INTERRELATIONSHIPS AMONG L2 LINGUISTIC KNOWLEDGE, WORKING MEMORY FUNCTIONS, AND L2 READING

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DECLARATION OF ORIGINALITY

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ABSTRACT

Interrelationships Among L2 Linguistic Knowledge,

Working Memory Functions, and L2 Reading

The purpose of the study is to investigate the relationships between processing/storage functions of working memory (WM) and explicit/implicit second language (L2) knowledge as well as the contributions of these variables to L2 reading comprehension. Participants were 84 moderately proficient late adult learners of English. WM capacity was measured through reading span tasks administered in L1 and L2 and an operation span task. An untimed grammaticality judgment test (GJT) and a metalinguistic knowledge test were administered to measure explicit linguistic knowledge in the L2 while a timed GJT and an elicited oral imitation test were used to measure implicit linguistic knowledge. Reading comprehension scores were obtained from a retired paper-based TOEFL. Results suggest that WM’s storage function is language independent and it is not affected by the type of secondary task employed. The findings also suggest that WM's processing function is not task-dependent. Furthermore, results corroborate previous studies arguing against a trade-off between the processing and storage functions of WM. Based on the findings regarding the relationship between linguistic knowledge and WM capacity, it can be argued that the type of knowledge assessed by the so called implicit knowledge tests could actually be automatized explicit linguistic knowledge resulting from large amounts of practice in late adults learners of advanced proficiency in an instructional context. This automatized and primarily explicit L2 linguistic knowledge and WM's processing function are the best

predictors of L2 reading comprehension, demonstrating the dominant role of automatized knowledge in efficient L2 reading comprehension for instructed L2 learners.

ÖZET

İkinci Dil Bilgisi, İşler Bellek Fonksiyonları ve İkinci Dilde Okuduğunu Anlama Arasındaki Karşılıklı İlişkiler

Bu çalışmanın temel amacı işler belleğin (İB) işlem yapma/bilgi depolama fonksiyonu ile ikinci dilde (D2) açık/örtük bilgi türleri arasındaki ilişkiyi ve bu değişkenlerin D2'de okuduğunu anlamaya katkılarını incelemektir. Katılımcılar D2 olarak İngilizceyi geç yaşta öğrenmeye başlayan ve ileri seviyede olan 84 yetişkinden oluşmaktadır. İB kapasitesi D1 ve D2'de uygulanan iki okuma aralığı testi ve bir işlem aralığı testi ile ölçülmüştür. D2'de açık bilgi türünü ölçmek için zaman kısıtlamasız dil bilgisel yargı testi (DYT) ve üstdil bilgi testi kullanılırken örtük bilgi türünü ölçmek için söyletimli öykünme testi ve zaman kısıtlamalı DYT kullanılmıştır. D2'de okuduğunu anlamayı ölçmek için ise TOEFL testi kullanılmıştır. Sonuçlar İB'nin depolama fonksiyonunun dilden ve ikincil görevin türünden bağımsız olduğunu ortaya koymuştur. Buna ilaveten sonuçlar İB hakkındaki alan-genel görüşü destekleyerek işlem yapma fonksiyonunun görev bağımsız olduğunu önermektedir. Sonuçlar ayrıca İB'nin işlem yapma ve depolama fonksiyonları arasındaki değiş-tokuş görüşüne karşı olan önceki çalışmaları teyit eder niteliktedir. İB ve dil bilgisi arasındaki ilişki sonuçlarına dayalı olarak sözde örtük bilgi testleri ile ölçülen bilgi türünün aslında otomatikleşmiş açık dil bilgisi olduğu öne sürülmektedir. Bu otomatikleşmiş açık dil bilgisinin ergenlikten sonra formel ortamlarda yoğun pratik ile ileri seviyede ikinci dil öğrenmiş katılımcıların elde ettiği bir sonuç olduğu düşünülmektedir. D2'de okuduğunu anlamanın en iyi yordayıcılarının bu otomatikleşmiş ve öncelikli olarak açık türde olan D2 dil bilgisi

ve İB’nin işlem yapma fonksiyonu olduğu bulgusu formel ortamlarda D2 öğrenen kişiler için otomatikleşmiş bilginin etkili okumada hakim bir rolü olduğunu ortaya koymaktadır.

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DEDICATION

To my mother, Türkan Çeçen, who has been losing her Memory since I started this dissertation (I already knew that Life could be ironic but I did not expect it to be that much) but still trying hard for her loved ones as she has always done so throughout her life. I hope we will remember each other till the last day of our lives.

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CHAPTER 1

INTRODUCTION

1.1 Background and purpose of the study

Given that the ultimate goal of language instruction is to promote development of the ability to use the target language efficiently (DeKeyser, 2007a; Hulstijn, 2001; Jiang, 2007; Segalowitz, 2003), it is important to conceptualize the constructs underlying second language (L2) learner knowledge and investigate its relationship with other cognitive constructs such as working memory (WM) and with language skills such as reading comprehension.

It has been of particular interest to second language acquisition (SLA) researchers to understand what L2 knowledge consists of especially considering the fact that it shows variation depending on learner factors such as the level of L2 proficiency (high vs. low), the type of L2 instruction (explicit vs. implicit), age of onset of L2 acquisition (early vs. late), and the kind of L2 exposure (instructed vs. naturalistic). The division between knowledge *of* language i.e., implicit knowledge, and knowledge *about* language i.e., explicit knowledge has originated from cognitive psychology and received close attention in the field of SLA. Whereas implicit knowledge is described as unanalysed, intuitive and procedural, explicit knowledge is described as analysed, conscious and declarative. To what extent L2 users are aware of their language knowledge is another criterion of operational definition according to which implicit knowledge is characterized as knowledge without awareness and explicit knowledge as knowledge with awareness (Ellis, 2005; Hulstijn, 2002, 2005; Williams, 2005). Finally, implicit knowledge is described as unverbalizable but explicit knowledge is described as verbalizable, not necessarily but possibly by using metalanguage (R. Ellis, 2004).

The question of whether learner knowledge is truly implicit or explicit or both (Norris & Ortega, 2012, p. 576) has been methodologically challenging for SLA researchers (Norris & Ortega, 2003). A recent line of research by R. Ellis and his colleagues has attempted to develop a test battery for assessment of implicit and explicit knowledge based on the above-mentioned operational definitions. The factor-analytic approach used in these studies (e.g., Bowles, 2011; R. Ellis, 2004, 2005, 2009b; Erlam, 2006; Elder, 2009; Gutiérrez, 2012; Philp, 2009) consistently yielded a two-factor solution in which tests aimed to tap implicit and explicit knowledge loaded separately. These researchers interpreted these two factors as evidence of relatively separable knowledge constructs.

However, more empirical investigation is warranted since a number of researchers (Shiu & Spada, 2012; Spada, 2015; Suzuki & DeKeyser, in press) have lately argued that measures of implicit knowledge may actually be tapping highly automatized knowledge (DeKeyser, 2009) or automatized explicit knowledge (Spada, 2015; Suzuki & DeKeyser, in press). Suzuki and DeKeyser (in press), for instance, question naming the factors obtained in those studies as implicit and explicit knowledge. They argue that the measures which loaded together were either time-pressured (e.g., an elicited oral imitation task, a timed grammaticality judgment test, an oral narrative task) or untimed (e.g., an untimed grammaticality judgment test and a metalinguistic knowledge test), which is an issue that deserves attention granted that the time-pressure as a criterion does not eliminate the possibility of accessing explicit knowledge (DeKeyser, 2003, 2009).

Among the cognitive factors that attract the individual differences research, WM stands out as an important individual learner variable that contributes to differences in L2 ultimate attainment, particularly with instructed L2 learners who have limited chance of practice. WM, as a limited-capacity system with its dual functions of processing and storage, is thought to serve for a wide range of complex cognitive activities. Thus, its relationship to L2 knowledge and skills attracted SLA researchers' attention in recent years especially seeing that WM has come to be considered as a critical component of language aptitude (Miyake & Friedman, 1998; Sawyer & Ranta, 2001; Skehan, 2002). Certain methodological issues need to be addressed in examining WM's role in L2 learning. These issues that need to be essentially addressed in the pursuit of the role of WM in L2 learning can be listed as follows: (1) whether WM should be measured in the L1 or L2, (2) whether a linguistically or non-linguistically oriented task should be employed, and (3) whether the storage scores or a composite of processing and storages scores should be used as a measure of WM capacity.

As such, the relationship between WM operations and L2 linguistic knowledge is also an unresolved issue. Theoretically, a significant relationship is expected between explicit knowledge and WM operations since both are said to be characterised by consciousness and controlled attention. However, some research findings point to a relationship between WM operations and implicit knowledge as well. Such contradictory findings raise further doubts about the validity of the instruments used to measure L2 linguistic knowledge. Finally, the role of WM in L2 reading comprehension has received great interest lately but investigating its contribution along with L2 linguistic knowledge has not been addressed in these studies.

With these issues in mind, this study aims to address a number of theoretical and methodological issues. Theoretically, it explores the relationship between explicit and implicit L2 linguistic knowledge, whether they are associated with

WM's processing and storage functions and to what extent L2 reading comprehension can be accounted for by L2 linguistic knowledge and WM's processing and storage functions. Methodologically, the study examines relationships among different measures of explicit and implicit linguistic knowledge and relationships among different measures of WM capacity. By using multiple measures of WM capacity, the study also attempts to investigate whether these relationships depend on the language (L1 vs. L2) and the type of secondary task (processing sentences vs. processing mathematical operations) employed in the span tasks.

The remaining chapters are organized as follows. Chapter 2 will first review the theoretical definitions as well as issues related to implicit and explicit L2 knowledge and then review the related methodology and empirical research. Similarly, Chapter 3 will first review the theoretical definition, models, and measurement of WM and then review WM research in relation to L2 reading and implicit/explicit L2 knowledge. Chapter 4 will start with a discussion of the purposes of this dissertation research and the research questions along with hypotheses driving the study. It will also describe participants, research instruments, research procedure, and the data analysis. Chapter 5 will report the results of the analyses employed to address the research questions of the dissertation research. Chapter 6 will discuss the results in relation to existing theoretical and empirical literature. Chapter 7 will present conclusions and implications drawn from the findings and conclude with limitations and suggestions for future research.

1.2 Definition of key terms

Implicit L2 knowledge: It refers to L2 knowledge that one is not aware of but can draw on through automatic processing (Hulstijn, 2005; Segalowitz, 2003; Segalowitz & Hulstijn, 2005). There has also been a recent operationalization of the construct with the following criterial characteristics: procedural, unanalysed, intuitive, and unverbalizable (R. Ellis, 1993, 1994, 2005, 2009).

Explicit L2 knowledge: It refers to L2 knowledge that one is aware of and can draw on effortful processing (Hulstijn, 2005; Segalowitz, 2003; Segalowitz & Hulstijn, 2005). Criterial characteristics recently proposed for this knowledge type can be listed as follows: declarative, analysed, conscious, and potentially verbalizable (R. Ellis, 1993, 1994, 2005, 2009).

Working memory (WM): It is a limited-capacity system capable of simultaneously storing and processing information while conducting a variety of cognitive tasks which require controlled processing (Baddeley, 2000, 2003, 2010; Baddeley & Hitch, 1974; Baddeley & Logie, 1999).

