could be reached based solely on disambiguating contextual cues. Participants were 36 L1 Italian young adults. At first, participants were introduced to an artificial mini language, BrocantoJ, during a vocabulary training section in which items were presented aurally with corresponding pictures or animations. Participants could only move onto the next stage after having completed a test with a performance of 100% correct answers. At the second phase, participants passively listened to full BrocantoJ sentences while watching corresponding visual animations. Importantly, sentences and visual animations referred to four possible moves in a game participants would play. Sessions of passive exposure were followed by sessions of game practice. After having played the game and finished the experiment, participants were interviewed and their verbalized explicit knowledge of BrocantoJ was assessed. To investigate the research questions of the study, participants' declarative memory was assessed using Rey-Osterrieth Complex Figure Task (visual declarative memory) and Logical Memory Subtest in the Wechsler memory scale (verbal declarative memory). Procedural memory was measured with an Alternating Serial Reaction Time (ASRT) task. Results showed that in both scenarios declarative learning ability was significantly and positively associated with sentence comprehension and accuracy increase across training. Procedural learning ability alone failed to show strong positive associations with accuracy in both scenarios. However, the best outcomes in scenario 1 were reached by participants with high levels of both declarative and procedural learning ability in the final practice session. Since in scenario 1 participants had to fully process form-meaning relationships, the author argues that high levels of both declarative and procedural abilities were needed to process and learn these relationships. Although the author does not provide a rationale regarding the declarative and procedural memory tests she used, two declarative memory tasks and one procedural memory test were used. Regarding DM,

one task investigated visual DM and the other investigated verbal DM. According to the considerations made in the review of literature, memory assessments for the purposes of second language acquisition research should not be verbal, because of possible contamination of other cognitive domains (such as language or attention) in the results. In regard to PM assessment, the author used Alternating Serial Reaction Time (ASRT) task, which is considered a valid assessment to probe learning in PM (MORGAN-SHORT; HAMRICK; ULLMAN, 2022; BUFFINGTON; DEMOS; MORGAN-SHORT, 2021).

The study reported in Saito and colleagues (2022) aimed at investigating if perceptual factors would predict independent variance in L2 speech acquisition, once cognitive factors were accounted for in a sample of 70 Japanese-English bilinguals. Participants differ in their level of proficiency in the L2. To investigate the research questions of the study, participants' declarative memory was assessed using LLAMA-B test (paired associates test of the LLAMA aptitude test battery) and procedural memory was measured with a Serial Reaction Time (SRT) task. Also, L2 speech abilities were measured by means of an identification task in which participants should identify contrasting phonemes in a minimal pair context. Saito and colleagues' study was exploratory in nature. Thus, their results should be interpreted cautiously. In a nutshell, their data indicated that auditory perception skills in L2 were a relatively independent construct compared to other cognitive abilities such as long-term memory learning abilities. However, an interaction was found between the performance of learners that studied abroad and their procedural memory abilities. Although authors do not provide a rationale regarding the declarative and procedural memory tests they used, LLAMA-B is considered a valid measure to probe learning in DM and the SRT is also considered a valid assessment to probe learning in PM (MORGAN-SHORT; HAMRICK; ULLMAN, 2022). However, despite being a very traditional test, the SRT needs further investigations for validity (BUFFINGTON; DEMOS; MORGAN-SHORT, 2021).

The study reported in Zhang and colleagues (2021) aimed at investigating if individual differences in nonlinguistic episodic memory abilities (a subsystem of declarative memory) would predict individual differences in L2 vocabulary knowledge in a sample of 38 higher proficiency late bilinguals. Participants had different L1s, for instance, Arabic, Chinese, Thai, Persian, Wolof, Algerian, Italian, Russian, Sinhalese, Spanish, and Ukrainian, but they were all speakers of English as an L2. To investigate this question, participants' nonlinguistic episodic memory abilities were assessed by Continuous Visual Memory Task (CVMT) and L2 vocabulary knowledge was assessed by Vocabulary Levels Test (VLT). Results from this study indicated that declarative memory, more specifically episodic memory abilities, was predictive

of L2 lexical abilities in more proficient bilinguals. Although authors do not provide a rationale regarding the declarative memory test they used, the CVMT is considered a valid measure to probe learning in DM in studies of vocabulary retention (MORGAN-SHORT; HAMRICK; ULLMAN, 2022).

In sum, four tests were used to assess declarative memory and two tasks were used to assess procedural memory, as presented in Table 2:

Table 2 - Declarative and procedural memory assessments

DM instrument	PM instrument
Rey-Osterrieth Complex Figure Task	ASRT
Logical Memory Subtest in the Wechsler memory scale	SRT
LLAMA-B	
CVMT	

Note: L1 = DM = Declarative memory; PM = Procedural memory; Rey-Osterrieth Complex Figure Task (OSTERRIETH, 1944); Logical Memory Subtest in the Wechsler memory scale (RYAN; MORRIS; YAFFA; PETERSON, 1981); ASRT = Alternating Serial Reaction Time (HOWARD, J. H.; HOWARD, D. V, 1997); LLAMA-B = paired associates test of the LLAMA aptitude test battery (MEARA, 2005); VLT = Vocabulary Levels Test (NATION, 1990); CVMT = Continuous Visual Memory Task (TRAHAN; LARRABEE, 1988); SRT = Serial Reaction Time (NISSEN; BULLEMER, 1987).