CHAPTER 2

IMPLICIT AND EXPLICIT LINGUISTIC KNOWLEDGE IN L2 LEARNING

2.1 Defining implicit and explicit L2 knowledge

The distinction between implicit and explicit L2 knowledge, which originally stems from cognitive psychology, has generated considerable interest in the field of SLA in order to better understand the role each knowledge type plays in language learning and use as well as the relationship between these two knowledge types (DeKeyser, 2003, 2009; N. Ellis, 2005, 2011; R. Ellis, 2005, 2009a; Hulstijn, 2002, 2005). Indeed, there are some key concerns to guide SLA researchers such as defining and measuring learner knowledge to be able to clearly demonstrate whether it is truly implicit or explicit knowledge (or both) that is employed (Norris & Ortega, 2012, p. 576).

An examination of the characteristics of these two knowledge types yield shark contrasts. Implicit knowledge of the L2 is described as procedural, unanalyzed, intuitive knowledge that is retrieved automatically in spontaneous language use and that cannot be verbalized. Implicit knowledge is neurolinguistically subserved by procedural memory and is not open to introspection. On the contrary, explicit knowledge of the L2 is described as declarative, analyzed, conscious knowledge that is accessible through controlled processing and that can be potentially verbalized. Explicit knowledge is neurolinguistically subserved by declarative memory and is open to introspection.

One central issue that divides SLA researchers into adopting two stances regarding the relationship between implicit and explicit knowledge is the interface/non-interface contrast. What is often meant by “interface” is that one type of knowledge, which is the explicit knowledge in the L2 domain, can be transformed into the other, i.e., the implicit knowledge, through certain learning mechanisms. The literature on interface is divided into two positions: non-interface versus interface (with a strong and a weak version).

The non-interface position rejects the possibility of one type of knowledge converting to the other through learning (Krashen, 1981, 1982; Paradis, 2009; Schwartz, 1993; Truscott, 1996). Explicit knowledge which develops from intentional learning of language rules or patterns through instruction (Schwartz, 1993) can never lead to implicit knowledge (acquired knowledge) which is primarily unconscious and develops through processing input for meaning (Krashen, 1982, 1985). As such, a case of non-interface is espoused given that the knowledge systems are assumed to remain separate. Ascribing a limited role to the explicit knowledge resulting from explicit learning, Krashen (1982) posits that L2 learners cannot draw on their explicit knowledge for spontaneous communication as it is prompted by implicit knowledge acquired through experience with comprehensible input. Thus, the role of L2 instruction is to provide large quantities of comprehensible input for implicit learning and this assigns a minor role to explicit instruction.

In stark contrast, the interface position holds that everything is learnable and teachable (Han & Finneran, 2014). There are two versions of the interface position i.e., a weak and a strong version. According to the weak version, explicit knowledge can become implicit under certain conditions. For instance, R. Ellis (1993, 1994, 2005) posits that the conversion is possible only when the learner is developmentally ready for the grammatical elements which are developmentally constrained. Regarding the non-developmental features, there is no such constraint as they can turn into implicit knowledge at any time. According to N. Ellis (1994, 2005) learning process is largely implicit. However, explicit knowledge accompanies the implicit knowledge when implicit knowledge is not sufficient. Explicit knowledge helps learners to notice differences between their output and instructional input and this results in some modifications in learners' implicit knowledge with practice. As a consequence, explicit knowledge contributes indirectly to the creation of implicit knowledge.

The strong interface position holds that explicit knowledge can be automatized through practice (DeKeyser, 1998, 2003, 2007a, 2007b; Sharwood Smith, 1981). According to DeKeyser (2007a), this position in SLA is closely tied to skill acquisition theory which originated within cognitive psychology (e.g., Anderson, 1983, 1993; Anderson, Bothell, Byrne, Douglass, Lebiere, & Qin, 2004, Carlson, 2003). The basic argument in the theory is that learning of a wide variety of skills, which is of course not limited to language learning, proceeds through three stages of development, i.e., declarative knowledge, proceduralization, and automatization (DeKeyser, 2007a).

During the first stage, the learner starts out first by learning a rule as explicit declarative knowledge. This might happen via observation and analysis of others while they are performing the skill, or predominantly this knowledge might be presented verbally or demonstrated slowly by an expert who is already skilful in it. In particular to instructed second language learning, a certain language feature taught via rule presentation (possible through different instructional treatments such as any focus on form type of activities) and thus learned as declarative knowledge is the outset for the second language learner. In the subsequent stage, the learner acts on this declarative knowledge and "knowledge that" turns into "knowledge how" i.e., procedural knowledge. Finally, through constant use and a large amount of practice in meaningful communication, this proceduralized knowledge can become automatized. The slow reduction of error rate, reaction time, and interference with/from other tasks characterize this automatization process. DeKeyser (2003) highlights that "… after large amounts of communicative use and complete automatization of the rules, learners eventually lose their awareness of the rules." (p. 329) and learners thereupon have procedural knowledge functionally equivalent to implicitly acquired knowledge.

Another view related to the interface debate stems from a neurocognitively motivated account of language acquisition, namely the declarative/procedural (DP) model of language acquisition proposed by Ullman (2001, 2004, 2005). It is important to note that Ullman's DP model offers a dual-system perspective in which the pairs of concepts are not considered isomorphic. Procedural memory (PM) involves one type of "implicit, non-declarative, memory system" but not "all non-declarative or implicit memory systems" (2004, p. 237), and similarly, declarative memory (DM) refers to a substantially but not thoroughly explicit system (2004, p. 235). Whereas DM stores the lexical/semantic knowledge, PM subserves the implicit learning, representation, and retrieval of rule-governed combinatorial grammar including phonology, morphology, and syntax.

From an L2 acquisitional viewpoint, the model posits that late L2 learning begins to be governed by the processing mechanisms of the declarative system, however, the model allows for interface at advanced levels of L2 proficiency (Ullman, 2004, 2005) as Ullman (2005) suggests a gradual "replacement of the controlled application of explicit rules by the automatic use of implicit procedures" (p. 157). With this gradual substitution in memory systems, it is not impossible for late L2 learners to become nativelike in their performance with extensive language use (Ullman, 2004, p. 256-257) which is suggestive of a significant change at the process level.

2.2 Measuring Implicit and Explicit L2 Knowledge

In order to measure implicit and explicit knowledge, recent research based on behavioral evidence in SLA (R. Ellis 1994, 2004, 2005, 2009b; Han & R. Ellis, 1998) first identified seven features that distinguish these knowledge types and then operationalized these constructs on the basis of seven criteria. The features that distinguish these two knowledge types have been listed as: (1) awareness, (2) type of knowledge, (3) systematicity, (4) accessibility, (5) use of knowledge, (6) self-report, and (7) learnability. In the light of these features, the conceptual underpinnings of these two constructs are as follows respectively: implicit knowledge is intuitive, procedural, systematic with low variability, accessed through automatic processing, used during tasks effortlessly, not verbalizable, and finally L2 learners' ability to learn implicit knowledge is constrained by age. On the other hand, explicit knowledge is conscious, declarative, and inconsistent with high variability, accessed through controlled processing, used as a tool in arduous linguistic tasks, potentially verbalizable, and can be learned at any age.

Based on the seven features listed above, R. Ellis (2004, 2005) identified seven criteria in operationalizing the constructs of L2 implicit and explicit knowledge as follows:

(1) *Degree of awareness*. Whether learners resort to feel (implicit knowledge) or rule (explicit knowledge) to complete a given task.
(2) *Time available*. Whether learners are given time (explicit knowledge) or not (implicit knowledge).

(3) *Focus of attention*. Whether learners focus on meaning (implicit knowledge) or form (explicit knowledge) while performing the task.

(4) *Systematicity*. Whether learners' response to a task is consistent (implicit knowledge) or variable (explicit knowledge).

(5) *Certainty*. How certain (implicit knowledge) or uncertain (explicit knowledge) learners are about their responses with respect to conforming to target language forms.

(6) *Metalanguage*. Whether learners are capable of (explicit knowledge) resorting to their metalingual terms or not (implicit knowledge).

(7) *Learnability*. Whether learners began learning the L2 as a child (implicit knowledge) or at a later age especially through instruction (explicit knowledge).

By manipulating these criteria, R. Ellis (2005) created a battery of five English language tests designed to measure implicit and explicit knowledge, which were carried out as a follow-up study of Han and Ellis (1998). The tests included an elicited oral imitation test (EOI), an oral narration test (ON), a timed grammaticality judgment test (TGJT), an untimed grammaticality judgment test (UGJT), and a metalinguistic knowledge test (MKT).

It is highly important to note, however, that researchers should take caution in interpreting results with regard to these criteria underlying knowledge types and tests measuring them since no pure measures of implicit and explicit knowledge exist. DeKeyser (2003) argues "researchers will have to content themselves with eliciting knowledge under conditions that are more or less conducive to the retrieval of implicit and explicit knowledge" (p. 320). Similarly, R. Ellis himself (2005) indicates that though learners might be inclined to draw on one type of knowledge rather than the other one in responding to tasks, we can never be sure that they would, indeed, do so. Finally, among the criteria identified, it has been argued that time pressure and a focus on meaning (Spada, 2015) do not ensure that learners will access their implicit knowledge given that they might also access their explicit knowledge during task performance.

2.3 L2 Studies measuring implicit and explicit knowledge

The field of SLA has been in pursuit of establishing and improving the validity and reliability of instruments that are suggested to provide relatively separate measures of implicit and explicit L2 knowledge (Bowles, 2011; Elder & R. Ellis, 2009, R. Ellis, 2004, 2005, 2009b, Erlam, 2006; Gutiérrez, 2012; Han & Ellis, 1998; Philp, 2009; Shiu & Spada, 2012). A consecutive series of studies have been conducted to improve the instruments in different ways, such as expanding the target grammatical structures examined, investigating different languages, and different learner populations.

In an effort to develop a test battery to measure implicit and explicit L2 knowledge, Han and Ellis (1998) aimed to explore ways of measuring these knowledge types as well as the relationship between them and general language proficiency. Forty-eight upper-intermediate adult learners of English took two proficiency tests (the TOEFL and the Secondary Level English Proficiency Test-SLPT) and completed the test battery including a timed oral production test (OPT), a TGJT, an UGJT, and an interview tapping metalinguistic knowledge. The test battery targeted one grammatical structure (verb complements).

Results showed that L2 knowledge test scores loaded on a two-factor model, in which timed measures (the OPT and the TGJT) and untimed ones (the UGJT and the metalinguistic knowledge) loaded separately. Han and Ellis interpreted these components as implicit and explicit knowledge, respectively. They reported statistically significant correlations among both types of L2 knowledge measures and the SLPT. However, only the untimed GJT was correlated with the TOEFL. They argued that this finding is line with the criticisms the TOEFL receives in relation to tapping heavily explicit, analyzed knowledge. On the contrary, it provides support to the arguments that the SLPT represents both implicit and explicit knowledge. Finally, neither of the proficiency tests was correlated with the metalinguistic knowledge test, leading Han and Ellis to conclude that metalanguage does not play an important role in general language proficiency. However, it should be noted that the study received criticism due to the fact that the test battery targeted just one grammatical structure. DeKeyser (2003) argues that the generalizability of the results is low due to this limitation and this drawback puts the explicit knowledge itself at a disadvantaged position.

In a further validation study, Ellis (2005) aimed to build on the earlier study by Han and Ellis (1998) in two ways: (1) investigating a larger range of grammatical structures, i.e., a range of seventeen grammatical structures in English representing both early and late acquired grammatical features presented at a range of instructional levels, as well as (2) expanding the range of available measures of implicit and explicit knowledge. Ninety-one learners of L2 English with differing language proficiency levels and twenty native speakers (NSs) of English completed a total of five tests, namely EOI, ON, TGJT, UGJT, and MKT.

The results revealed high reliability of all tests, with Cronbach's alpha coefficients between .81 and .90. Furthermore, exploratory principal components factor analysis consistently yielded a two-factor model in which three tests measuring implicit knowledge (the EOI, the ON & the TGJT) and the two measuring explicit knowledge (the UGJT and the MKT) loaded on separate factors. Ellis and Loewen (2007) also employed a confirmatory factor analysis with the same data set and replicated the same results. Thus, these findings seem to provide support for the test battery to be reliable and valid with regard to providing relatively separate measures of L2 implicit and explicit knowledge.

Among a subsequent series of work carried out extensively by Ellis and his colleagues (2009), Elder and Ellis (2009) undertook two studies as a follow-up of Han and Ellis with the newly validated test battery. They investigated to what extent the distinction between implicit and explicit L2 knowledge can explain proficiency as measured by standard tests such as the TOEFL and the IELTS. In the first study, participants ($N = 111$) completed one measure of implicit knowledge (a TGJT) and two measures of explicit knowledge (a UGJT and an MKT). Language proficiency was measured via a computer-based TOEFL and a pilot version of the internet-based TOEFL.

Elder and Ellis reported that the scores obtained from the explicit knowledge measures loaded on the same factor with the scores on all sections of both versions of the TOEFL test in the PCA. The scores obtained from the implicit measure, however, loaded on a separate factor. The authors concluded that these standardized proficiency tests, at least the versions specific to their study, seem to draw heavily on learners' explicit knowledge and fail to elicit unanalyzed implicit language knowledge.

In the second study, Elder and Ellis (2009) investigated whether implicit and explicit knowledge of specific grammatical structures targeted in the test battery are related to and can predict scores on the different sections of another proficiency test i.e., IELTS. Participants were a different group of L2 learners of English (*N* =50) and completed four tests, two of which measuring implicit knowledge (an EOI and a TGJT) and two of which measuring explicit knowledge (a UGJT and an MKT). They also took the IELTS. Results revealed that, unlike the first study, both implicit and explicit knowledge of the grammatical structures correlated with the IELTS scores. Furthermore, both knowledge types contributed significantly to IELTS score, predicting 34% of the variance in IELTS total scores.

Overall, whereas both types of knowledge are implicated in language proficiency as measured by the IELTS in the second study, it was only the explicit knowledge as measured by the TOEFL in the first study. Elder and Ellis (2009) provided three possible explanations for this incongruent finding in relation to the differences available in the nature of two studies. First, the type of knowledge these two proficiency tests encourage seems to be different. It is argued that the TOEFL is mainly a measure of cognitive academic knowledge which taps explicit knowledge, whereas the IELTS, especially the speaking and listening sections of it, relies mainly on interpersonal interactional skills and fails to capture academic competence on these skills. This makes it a general proficiency test tapping both types of knowledge. Second, the measures of implicit knowledge used in each study are different. The first study might have failed to find a relationship between implicit knowledge and the TOEFL given that to measure the implicit knowledge only TGJT was administered, unlike the second study in which it was accompanied with an EOI. This was taken as a further support to the study conducted by Philp (2009) who proposed the EOI as the best measure of implicit knowledge. Finally, the last explanation for the different results found between the two studies lies in the second study's more specific analysis regarding grammatical structures over the first study. The second study examined the specific scores on the seventeen grammatical structures included in the measures of implicit and explicit knowledge, whereas the first study looked at total scores.

Bowles (2011) aimed to validate whether the battery of tests in R. Ellis (2005) yield rather separate measures of implicit and explicit L2 knowledge in another target language i.e., Spanish, and also with another population of learners i.e., classroom L2 leaners of Spanish and naturalistic heritage language (HL) learners of Spanish along with the NSs. She specifically inquired whether HL leaners who learned Spanish naturalistically since birth would presumably score higher on tests of implicit knowledge compared to L2 learners of Spanish who learned it in a classroom setting after puberty and thus they were expected to score higher on tests of explicit knowledge. NSs were expected to perform near ceiling on all tests with the exception of metalinguistic knowledge. NSs (n = 10), Spanish HL learner (n = 10), and L2 Spanish learners (n = 10) completed an EOI, an ON test, a timed GJT, an untimed GJT, and an MKT, all of which were designed by following Ellis's guidelines.

The results of a confirmatory factor analysis revealed that measures loaded on a two-factor solution as in Ellis (2005), which was taken as a further evidence providing support for the construct validity of the test battery. Moreover, as hypothesized, L2 learners scored highest on tests that tap explicit knowledge and scored lowest on tests that tap implicit knowledge whereas it was the contrary for the HL learners. Based on these findings, Bowles (2011) concluded that these tests tap separate pools of language knowledge given that the language knowledge attained by learners from two different learning contexts, which are instructed versus naturalistic, map onto the theoretical distinction underpinning the L2 knowledge types.

To summarize, these studies demonstrated high internal consistency, with Cronbach alpha coefficients exceeding .80, and the results of exploratory/confirmatory factor analyses have consistently yielded two-factor solutions in which tests measuring implicit knowledge and explicit knowledge loaded separately, leading the researchers to conclude that they measure relatively separate knowledge constructs.

Despite converging evidence for a two-factor model, some researchers (e.g., Shiu & Spada, 2012; Spada, 2015; Suzuki & DeKeyser, in press) have recently drawn attention to the validity of these tests, especially the EOI that is claimed to be the 'best' measure of implicit knowledge (Philp, 2009), regarding the type of knowledge drawn on them. A recent validation study by Shiu and Spada (2012) provided qualitative evidence regarding the type of knowledge tapped by the EOI. Through a retrospective questionnaire which required the participants to state what they were thinking about during task completion, they examined whether the learners would resort to form or meaning in their response to an open-ended item on the questionnaire.

Results revealed that 40% of the students were thinking about either form or both form and meaning during the task, which primarily aims to tap implicit knowledge by putting time pressure and demanding focus on meaning. Based on these findings, Spada (2015) argues that learners are able to complete the task by accessing either their explicit knowledge only or some combination of implicit and explicit knowledge. Thus, she concludes that learners might have completed the task successfully by "rapidly accessing their explicit knowledge" (p.9). Similarly, DeKeyser and Juffs (2005) suggest that language learners can proceduralize their explicit knowledge through practice, in other words, "explicitly acquired knowledge can be automatized" (p. 444).

Another study providing further evidence that the EOI may be tapping primarily explicit knowledge was conducted by Suzuki and DeKeyser (in press) who compared elicited imitation (EI) with word monitoring. Participants were a group of Chinese native speakers who are advanced speakers of Japanese L2. Results revealed that EI correlated with an MKT measuring explicit knowledge whereas word monitoring correlated with a serial reaction time task measuring implicit learning ability. Thus, Suzuki and DeKeyser suggest that EI is not a measure of implicit knowledge but automatized explicit knowledge.

In a longitudinal study, Serafini (2013) investigated the role learner individual differences (i.e., L2 aptitude, WM capacity, phonological short-term memory, processing speed, L2 motivation) play in mediating the development of L2 grammatical knowledge in instructed adult learners of Spanish at different and increasing levels of proficiency. In her comprehensive study, she also aimed to improve the validity and reliability of tests of implicit and explicit knowledge with these learners. Participants were eighty-seven university-level students learning Spanish in their 2nd (beginning), 4th, (intermediate) and 6th (advanced) semester. They completed an EOI test and an UGJT as measures of implicit and explicit knowledge respectively, in addition to four tests of cognitive ability, i.e., the MLAT, an OST, a digit span task, and a digit symbol coding task to measure processing speed as well as two questionnaires of motivation (i.e., the Attitudes Motivation Test Battery and the Possible Selves Questionnaire).

The results revealed that all proficiency groups developed their L2 knowledge over time with classroom instruction, providing further evidence for the facilitative role of instruction in improving the development of both implicit and explicit knowledge of L2 grammar. Exploratory and confirmatory factor analyses revealed a two-factor model in which implicit (EOI) and explicit knowledge (UGJT) measures loaded separately. However, it was also found that the factor model showed variation according to learners' proficiency level in that two factors were extracted for the intermediate and advanced groups whereas three factors for the beginners with overlaps in factor loadings for grammatical and ungrammatical items of explicit and implicit measures. Based on these findings, Serafini concludes that implicit and explicit knowledge in instructed learners is best viewed as a continuum (p. 311).

In sum, the distinction between explicit and implicit knowledge has long attracted the attention of SLA researchers. The test battery developed by R. Ellis and his colleagues as a result of a subsequent series of studies indicates relatively separate knowledge constructs whereas a recent line of research argues that it might not be that easy to distinguish these two knowledge types behaviorally since it is difficult to develop pure measures of implicit and explicit knowledge. Therefore, further research is needed to gain a better understanding of the type of knowledge investigated in SLA studies.

CHAPTER 3

WORKING MEMORY IN L2 LEARNING

3.1 Defining working memory capacity

WM has been a significant theoretical construct in the field of cognitive psychology for several decades. Its earlier conceptualization in the 1960s was based on short-term memory (STM), which was thought to function as a temporary storage for the retention of small amounts of information over brief time intervals (Baddeley, 2000). The most influential model of this period was proposed by Atkinson and Shiffrin (1968), which became known as the *modal model*. In an attempt to describe how information is processed in memory, the model assumes that information in the environment comes in through sensory registers such as visual, auditory or haptic and enters the short-term memory store.

Considering the fact that both STM is of limited capacity that can hold at most only a few items and information decay in STM is rapid (a few seconds), if the items are to be learnt, in other words to be transferred to long-term memory (LTM), the central-control processes start a plan for memorizing, such as rehearsal. Once the information is registered in LTM, it can be retrieved when desired (Miyake & Shah, 1999). Information transferred to LTM can also be forgotten, but at a much slower rate compared to STM. In short, Atkinson and Shiffrin's model underlines the storage function of STM, controlled by memorization strategies (Miyake & Shah, 1999).

The concept of WM, introduced by Baddeley and his colleagues (Baddeley, 1986, 2000, 2007; Baddeley & Hitch, 1974; Baddeley & Logie, 1999) replaced the older concept of short-term memory in the mid-seventies. Studies which showed that patients with a grossly defective short-term store appear to have a normal long-term learning capacity and the studies conducted with unimpaired subjects by using dual-task techniques refuted the idea of a single unitary short-term store which also served as a WM, as suggested by Atkinson and Shiffrin (1968). In 1974, Baddeley and Hitch proposed a model by dividing the short-term memory into separable components, which functioned together as part of a unified WM system serving for a wide range of complex cognitive activities.

WM, as a limited-capacity system with its dual functions of processing and storage (Baddeley & Hitch, 1974; Baddeley, 2000, 2003, 2010) conducts a variety of cognitive tasks that require controlled processing such as comprehension, learning and reasoning (Baddeley & Logie, 1999). Also, tasks we perform in our daily life such as reading a newspaper article or mentally rearranging furniture in one's living room to create space for a new sofa (Miyake & Shah, 1999) can be given as examples of every day cognitive tasks in which WM plays an important role while completing them.