Source: Own authorship.

The next section presents the synthesis of research and the conclusion of this review as well as its limitations.

5 CONCLUSION

This final section is divided into two subsections. The first subsection, “Synthesis” discusses the main results of this study. The second subsection, “Limitations and suggestions for future research”, acknowledge the limitations of the scoping review.

5. 1 Synthesis

Comprehending how L2 learning occurs is of keen importance to broaden our understanding of language (acquisition) and the organization of the human mind (DOUGHTY; LONG, 2003; HAGOORT, 2023). In a psycholinguistic perspective, it is also important to have very clear models of how language is mentally organized. Studies that investigate L2

acquisition focus in describing the learning mechanisms subserving knowledge in the L2. It is common to use an associative approach to study this topic: measures of linguistic abilities are associated with assessments of declarative and procedural memory. However, assessing declarative and procedural learning is not simple. Therefore, the objective of this study is to map what instruments were used to assess declarative and procedural memory in SLA research in the past three years (2020-2023).

Overall, according to the literature, with the exception of the Logical Memory Subtest in the Wechsler memory scale, the DM and PM assessments are valid and reliable to be used in psycholinguistic studies (MORGAN-SHORT; HAMRICK; ULLMAN, 2022). More specifically, recent studies have attested to the validity and reliability of instruments used to assess procedural memory (BUFFINGTON; DEMOS; MORGAN-SHORT, 2021; GODFROID; KIM, 2021). Of important consideration, however, is the fact that there is a need to attest to the validity and reliability of these tests in different populations. This is related with cultural, geographical and societal variability that need to be taken in consideration when selecting an instrument to assess a specific sample (FERNÁNDEZ; MARCOPULOS, 2019). For instance, it is not clear if non-WEIRD samples could be reliably assessed with instruments developed and tested with WEIRD populations (HENRICH; HEINE; NORENZAYAN, 2010). This points out, for example, the need to investigate memory assessments used in the Brazilian SLA scenario.

In the three studies synthetized in this review, justifications about the selection of the tests were absent. This points out the need for researchers to be transparent and present the rational for selecting instruments in their studies. This information would allow the identification of the pros and cons of selecting a specific instruments. Also, it would facilitate the evaluation, by the research community, if a test could be used, for instance, in different research scenarios and (non-WEIRD) populations.

While screening the literature, I noticed a trend of investigations regarding implicit and explicit learning aptitude, as well as a focus in statistical learning as being one of the mechanisms subserving implicit knowledge (GODFROID; KIM, 2021). Although the topic of aptitude is not new in SLA, recent studies (e.g., GODFROID; KIM, 2021) have attempted at validating specific tasks to assess aptitude as individual differences in L2 acquisition, as well as the learning mechanisms related with each type of aptitude (implicit *versus* explicit). The studies compiled in this review do not account for this trend, which also employs assessments of DM and PM.

The contribution of the present review to the SLA field is twofold. First, it presents DM and PM assessments used recently in psycholinguistic investigations of L2 learning and identifies the tests that are valid and reliable, according to criteria presented in the literature (MORGAN-SHORT; HAMRICK; ULLMAN, 2022). Second, it indicates that researchers should be more transparent and explain the rationale behind the selection of neuropsychological tests used in SLA research.

After discussing the main results, the next section addresses the limitations of the present scoping review.

5.2 Limitations and suggestions for future research

This research was conducted as a small-scale project, thus, it has some limitations. I acknowledge three limitations of the scoping review. The first one is that I searched for literature in only one database (Web of Science). Future research could use more databases to expand the number of records found and, possibly, articles included in the synthesis. The second limitation is the selection of keywords. Even though there was a rationale behind my choice, it did not account for the recent trend in implicit learning aptitude, for instance. Also, it is possible that using other terms (e.g., SLA, L2, episodic memory, implicit language aptitude, explicit language aptitude, etc.) would elicit more related material. Thus, future research could use other keyword combinations or, even, use keywords separately and then combine the set of results with database mechanisms to avoid targeting the literature into very specific research articles. Finally, the third limitation is the year interval chosen for the literature search (2020-2023). Initially, my idea was to map the last ten years of research. However, it was not possible due to time constraints. Future research could expand this interval for ten or fifteen years to better understand the historical trends and state of affairs of the research on the interplay between memory and L2 acquisition.

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APPENDIX A

List of excluded articles from the final sample and justification for exclusion.

Table 3 - List of excluded articles, in a descendent order of publication

Article	Justification for exclusion
Rastelli (2023)	It is not a research article.
Menks *et al.* (2022)	It is not a research article.
Godfroid and Kim (2021)	It did not have the objective of investigating a measure of language and memory directly.
Buffington, Demos and Morgan-Short (2021)	It did not have the objective of investigating a measure of language and memory directly.
Murphy, Miller and Hamrick (2021)	It is not available on the internet as a full-text.
Thompson *et al.* (2021)	It did not have the objective of investigating a measure of language and memory directly.
Sengottuvel *et al.* (2020)	It did not have the objective of investigating a measure of language and memory directly.
Miller and Godfroid (2020)	It did not have the objective of investigating a measure of language and memory directly.

Note: The complete reference of excluded articles can be found in the bibliographic list.
Source: Own authorship.