There are different models of WM which have been particularly popular within SLA circles (Sagarra, 2013). They can be listed as follows: (1) the domain-specific single-resource model (Just & Carpenter, 1992), (2) the domain-specific multiple-resource model (Baddeley & colleagues), and (3) the domain-general attentional models (Engle & colleagues). As the names of the models make it apparent that two fundamental issues arise among different WM models, i.e., the question of domain-generality versus domain-specificity (Sagarra, 2013; Shah & Miyake, 1999) and the question of trade-off versus independency between processing and storage (Sagarra, 2013).

According to Just and Carpenter's (1992) Constrained Capacity Theory, the domain-specific single-resource model, posits that processing and storage components of WM compete for a shared pool of resources which are constrained with a limited capacity and result in individual differences. Accordingly, processing and storage components act in a trade-off relationship due to capacity constraints. For instance, storage decreases and processing slows down when a task is cognitively challenging and exceeds an individual's WM capacity.

The multicomponent model of WM proposed by Baddeley (2000, 2007) posits that processing and storage components are relatively independent of one another. Baddeley divides WM into a supervisory domain-general system, the "central executive', which is responsible for attentional functions such as switching, coordinating, maintaining and retrieving information, and two domain-specific short-term storage systems, the "phonological loop" and the "visuospatial sketchpad" each of which processes and maintains speech-based information such as remembering a phone number and visual information such as remembering the place of objects in a room. Baddeley (2000, 2003) added a third cross-modal store, "episodic buffer", in the later versions of the model. The buffer delivers information between the storage components and long-term memory. Under this view, processing (central executive) and storage components (phonological and visuospatial sketchpad) communicate through episodic buffer in retrieving relevant episodic information from long-term memory though they operate independently to some extent.

Engle and colleagues' domain-general attentional model of WM (Engle, 2002; Engle, Kane, & Tuholski, 1999; Engle & Kane, 2004; Kane, Conway, Hambrick, & Engle, 2007) highlights "the synergy of attentional and memorial processes in maintaining and recovering access to information that is relevant to ongoing tasks and blocking access to task-irrelevant information" (Kane, et al., 2007, p. 22). Under this view, STM is viewed as a store represented by LTM traces that are activated above threshold and maintained in limited focus of attention or through domain-specific rehearsal processes. Domain-general executive processes sustain relevant information in an active state, or retrieve information from inactive memory under conditions of interference and distraction via inhibition. In other words, WM is viewed as the general ability to control attention to inhibit the irrelevant information while maintaining relevant information in an active state. Under this conceptualization, processing and storage components operate independently and individual variation in WM capacity is attributed to one's ability to maintain or block information. Unlike domain-specific models, WM is not seen as a gateway to LTM but it is seen as an activated part of LTM that consists of STM traces.

Although the theoretical underpinnings of WM models differ from each other to some extent, they all agree that WM should not be equated with STM. Rather, it is recognized as a limited-capacity processing and storage system for conducting a collection of cognitive tasks including focusing and sustaining attention, task switching, inhibition, and retrieval (Baddeley, 2007). Logie (2011) argues that researchers following different line of WM theories are investigating different but in fact complementary research questions. For instance, the domain-specific multiple-resource model focuses on the organization of the underlying functions that are likely to give rise to capacity limit whereas the domain-general attention model focuses on how the capacity limit affects task performance (Logie, 2011, p. 242). Whatever the focus of a given WM model might be, it is of high importance to measure the limited capacity defining WM with valid tools.

3.2 Measuring working memory capacity

Wide ranges of measures are used extensively to study the individual differences in working memory. However, it should be noted that tasks that have been designed to measure WM capacity have been grouped as simple WM measures that primarily tap passive storage with low level of processing and complex WM measures that involve both storage and a high degree of processing (Juffs & Harrington, 2011).

Simple WM measures such as digit and word span tasks involve the recall of unrelated digits or words. In forward digit span (FDS), participants hear strings of digits presented at the rate of one digit per second, and then recall them in exact order. Similarly, in word span task (WST), participants hear lists of words presented at the rate of one word per second, and then recall them in order. These two tasks measure the phonological loop of Baddeley's model since they involve recall of aurally presented words and visually presented digits. Span is defined as the longest string of digits or words a participant can recall and repeat correctly. As such, these tasks which require only information maintenance and recall have received criticism since they tap only the storage component of WM (van den Noort, Bosch, & Hugdahl, 2006) and do not correlate well with higher cognitive order tasks such as reading comprehension (Daneman & Merikle, 1996).

As a limited-capacity processing and storage system, WM is typically tested through complex span tasks that require the active maintenance of information to be remembered while engaged in concurrent processing (Conway et al., 2005). Turner and Engle (1989) posit that the processing component of these tasks may deprive participants of using memory strategies like rehearsal and reflect a more genuine measure of WM capacity. As such, the dual-task paradigm employed in the assessment of WM capacity involves the recall of digits or words (primary task) as a storage measure and reading sentences for grammatical accuracy or semantic plausibility, solving arithmetic operations, or counting certain shapes among distractor items (secondary task) as a processing measure. A number of studies using complex span tasks have illustrated the relationship between WM and an array of higher-order cognitive skills, such as reading and listening comprehension (Daneman & Carpenter, 1983; Daneman & Hannon, 2001), generating hypotheses (Dougherty & Hunter, 2003; Sprenger & Dougherty, 2006), academic performance (Aronen, Vuontela, Steenari, Salmi & Carlson, 2005; Gathercole & Pickering, 2000), and reasoning (Barrouillet, 1996; Copeland & Radvansky, 2004).

Complex span tasks commonly used to measure WM capacity can be listed as follows: reading span task (RST), operation span task (OST), counting span task (CST), and backward digit span task (BDST). In the RST, participants read sets of sentences aloud and then recall the last word of each sentence at the end of each set (Daneman & Carpenter, 1980). In the OST, participants solve mathematical operations while they try to remember the words paired with the equations (Turner & Engle, 1989). The CST involves counting sets of target shapes and recalling the total number of targets for later recall (Case et al., 1982). Finally, in the BDST, participants are required to repeat the sequence of spoken random digits presented in reverse order (Kormos & Sáfár, 2008).

The RST was first developed by Daneman and Carpenter (1980). Gathercole and Baddeley (1993) argue that it is different from other span tasks like the digit span task or word span task since it taps both storage and processing capacity of the WM system. In Daneman and Carpenter's (1980) first version of the RST, the participants were required to read sets of two to six sentences (13-16 words in length and 60 unrelated sentences in total) aloud at their own pace and were asked to recall the last word of each sentence at the end of each set in the order in which they were presented. The participant's span was the largest set size from which s/he could recall all the sentence-final words. In their study, Daneman and Carpenter (1980) found substantial correlations between the RST and Verbal Scholastic Assessment Test (r = .59) and also the tests involving fact retrieval (r = .72) and pronominal reference (r = .90). Yet, significant correlations were not obtained between these reading comprehension measures and a simple word-span administered to the same participants.

In a second experiment they conducted, participants verified the truthfulness of sentences they read by responding true or false as a secondary comprehension task. The sentences for the task were collected from general knowledge quiz books and centred on the themes such as literature, geography, history, and science. The study yielded similar results. Specifically, significant correlations of the RST with the Verbal Scholastic Assessment Test (r = .55) and with the tests involving fact retrieval (r = .81) and pronominal reference (r = .84) were obtained.

It is of high importance to note that criticism was levelled at Daneman and Carpenter's (1980) RST by Waters and Caplan (1996) for two main reasons. First, they argued that, instead of reading aloud the sets of sentences, semantic or syntactic acceptability judgments should be included as part of the RST simply because reading aloud may result in shallow processing and may not guarantee sentence processing. The second criticism targeted the use of storage scores (the maximum number of words recalled correctly) as a measure of reading span. Such scoring does not take into account the possibility that there could be a trade off between processing and storage components of the task.

In their version, Waters and Caplan (1996) administered a computerized version of the RST to which they incorporated a plausibility judgment task in which unacceptable sentences violated the thematic roles in relation to the requirements of the verbs (e.g., *It was the child that fascinated the toy*). Also, sentences in the task showed variation in two respects. First, the number of propositions in sentences was either one or two (e.g., *It was the gangsters that broke into the warehouse* versus *The man hit the landlord that requested the money*). Second, the syntax of sentences was either simple in which the first noun was the agent and the second noun was the theme (e.g., *It was the gangsters that broke into the warehouse*) or complex in which the thematic roles were not assigned canonically (e.g., *It was the broken clock that the jeweller adjusted*).

Waters and Caplan (1996) examined the correlations of the scores on the Nelson-Denny reading test with separate processing and storage scores of the RST on one hand, and composite scores of processing and storage on the other. Moreover, they ran a step-wise multiple regression analysis. Correlational and regression analyses showed that the sentence processing component of the RST was the best predictor of reading comprehension as the reading scores correlated strongly with the processing scores ($r = .70$). Thus, sentence processing accounted for 42% of the variance in reading comprehension when it was entered into the analysis first. Yet, the correlation between the storage and the reading comprehension score was rather low ($r = .36$) and the storage component had a small independent contribution in the regression analysis with 11% of the variance when it was entered first. Waters and Caplan (1996) concluded that most of the variance shared by the RST and reading comprehension was due to the processing component, along with significant but small contribution of the storage component.

Another issue that concerns the use of RSTs is the administration of a linguistic versus non-linguistic task as part of the processing component, which corresponds to the domain-specific versus domain-general views of WM. The most widely used complex span task with a non-linguistic processing component is the OST in which participants solve mathematical operations while they try to remember the words paired with the equations. In Turner and Engle's (1989) study, operation processing as a concurrent processing task (secondary task) correlated with the Nelson-Denny reading test which was taken as an evidence that it is not necessary for the processing component in WM capacity measures to involve reading to predict reading comprehension.

This is in line with Engle and colleagues' domain-general view of WM given that executive attention demands of the OST makes it possible to predict complex cognitive behaviour across domains (Conway et al., 2005). In fact, Daneman and Merikle (1996) carried out a meta-analysis which included seventy-seven studies using complex span tasks (e.g., RST, OST, BDST, CST) or simple WM measures (e.g., FDS, WST). In addition to the correlations obtained between reading comprehension and verbal process span tasks such as the RST, the results of the meta-analysis showed that measures which tap the combined math processing and storage capacity of working memory such as the OST are good predictors of comprehension given that they correlated with the global or standardized tests of reading comprehension (r = .30) and specific tests that ask for computing the referent for a pronoun, making inferences, detecting ambiguity, etc. (r = .48). Daneman and Merikle (1996) concluded that this result surpasses the argument that sentence comprehension correlates with paragraph comprehension in the RSTs but further "…

suggests that it is an individual's efficiency at executing a variety of symbolic manipulations and computations that is related to comprehension ability." (p. 428).

3.3 Working memory capacity and L2 reading

WM, the brain system serving for a wide range of complex cognitive activities, plays a significant role in both L1 and L2 learning (Miyake & Shah, 1999). The body of research regarding the role of WM capacity in L1 is extensive and WM capacity measured by complex span tasks have been found to strongly correlate with higher-level cognitive abilities in L1 such as reading comprehension (Caplan & Waters, 1999; Daneman & Carpenter, 1980, 1983; Daneman & Hannon, 2001; Seigneuric, Ehrlich, Oakhill, & Yuill, 2000), processing syntactically complex sentences (Miyake, Carpenter, & Just, 1994), and vocabulary learning (Daneman & Green, 1986).

Though it is scarce compared to L1 studies, WM has also attracted the attention of L2 researchers as it is highly possible for L2 learners to "find themselves in situations where their WM limitations are being exceeded." (Sawyer & Ranta, 2001, p. 341) such that the role of WM capacity may even be stronger in L2 compared to L1 (Geva & Ryan, 1993). Thus, studies on the role of WM capacity in L2 have been conducted with respect to demonstrating its importance in various L2 processes including L2 reading comprehension (Alptekin & Erçetin, 2009, 2010, 2011; Harrington & Sawyer, 1992; Leeser, 2007; Walter, 2004, 2007), L2 writing (Abu-Rabia, 2001; Adams & Guillot, 2008), L2 pronunciation (Trude & Tokowic, 2011), the spoken production in instructional contexts (Mackey et al., 2002, 2010), the efficacy of feedback type on the development of L2 linguistic forms (Goo, 2012; Trofimovich et al., 2007; Yilmaz, 2013), and study abroad (O'Brien et al., 2006; Tokowicz et al., 2004).

The role of WM capacity in L2 reading comprehension has particularly attracted close attention given that readers must hold previous information while integrating new information as they read a text, which is a high-order cognitive task requiring controlled attention. Though there is strong evidence that WM predicts L2 reading comprehension, there are some key issues addressed in studies examining the role of WM in L2 reading comprehension.

The relationship between L1 and L2 WM span tasks is one of the central issues specific to the role of WM in L2 reading in relation to whether there is a common underlying WM capacity for both languages. Harrington and Sawyer (1992) found a moderate but significant correlation between scores on the L1 (Japanese) and L2 (English) reading span tasks ($r = .39$). Likewise, Osaka and Osaka (1992) investigated the relationship between WM capacity in the L1 and L2 to verify whether WM capacity was language dependent. They found a significant correlation between L1 (Japanese) and L2 (English) reading spans ($r = .72$) and concluded that WM capacity is language independent. Osaka et al., (1993) aimed to confirm the language independence of WM in a follow-up study they carried out with L1 Swiss German/L2 French participants. Analyses yielded a significant and high correlation between L1 and L2 reading spans ($r = .85$). In the light of these findings, it is suggested that L2 processing may draw from the same WM resources as L1 processing at least with proficient users (Miyake & Friedman, 1998). The evidence that L1 and L2 WM capacities share considerable amounts of variance suggests that WM capacity is language independent.

Another issue that is important to investigate in relation to WM's role in L2 reading is the degree of competence in the L2. Service et al. (2002) found that the participants with less proficiency in the L2 (English) had higher reading spans in their L1 (Finnish), whereas there were no differences between L1 and L2 spans for more advanced L2 users. Similarly, Van den Noort et al. (2006) examined the interaction between WM capacity and the level of proficiency with native speakers of Dutch (L1) who were highly proficient in German (L2) and who had been learning Norwegian (L3) for six months. They administered a computerized version of reading span task and the results showed that the storage capacity and the processing speed of the participants increased in parallel with their level of proficiency (L1 >L2 >L3).

Miyake and Friedman (1998), who propose that WM is a crucial component of language aptitude to explain individual differences in L2, reported a study in which they aimed to go beyond correlations through path analysis to examine how WM may influence L2 syntactic comprehension and how cue preferences may mediate this relation with Japanese learners of English. As measures of WM capacity, they used listening span measures in L1 (Japanese) and L2 (English). They measured learners' comprehension of syntactically complex sentences in L2 with a syntactic comprehension test, and finally they used an English version of an agent identification task to assess learners' linguistic cue preferences in L2. Not only did they find correlations among the four variables (i.e., L1 WM, L2 WM, syntactic comprehension, and cue preference distance), but also path analysis results showed that whereas L2 WM directly determined both syntactic comprehension and cue preference distance, L1 WM was found to be a mediator variable. Miyake and Friedman's (1998) findings suggest that L2 WM capacity is directly related to L2 comprehension.

Regarding the relation between WM and L2 reading comprehension, research findings thus far have shown that WM capacity measured through complex span tasks of a linguistic (L1 and/or L2) or non-linguistic nature correlate positively with L2 reading comprehension. For instance, Harrington and Sawyer (1992) found significant correlations between L2 RST scores and TOEFL reading ($r = .54$), suggesting that higher L2 reading span learners were more successful in reading comprehension compared to lower L2 reading span learners.

A study that demonstrated the indirect relation of L1 WM capacity to L2 reading comprehension is that of Payne, Kalibatseva, and Jungers (2009). They examined the contribution of WM capacity (measured in the first language through counting span task), L1 reading comprehension, and domain experience (time spent actively learning the language) on L2 reading in Spanish. Also, being inspired by earlier research on the role of WM capacity and domain knowledge (Hambrick & Engle, 2002; Hambrick & Oswald, 2005), they tested the potential for an interactive relationship between WM capacity and domain experience. The results were consistent with previous L1 research investigating influences of WM and domain knowledge and supporting the independent influences hypothesis (Hambrick & Engle, 2002; Hambrick & Oswald, 2005) since there was no interaction between WM capacity and domain experience and both variables independently influenced L2 comprehension. However, as noted by Payne, Kalibatseva, and Jungers (2009), WM capacity, measured in the first language, did not directly influence L2 comprehension but was mediated by L1 reading comprehension in this study, which was similar to findings reported by Miyake and Friedman (1998).

Thus, the relationship between WM and L2 reading comprehension seems to be moderated by the proficiency level of the L2 user as well. Walter (2004) carried out a study in which she investigated the relationship between reading span, administered in both languages (L1-L2), and L2 reading comprehension with a group of lower- and upper-intermediate French EFL learners. Analyses yielded a significant correlation between WM and L2 reading comprehension for both groups of learners which means that higher WM capacity (both L1 and L2) results in better reading comprehension for both proficiency levels. However, the correlations between L2 WM and L2 reading comprehension scores (summary completion) yielded a significant relationship for the lower-intermediate group, but not for the upper-intermediate group. Walter (2004) suggested that the comprehension task imposed more demand on WM resources of the lower-intermediate group. Moreover, the correlation of L2 WM scores with L2 reading comprehension ($r = .73$) was more substantial than that of L1 WM scores ($r = .33$), which was taken as an evidence that L2 WM capacity is a better predictor of L2 reading comprehension compared to L1 WM capacity.

Another study that investigated the interaction between WM capacity and topic familiarity in text recall was conducted by Leeser (2007), with L2 learners of Spanish. Leeser found that WM capacity was a significant variable in reading comprehension but under certain familiarity conditions. Specifically, high and medium WM learners outperformed low WM learners only if they were familiar with the topic and this was concluded as a support for the *rich-get-richer* hypothesis. Leeser (2007) concludes that WM has a central role in learners' reading comprehension depending upon their previous domain knowledge.

Alptekin and Erçetin (2011) also examined the effects of WM capacity and content familiarity on literal and inferential comprehension in L2 reading with advanced Turkish learners of English. They found that whereas the performance of both high-span and low-span readers was similar in literal understanding, high-span readers outperformed low-span readers in their inferential comprehension scores.

The authors suggest that the findings demonstrate the crucial role of WM in dealing with complex cognitive operations such as inferencing. Regarding the combined effects of WM capacity and content familiarity on literal and inferential comprehension in L2 reading, their findings were consistent with Hambrick and colleagues since there was no interaction effect on either literal or inferential comprehension. Thus, Alptekin and Erçetin (2011) concluded that WM capacity and content familiarity have additive and independent effects on L2 reading comprehension since they operate independently.

In another study where they treated reading as a global construct, Alptekin, Erçetin and Özemir (2014) aimed to investigate the relationship between WM capacity and L2 reading comprehension by examining the linguistic nature of the secondary task (semantic versus morphosyntactic) and the language it was presented in (L1 versus L2). They administered four reading span tasks (two in Turkish, two in English) in which the participants were required to judge the anomaly embedded in the sentences either semantic or morphosyntactic. Participants also completed a standardized reading comprehension test of English (i.e., Nelson-Denny).

The results of exploratory factor analysis revealed that the storage component of span task is task- and language-independent because four storage components loaded together on the same factor (Factor 1). However, processing is affected by both the task demand and language of the task since the processing component of the L1 and L2 span tasks involving semantic plausibility along with L2 span task involving morphosyntactic accuracy loaded together (Factor 2) and excluded the L1 reading span task with morphosyntactic accuracy which loaded on a separate factor on its own (Factor 3). In the multiple regression analysis, Factor 2 (i.e., the processing dimension) explained 7.6% of the variance and Factor 1 (i.e., the storage dimension) explained an additional 4.9% of the variance in L2 reading comprehension. The researchers concluded that L1 morphosyntactic processing shows no relationship to L2 reading whereas semantic processing in L1 and L2 as well as L2 morphosyntactic processing contribute to L2 reading. In general, their findings were interpreted as supporting Ullman's (2001, 2004) DP model.

To sum up the discussions above, there are some key issues that need to be addressed in studies examining the role of WM in L2 learning in general and in L2 reading comprehension specifically. First, the strong correlations obtained between L1 and the L2 WM spans suggest that WM capacity is language-independent (Alptekin & Erçetin, 2010; Harrington & Sawyer, 1992; Osaka & Osaka, 1992; Osaka, Osaka, & Groner, 1993). Despite the strong relationship between L1 and L2 spans, a group of researchers maintain that WM capacity should be measured in L1 (Sagarra, 2013) or a domain-general span task with a non-linguistic secondary task like the operation span task so that the limitations in processing the verbal input in L2 do not confound the measurement of WM capacity.

Second, the proficiency level in the L2 may mediate not only the relationship between L1 and L2 spans in that the relationship gets stronger when the proficiency in the L2 is advanced (Service, Simola, Metsaenheimo, & Maury, 2002; van den Noort, Bosch, & Hugdahl, 2006; Wen, 2012). Additionally, in spite of studies showing that WM capacity correlated positively with L2 reading comprehension (Alptekin & Erçetin, 2009, 2010; Harrington & Sawyer, 1992; Leeser, 2007; Payne, Kalibatseva, & Jungers, 2009), some research findings suggest that only L2 reading span has a meaningful relationship with L2 reading comprehension (Service et al., 2002; Walter, 2004), with L1 reading span playing a mediating role at best (Alptekin & Erçetin, 2010; Miyake & Friedman, 1998), contrary to the generally accepted belief that verbal WM is not language-specific. The mediating role of proficiency level has been demonstrated by Walter (2004) who found that the contribution of span to reading was greater for lower-intermediate L2 learners than for upper-intermediate learners.

A final point that needs to be made regarding the role of WM in L2 reading involves the operationalization of reading comprehension. Alptekin and Erçetin (2011) have shown that, for advanced learners of English, WM's contribution to L2 reading is observed if the reading task involves controlled effortful processes such as inferential comprehension rather than literal comprehension. Still, more empirical research is needed to clarify the relationship between WM capacity and L2 reading comprehension.

3.4 Working memory, L2 implicit/explicit knowledge and L2 reading

Although the empirical studies detailed above investigating the role of WM capacity in L2 reading are inconclusive and warrant further research, they still outnumber the studies examining its relationship to implicit and explicit L2 linguistic knowledge. There is limited research investigating the relationship between WM capacity and L2 linguistic knowledge compartmentalized into implicit and explicit knowledge sources. Following the arguments in cognitive psychology, it appears that WM capacity is likely to be associated to explicit knowledge given that typical WM functions are characterized by consciousness and attentional control. For instance, Paradis (2009) argues that WM is only responsible for the conscious processing of explicit knowledge and closed to implicit knowledge (p. 50). However, the limited research available in the field of SLA is not conclusive in that respect.

In an instructed language context, Roehr and Gánem-Gutiérrez (2009) investigated the role of WM, language learning aptitude, and language learning history in the development of metalinguistic knowledge with adult L2 learners at the university level. Participants, who were thirty-nine native English-speaking adults learning German (n = 19) or Spanish (n = 20) for relatively four years, completed five instruments which comprised an RST in L1, an RST in L2, the MLAT, German and Spanish MKTs, and a biodata questionnaire.

The study found moderate and significant correlations between MLAT4 (Words-in-Sentences) and two sections of the MKT (language-analytic ability and description/explanation ability) (r = .41 and r = .45, respectively). However, there was no significant correlation between WM capacity (both in L1 and L2) and metalinguistic knowledge contrary to what was expected. The authors found that four significant predictors explained 60% of the variance in the development of learners' metalinguistic knowledge, particularly cumulative years of study of other languages (26%), years of formal L2 study (19%), the MLAT IV (9%), and MLATV (6%). In short, the participants' amount of language learning experience in formal (classroom) settings was found to be the strongest predictor of metalinguistic knowledge followed by their level of metalinguistic knowledge. The authors attribute the lack of a relationship between WM and metalinguistic knowledge to the difference inherent in the type of measurement employed in that the RST being timed and the MKT untimed. They also argue that metalinguistic knowledge involving analytic reasoning about language is a higher-level mental faculty and more domain-specific, whereas WM involving online storage and processing of linguistic information is a lower-level and more generic mental faculty.

Serafini (2013) investigated the role WM capacity, in addition to other variables of learner individual differences (e.g., L2 aptitude, phonological short-term memory, processing speed, L2 motivation), played in mediating the development of

L2 implicit and explicit knowledge in a longitudinal study. Regarding the relation between WM capacity and explicit/implicit linguistic knowledge, WM capacity effects were particularly reported for beginning learners and with a more robust relationship with explicit knowledge. However, WM capacity was also found to play a role in accessing implicit knowledge as measured on the oral imitation task (p. 280). Serafini concluded that the relatively more robust relationship found between WM capacity and explicit knowledge is not out of line as it is theoretically expected. The unexpected result was the relationship between WM capacity and implicit knowledge. She claimed that the result might stem from the nature of the elicited oral imitation task given that the task requires participants to aurally process the input and produce it back in a recursive manner. This dual requirement of the task might have challenged the WM capacity limitations of the beginning learners.

In an effort to expand the focus of the research on the role of explicit and implicit knowledge in particular to a language skill in the L2, Erçetin and Alptekin (2013) examined the relationships among WM capacity, explicit/implicit knowledge, and L2 reading comprehension. Participants were fifty-one Turkish university learners at a relatively advanced proficiency level. They completed an RST to measure WM capacity in the L2, an UGJT to measure explicit knowledge in the L2, a TGJT and an EOI to measure implicit knowledge in the L2, and a standardized reading comprehension test of English (the Nelson-Denny).

The results revealed statistically significant correlations not only between explicit knowledge and WM capacity but also between implicit knowledge and WM capacity. Pearson product-moment correlations between scores on all four tests and L2 reading comprehension indicated that WM capacity and explicit knowledge correlated with L2 reading comprehension but implicit knowledge did not. The PCA results showed that WM, explicit knowledge, and reading comprehension loaded on the same component whereas implicit knowledge loaded on a separate component on its own. Based on these findings, Erçetin and Alptekin concluded that L2 explicit knowledge and WM operations, which are capable of manipulating and storing both explicit and implicit L2 linguistic knowledge, are associated with L2 reading comprehension. To my knowledge the only study that investigated the relationships among implicit/explicit knowledge, WM capacity, and L2 reading was conducted by Erçetin and Alptekin.

In summary, the empirical studies investigating the role of WM capacity in relation to explicit and implicit L2 knowledge are not only limited in number but also inconclusive. Not only Serafini (2013) but also Erçetin and Alptekin (2013) found explicit knowledge to be in a more robust relationship with WM, however the finding of Roehr and Gánem-Gutiérrez (2009) was not congruent with theirs as there was a lack of relationship between metalinguistic knowledge, which was measured to tap explicit knowledge, and WM capacity. Furthermore, the unexpected relationship between implicit knowledge and WM was only limited to beginner level students in Serafini's study whereas it was also found with a relatively advanced group in Erçetin and Alptekin's study. Finally, to my best knowledge, the study that investigated the contributions of WM capacity and implicit/explicit knowledge to L2 reading comprehension was conducted by Erçetin and Alptekin (2013) and a further study is needed to provide a more complete picture of interrelationships among these variables by making use of processing score and storage score separately as an index for WM capacity measurement and by using multiple measures for both implicit/explicit L2 knowledge and WM capacity. The current study aims to contribute in that respect. The methodology of the present study and the research questions are presented in the next chapter.

CHAPTER 4

METHODOLOGY

The following sections of this chapter describe the method used to investigate the research questions raised in this study. In order to do so, research questions and related hypotheses are presented first and then followed by a description of the participants, the instruments and procedures of data collection and analysis.

4.1 Research questions and hypotheses

The present study aimed to explore the relationships between WM's processing and storage functions when WM was measured both in L1&L2 and in different background task. It further aimed to explore the relationships between explicit/implicit knowledge in L2 and how these knowledge types are related to WM operations. Finally, it aimed to investigate whether L2 reading comprehension is related to the processing and storage functions of working memory (WM) as well as explicit and implicit sources of knowledge in the L2. With these objectives in mind, the following research questions were generated:

1. Do WM's processing and storage functions show significant relationships when they are measured by L1 and L2 RSTs as well as an OST?

It was hypothesized that the storage scores obtained from all three WM measures would correlate significantly (Hypothesis 1) given the research findings indicating that the storage component of the span task is a language-independent (Alptekin & Erçetin, 2010; Alptekin, Erçetin, & Özemir, 2014; Juffs, 2005; Osaka & Osaka, 1992; Osaka, Osaka, & Groner, 1993; Trofimovich, Ammar, & Gatbonton, 2007) and it is not affected by the type of secondary task (Conway et al., 2005; Cowan, 2011; Kane & Engle, 2002; Turner & Engle, 1989). Likewise, it was hypothesized that there should be a statistically significant relationship among the processing scores obtained from all three WM measures (Hypothesis 2) based on the domain general view of WM, which posits that WM capacity does not depend on processing efficiency for a particular task (Conway et al., 2005; Dehn, 2008; Engle et al., 1992; Turner & Engle, 1989). As for the relationship between WM's processing and storage functions, the distribution of these resources is an unresolved issue. If processing and storage competed for the same resources (Daneman & Carpenter, 1980), there should be a negative relationship between them, indicating trade-off between the two components. If, on the other hand, the efficiency of switching between processing and storage determines the capacity (Conlin, Gathercole, & Adams, 2005; Towse & Hitch, 1995), such trade-off should not be observed (Hypothesis 3).

2. Are WM's processing and storage functions related to explicit and implicit sources of L2 knowledge?

Since WM functions involve consciousness and attentional control processes, both processing and storage scores are expected to correlate significantly with explicit linguistic knowledge that is also conscious (Ellis, N., 2008). By contrast, there should be a statistically nonsignificant relationship between WM functions and implicit knowledge (Hypothesis 4).

3. Do WM's processing and storage functions along with explicit/implicit sources of L2 knowledge form coherent subsets that are independent of each other?

Based on the hypothesized relationships listed in the first and second research questions, three factors were expected, with the storage scores obtained from all three WM measures loading together on a single factor while the processing scores loading on a separate factor. In addition, the measures of explicit knowledge were expected to load together with WM measures while those of implicit knowledge were hypothesized to form a separate factor on their own (Hypothesis 5).

4. How much variance in L2 reading comprehension is accounted for by the factors formed by WM's processing/storage functions and explicit/implicit sources of L2 knowledge?

Given the significant relationship observed between WM and L2 Reading (Alptekin & Erçetin, 2010, 2011; Harrington & Sawyer, 1992; Walter, 2004) as well as the relationships among explicit knowledge, WM and L2 reading (Erçetin & Alptekin, 2013), it was predicted that factors formed by WM's processing/storage functions and explicit sources of L2 knowledge would explain a significant amount of variance in L2 reading comprehension but not the factor formed by implicit L2 knowledge (Hypothesis 6).

4.2 Participants

A total of eighty-four freshman students enrolled at the Department of English Language Education, Boğaziçi University, where the medium of instruction is English, took part in the study. They all passed the Boğaziçi University English Proficiency Test (BUEPT) by a minimum score of "C" before they had started studying at the department. At Boğaziçi University, students are required to prove their English proficiency either with a minimum score of 79 on the TOEFL-IBT, with 22 on the Test of Written English; a minimum score of 6.5 on the IELTS; or a minimum grade of C on BUEPT, the institutionally administered English proficiency test. As such, it can be suggested that the participants were moderately proficient in English. Of the eighty-four students who took part in the study, sixty-nine were female and fifteen were male. Their ages ranged from 20 to 23. All were native speakers of Turkish. The participants were rather homogenous in terms of their educational background and academic achievements since they were ranked in the first percentile of a nation-wide university entrance exam and enrolled in the Department of Foreign Language Education to become teachers of English. The participants received extra credit for above the average performance in the group.

4.3 Materials

Materials for the proposed study comprised (i) three tasks designed to assess WM capacity: a reading span task (RST) in L1 (Turkish), an RST in L2 (English) and an operation span task (OST) in L1 (Turkish); (ii) two tests designed to measure implicit L2 knowledge: a timed grammaticality judgment test (TGJT) and an elicited oral imitation test (EOI); (iii) two tests designed to measure explicit L2 knowledge: an untimed grammaticality judgment test (UGJT) and a metalinguistic knowledge test (MKT); and (iv) a standardized reading comprehension test of English (TOEFL). In what follows, a detailed explanation of all the tests will be provided.

4.3.1 Working memory measures

4.3.1.1 Reading span tasks

A computerized RST in L1 (Turkish) and a computerized RST in L2 (English) were administered to obtain a measure of WM (see Appendix A and B). The RSTs used in this study were based on the tests reported in Alptekin, Erçetin, & Özemir (2014), a modified version of Daneman and Carpenter (1980) test.

The tests consisted of 42 affirmative sentences, each with 7-11 words in length in Turkish or 9-13 words in length in English. Half of the sentences were semantically plausible (e.g., Genç bir hanım gürültü yapan yavru kediyi dışarı çıkardı / A naughty kid has instantly blown candles on all the cakes) and half were implausible (e.g., Halam elde yıkamadan lekeli görevi makineye soktu / The librarian will suitably shave the books in another room). The participants viewed those randomly arranged sentences on a computer screen which was run on the SuperLab Pro 4.0 computer program. Each sentence remained on the screen for 7 seconds. The test had been grouped into four levels ranging from two to five sentences in which each level contained three sets of sentences; these included three sets of 2 sentences, three sets of 3 sentences, three sets of 4 sentences, and three sets of 5 sentences.

While reading each of the sentences, participants were required to do two tasks: (a) they had to decide whether the sentence was semantically plausible, which aimed to ensure that participants processed the sentences, and (b) they were required to recall the last word of each sentence that was taken as the measure of storage. When the sentence was semantically plausible, they pressed "T" (True) on the keyboard but when it was not they pressed "F" (False). When they finished reading all three sets at one level, they needed to recall the last word of each sentence and write them in a field box that appeared on the computer screen. Afterwards, they continued with set 1 of the next level that increased in size, which required them to process more sentences and recall more words as the test proceeded. That is, for a two-sentence set, the participants had to judge the semantic plausibility of two sentences and recall two sentence-final words; for a five-sentence set, they had to judge semantic plausibility of five sentences and recall five sentence-final words. This progressive increase in the sets of sentences increased the load on WM accordingly. There was a practice session before the tests started and it took about 15-20 minutes to complete the tests.

Regarding scoring, the participants' judgments regarding the semantic plausibility of the sentences represented the processing measure of their reading span. Concerning the measure of storage, it was the total number of sentence-final words recalled accurately. The spelling mistakes and the wrong order of the final words were not taken into consideration during scoring.

4.3.1.2 Operation span task

Similar to the RST, the dual-task paradigm of OST involves a processing measure (primary task) i.e., verification of arithmetic operations and a storage measure (secondary task) i.e., recall of a single target word presented after each operation. The computerized version of the OST administered in this study was a modified version of the original test designed by Turner and Engle (1989) and differed from the original test in that the words to be recalled were in L1 of the participants, which was Turkish, not English (see Appendix C). The procedure was similar to that of the RST described above.

The test consisted of 42 mathematical operation strings followed by a to-be-recalled word in L1 (Turkish). Each string involved a mathematical equation with two arithmetic operations and a stated solution e.g., (9/3) – 2= 1. The first operation was a simple multiplication or division problem and had to be solved before the second operation that was a simple addition or subtraction operation. Half of the stated solutions were correct in the test and the other half were incorrect. To-be-recalled word following the mathematical operation was a three-to six-letter concrete noun in L1 (Turkish). The stimulus (e.g., (6/2) – 2=1 ÇANTA) was displayed on the computer screen one after another at 7-second intervals. Similar to RST, the test involved four levels, from two to five, with three trials for each level. First, participants had to decide whether the equation was correct or not and press “T” (True) or “F” (False) on the keyboard, accordingly. When they finished verification of all three sets at one level, a field box appeared on the screen for participants to write the words that followed the equations in the last set they finished. Afterwards, they continued with set 1 of the next level. There was a practice session before the test started and it took about 15 minutes to complete the test.

As in the RST, regarding scoring, the participants' verifications of arithmetic operations represented the processing measure of their reading span. Concerning the measure of storage, it was the total number of words recalled accurately. The recall words were scored regardless of spelling errors.

4.3.2 Tests of L2 implicit knowledge

4.3.2.1 Timed grammaticality judgment test

To measure L2 implicit knowledge, the TGJT adapted from R. Ellis and colleagues (2009) was computer-delivered using SuperLab Pro 4.0 (see Appendix E). The test was timed to necessitate a reliance on implicit linguistic knowledge (Loewen, 2009).

The test contained 68 sentences evenly divided between grammatical and ungrammatical covering 17 morphosyntactic structures which were chosen on the basis of four considerations as suggested by R. Ellis (2009b): (1) They were known to be universally problematic to learners; (2) They represent both early and late acquired grammatical features; (3) They represent a broad range of proficiency levels; (4) They include both morphological and syntactic features (R. Ellis, 2009b, p. 42). These morphosyntactic structures included in the test were as follows: verb complements, regular past tense, question tags, yes/no questions, modal verbs, unreal conditions, since and for, indefinite article, ergative verbs, possessive –s, plural –s, third person –s, relative clauses, embedded questions, dative alternation, comparatives, adverb placement. There were four sentences, two grammatical and two ungrammatical, for each of the 17 morphosyntactic structures.

The sentences were presented in written form on a computer screen. The participants were required to indicate whether each sentence was grammatical or ungrammatical within 3.5 seconds (Bialystok, 1979; Han, 2000). They pressed "T" (True) if the sentence was grammatically correct and "F" (False) if the sentence was incorrect. Each item was scored dichotomously as correct/incorrect. The items not responded were scored as incorrect. There was a practice session before the test started.

4.3.2.2 Elicited oral imitation test

To measure L2 implicit knowledge, the EOI was also administered since it has been shown to be the "best" measure of implicit knowledge (R. Ellis, 2009b, p. 59). The test consisted of 34 statements targeting 17 morphosyntactic structures listed above in the part TGJT is described (see Appendix D). There were 2 test items per structure: one grammatical and one ungrammatical. The participants listened to each sentence over headphones and first indicated whether they agreed with, disagreed with or were not sure about the content of it. This necessitated them to pay attention to meaning first. They then repeated the sentence orally in correct English. The participants were never explicitly told that they would be hearing ungrammatical sentences, as suggested by Erlam (2009). Their responses were audio recorded and later analyzed by spotting whether the target structures were supplied or not in the required occasions. Regarding scoring, if the target structure in each sentence was correctly supplied, the response was scored as correct, whereas if the target structure was either avoided or attempted but incorrectly supplied, the response was scored as incorrect. There was a practice session before the test started.

4.3.3 Tests of L2 explicit knowledge

4.3.3.1 Untimed grammaticality judgment test

To measure L2 explicit knowledge, the UGJT adapted from R. Ellis and colleagues (2009) was administered as pen-and-paper test with no time limit in a classroom. The test was not timed so that the participants had a chance to reflect on the sentences and draw on their explicit knowledge, as suggested by Ellis (2004). The sentences were same in both the Timed and Untimed GJTs and the procedure was similar to that of the TGJT described above except the fact that no time limit was exposed for the UGJT. Again, the participants were required to first read a sentence and then indicate whether each sentence was grammatical or ungrammatical, this time by circling "True" or "False" which were written next to the sentence. Each item was scored dichotomously as correct/incorrect. The items not responded were scored as incorrect.

4.3.3.2 Metalinguistic knowledge test

The MKT was also used to measure L2 explicit knowledge (see Appendix F). R. Ellis and colleagues (2009) adapted this test from an earlier test of metalanguage devised by Alderson et al. (1997). The test was administered as a pen-and-paper test with no time limit.

The test consisted of two parts. In the first part, the participants were presented with 17 ungrammatical sentences that contain those 17 structures listed above in the part TGJT was described. The erroneous part was underlined in each ungrammatical sentence. Participants were provided with four options providing explanations for the underlined erroneous part. They were asked to select the rule that best explained each error out of four options listed.

The second part of the test consisted of two sections. In section 1, the participants were presented with a short passage to find one example for 19 specific grammatical features from the passage (such as a preposition or a finite verb). They were asked to write their example for each feature in the table provided. In section 2, they were presented with a set of four sentences and asked to underline the named grammatical parts (e.g., 'subject' and 'indirect object') in those sentences.

Regarding scoring, each item was scored dichotomously as correct/incorrect in part 1 of the test. The items not responded were scored as incorrect. In part 2 of the test, a marking key was developed by two applied linguists so as to determine the acceptable answer/answers to each item. The inter-rater reliability was .92. The total maximum score for the test was 40.

4.3.4 L2 reading comprehension test

In order to assess participants' L2 reading comprehension, the reading comprehension section of a retired paper-based TOEFL was administered. The test consisted of five reading passages followed by multiple-choice comprehension questions, 30 in total. The maximum possible score was 30.

4.4 Procedure

The data for this study were collected in six sessions, in which 8 tests were administered in total. The data collection sessions for computerized tests were conducted in the Computer Laboratory of Faculty of Education at Boğaziçi University, while the sessions for the pen-and-paper tests took place in a lecture hall of Faculty of Education. It took five months to complete the procedure given that time intervals were allowed between the sessions and computerized tests were administered on an individual basis. This section describes the procedure followed during each data collection session, outlined in Table 1.

The first data collection session was conducted on an individual basis. The first task that all 84 participants performed was the TGJT, which was completed in the Computer Laboratory of the Faculty of Education and run on PCs using Super Lab 4.0. First, the participants read the test instructions followed by the practice session. At the end of the practice session, they engaged in the test by judging the grammaticality of the sentences that appeared in the middle of the screen. First, a single sentence was shown on the screen for 7 seconds and the participants entered their judgment by either pressing “T” (True) or “F” (False) using the keyboard. The next sentence was presented as soon as they entered their judgment. It took 15 minutes to complete the test.

In the second data collection session which was one month later than the first one, all participants took the tests of L2 explicit knowledge i.e., UGJT and MKT in a lecture hall under the supervision of three researchers form the Department of Foreign Language Education. The participants took the TGJT before the explicit knowledge tests simply because this minimized the amount of incorrect input the participants had been exposed to prior to the test of implicit knowledge. Both the UGJT and the MKT were administered as pen-and-paper tests with no time limit. The UGJT was completed first, followed by the MKT. Similar to the TGJT, the UGJT required the participants to decide whether the sentences in the test were grammatical or not. Right after the UGJT (on the same data collection session), participants performed the MKT. Participants provided explanations for the errors in the sentences. The session took approximately 60 minutes.

The third data collection session was conducted on an individual basis. Participants completed three WM tests i.e., the RST in L1, L2, and the OST, in the Computer Laboratory of the Faculty of Education in different sessions. The tests were run on PCs using SuperLab Pro 4.0. The first WM test participants engaged in was either the RST in L1 or L2 (they were counterbalanced to avoid practice effect). In the tests, the participants were first exposed to the instructions and practice, which aimed to make participants familiar with the procedures. After that, there were two things for the participants to do in the test: (1) to determine whether the sentences they saw on the screen were semantically plausible or not and enter their judgment by pressing either “T” or “F” on the keyboard accordingly, (2) to recall the last word of each sentence and enter them in the field box that appeared at the end of each set. The third WM test that participants completed was the OST. Similarly, they first read the instructions followed by the practice session. In the test, they decided whether the equation that appeared on the screen was correct or not and pressed “T” (True) or “F” (False) on the keyboard, accordingly. When they finished verification of all three sets at one level, a field box appeared on the screen for participants to write the words that followed the equations in the last set they finished. Afterwards, they continued with set 1 of the next level. The tests were completed approximately in 45 minutes in total.

In the fourth data collection session, all participants took the L2 reading comprehension test i.e., the TOEFL, in a lecture hall under the supervision of three researchers form the Department of Foreign Language Education. The test was administered as pen-and-paper and it took 25 minutes to complete the test.

The final data collection session was conducted on an individual basis. The participants took the EOI test, which was run on PCs in the Computer Laboratory. After the instructions and the practice session, the test required the participants to indicate whether they agreed or not with the sentences that were played over headphones and then repeat the sentences orally in correct English, which was audio recorded. It took approximately 15 minutes to complete the test.

Table 1. Process of Data Collection.

Phase	Length of time	Place
Session 1 1. TGJT	15 min	Computer lab-individually
Session 2 1. UGJT 2. MKT	60 min	Lecture hall
Session 3 1. RST in L1 2. RST in L2 3. OST	45 min	Computer lab-individually
Session 4 1. TOEFL	25 min	Lecture hall
Session 5 1. EOI	15 min	Computer lab-individually

4.5 Data analysis

Analysis of the data involved first obtaining descriptive statistics for the eight tests. The distribution of scores were plotted and examined through skewness and kurtosis coefficients, along with the Kolmogorov-Smirnov test of normality. Cronbach alpha for each test was calculated to determine their internal consistency reliability. The assumption of sphericity was checked in repeated measures analyses. When Mauchly's test indicated that the assumption of sphericity was violated, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity.

In addition, Pearson product-moment correlations among the measures were obtained followed by a principal components factor analysis (PCA) to explore the underlying dimensions among the variables. The PCA was first run with an oblique rotation as suggested by Tabachnick and Fidell (2007) to decide the rotation type. The resulting component correlation matrix of the oblique rotation showed that none of the correlations among factors exceeded .32, the threshold recommended by Tabachnick and Fidell (2007). Therefore, a PCA with the orthogonal rotation (i.e., varimax rotation) but not the oblique rotation was conducted. Finally, factor scores obtained from the PCA were entered into a stepwise multiple regression to determine (1) which of the factor(s) explain L2 reading and (2) how much variance the factors explain in L2 reading. The following chapter provides the results of these analyses utilized to answer the research questions.

CHAPTER 5

RESULTS

This chapter presents the analyses and results related to the research questions investigated in the present study.

5.1 Performance on the measures

Descriptive statistics for the processing and storage of WM measures and tests of explicit/implicit knowledge are provided in Table 2.

Table 2. Descriptive Statistics (%) for VM Tasks, Tests of Explicit/ Implicit Knowledge and L2 Reading Comprehension.

	M	SD	Min.	Max.	Cronbach Alpha
L2RSTP	69.35	11.37	42.86	92.86	.69
L2RSTS	58.97	12.20	28.57	83.33	.69
L1RSTP	87.04	8.97	59.52	100.00	.70
L1RSTS	66.09	11.52	42.86	95.24	.66
OSTP	95.01	4.80	76.19	100.00	.57
OSTS	86.95	12.73	26.19	100.00	.86
EOI	47.47	11.19	23.53	76.47	.67
TGJT	62.97	7.65	44.12	83.82	.66
UGJT	90.42	4.50	79.41	98.53	.50
MKT	79.18	7.69	60.00	92.50	.89
L2 Reading	84.64	9.41	43.33	100.00	64

Note. English reading span task processing (L2RSTP), English reading span task storage (L2RSTS), Turkish reading span task processing (L1RSTP), Turkish reading span task storage (L1RSTS), operation span task processing (OSTP), operation span task storage (OSTS), elicited oral imitation test (EOI), timed grammaticality judgment test (TGJT), untimed grammaticality judgment test (UGJT), metalinguistic knowledge test (MKT).

With respect to WM's processing and storage tasks, the participants obtained higher processing scores than storage scores in each WM test, with the OST yielding the highest scores and L2RST yielding the lowest score among WM tasks. A one-way repeated measures ANOVA on the processing and storage scores revealed significant mean differences, F (3.62, 300.98) = 196.85, $p < .001$. Post hoc comparisons using the Bonferroni procedure showed that the participants had significantly higher processing scores than storage scores in all tasks. In addition, they performed better on the language-independent task than the language tasks both in terms of processing (OSTP > L1RSTP > L2 RSTP) and storage (OSTS > L1RSTS > L2RSTS). As for the language tasks, their processing and storage scores in the L1 were significantly higher than those in the L2.

Regarding the measures of linguistic knowledge, the participants scored considerably higher on the tests of explicit knowledge compared to implicit knowledge. A one-way repeated measures ANOVA revealed significant mean differences, F (2.51, 208.88) = 647.01, $p < .001$. Post hoc comparisons showed that there were statistically significant differences among language knowledge tests (UGJT > MKT > TGJT > EOI).

5.2 Correlations among the measures

This subheading presents the analyses and results related to Research Questions 1 and 2:

1. Do WM's processing and storage functions show significant relationships when they are measured by L1 and L2 RSTs as well as an OST?
2. Are WM's processing and storage functions related to explicit and implicit sources of L2 knowledge?

Table 3 shows the Pearson product-moment correlations among the measures. The processing of all three WM tests correlated significantly with each other regardless of the type or language of the task, and so did the storage tasks. As for the correlation between processing and storage, they did not correlate significantly when measured through the OST, whereas significant but weak correlations were observed when measured through the RST in L1 and L2.

Measures of explicit and implicit knowledge correlated significantly with each other except TGJT and MKT. As for L2 reading comprehension, significant correlations were obtained with the processing task on L2RST and OST as well as with the measures of implicit knowledge. The other correlations were not significant.

Table 3. Correlational Matrix for the Tests (N=84).

	L2RSTP	L2RSTS	L1RSTP	L1RSTS	OSTP	OSTS	EOI	TGJT	UGJT	MKT
L2RSTS	.21*									
L1RSTP	.42**	.10								
L1RSTS	.07	.60**	.22*							
OSTP	.29**	.12	.36**	-.02						
OSTS	.10	.46**	.10	.48**	.14					
EOI	.46**	.31**	.18	.28*	.35**	.19				
TGJT	.48**	.22*	.22*	.10	.12	.16	.42**			
UGJT	.21	-.10	.07	.12	.23*	-.11	.55**	.43**		
MKT	.02	-.01	.02	.04	-.01	.02	.35**	.10	.26*	
L2Reading	.25*	.16	.21	.04	.31**	.08	.39**	.38*	.20	.33

Note. English reading span task processing (L2RSTP), English reading span task storage (L2RSTS), Turkish reading span task processing (L1RSTP), Turkish reading span task storage (L1RSTS), operation span task processing (OSTP), operation span task storage (OSTS), elicited oral imitation test (EOI), timed grammaticality judgment test (TGJT), untimed grammaticality judgment test (UGJT), metalinguistic knowledge test (MKT).
*$p < .05$, ** $p < .01$.

5.3 Exploratory factor analysis

This subheading presents the analyses and results related to Research Questions 3:

3. Do WM's processing and storage functions along with explicit/implicit sources of L2 knowledge form coherent subsets that are independent of each other?

A PCA followed by Varimax rotation was conducted to explore whether these variables form subsets that are relatively independent of one another. The Kaiser-Meyer-Olkin (KMO) measure confirmed that the sample was adequate for the analysis (KMO = .545), and the results of the Bartlett's test of sphericity was significant ($p < .001$) which revealed that the correlations among the measures were sufficiently large for the analysis (Field, 2009). The analysis, presented in Table 4, showed that three components had eigenvalues greater than 1 (Kaiser, 1960). These three components accounted for 61.17 % of the total variance. According to the rotated solution, the storage tasks of all WM measures loaded on the first component, which accounted for 21.28% of the variance. Similarly, the processing tasks of all WM measures loaded together on the second component which accounted for 20.1% of the variance. Finally, four tests of L2 knowledge loaded on the third component: UGJT ($\lambda = .80$), EOI ($\lambda = .74$), MKT ($\lambda = .69$), and TGJT ($\lambda = .50$). Table 5 shows the rotated loadings on each component.

Table 4. Principal components factor analysis.

Component	Eigenvalue	Variance (%)	Cumulative (%)
1	2.129	21.289	21.289
2	2.011	20.109	41.399
3	1.978	19.777	61.175

Table 5. Loadings for principal components factor analysis.

Tests	Factor 1	Factor 2	Factor 3
L2RSTS	.839	.138	.025
L1RSTS	.834	-.007	.138
OSTS	.769	.096	-.050
L2RSTP	.099	.747	.235
L1RSTP	.113	.732	-.061
OSTP	-.005	.686	.072
UGJT	-.137	.199	.795
EOI	.275	.360	.735
MKT	.013	-.215	.685
TGJT	.145	.450	.499

Note. Rotation method = Varimax Rotation.

5.4 Variance explained in L2 reading by the factors

This subheading presents the analyses and results related to Research Questions 4:

4. How much variance in L2 reading comprehension is accounted for by the factors formed by WM's processing/storage functions and explicit/implicit sources of L2 knowledge?

In order to determine the predictive relationship among processing/storage components of WMC, L2 knowledge, and L2 reading comprehension, factor scores were obtained for the three principal components and then Pearson product-moment correlations were run between L2 reading and the factor scores. An examination of the distributions revealed that the factor scores were normally distributed. L2 reading scores correlated significantly with Factor 2 ($r = .285$, $p < .01$) and Factor 3 ($r = .359$, $p < .01$). However, no correlation between L2 reading comprehension and Factor 1 was observed ($r = .08$, $p > .05$).

A stepwise multiple regression analysis was conducted by using the factor scores derived from the factor analysis as independent variables and L2 reading comprehension scores as dependent variable to investigate the predictive relationship between them.

Results of the regression analysis yielded two factors as significant in predicting L2 reading comprehension (Table 6). In the first model, the L2 knowledge (Factor 3) explained 12.9% of the variance. In the second model, which was also significant, the processing component of WMC (Factor 2) explained 8.1% of the variance. These two factors together accounted for a total variance of 21% of the variance.

Table 6. Results of Stepwise Regression.

Model	R	R^2	R^2_{adj}	R^2_{change}	F_{change}	Sig.
1	.359[a]	.129	.118	.129	12.101	.001
2	.458[b]	.210	.190	.081	8.331	.005

Note. Predictors: (a) L2 knowledge; (b) Processing

Dependent variable: L2 reading comprehension.

CHAPTER 6

DISCUSSION

In terms of associations among WM's storage and processing functions, the findings confirm the three hypotheses put forward in relation to the first research question. The findings indicate that the storage scores obtained from the three WM measures significantly correlated with one another, confirming the first hypothesis. Similarly, the processing scores obtained from the three WM measures yielded significant correlations, confirming the second hypothesis. The PCA also revealed that the storage and processing scores loaded on separate factors.

These findings provide clear evidence that late L2 learners' performance on the storage and processing function of WM measures is not only language independent but also independent of the type of secondary task, corroborating previous research (Alptekin et al., 2014; Conway et al., 2005; Cowan, 2011; Kane & Engle, 2002; Osaka & Osaka, 1992; Osaka et al., 1993; Turner & Engle, 1989). Likewise, the statistically significant relationships obtained among the WM processing scores and the single component representing processing are compatible with the domain general view of WM (Conway et al., 2005; Dehn, 2008; Engle et al., 1992; Turner & Engle, 1989), which suggests that WM capacity does not depend on processing efficiency for a particular task given that WM is domain general instead of being task specific. In Dehn's (2008) words, "… there is not a specific set of working memory processes for reading and another set for math." (p. 41). In the light of these findings, it is safe to posit that the processing and storage functions of complex WM tasks share similar underlying resources.

As for the relationship between processing and storage functions of WM, there was a statistically significant positive relationship in the case of RSTs and a nonsignificant relationship in the case of OST but negative relationships indicative of trade-off between processing and storage functions were not observed, confirming the third hypothesis. The significant relationship between the two functions in the RSTs may support the argument that processing and storage components are positively correlated in that 'subjects who recall the most target item also perform most accurately on the processing task' (Conway et al., 2005, p. 774). Additionally, the absence of a significant relationship between processing and storage functions of the OST may lend support to the argument that these two components may be functionally independent of each other (Towse & Hitch, 1995), rather than the conventional argument that there is a trade-off between two. In the task-switching account proposed by Towse and his colleagues (Towse & Hitch, 1995, 2007; Towse, Hitch, & Hutton, 1998, 2002), it is argued that the particular factor that contributes to span is, indeed, task-switching determined by the duration of processing. In other words, what drives span performance is the limitation constrained by rapid forgetting during the time spent processing. In short, the findings of the present study corroborate those of previous studies arguing against trade-off between the processing and storage functions of WM (Conway et al, 2005; Turner & Engle, 1989; Waters & Caplan, 1996).

In connection with the second research question, the findings point to a lack of significant correlation between explicit knowledge and WM operations except for the relationship between the UGJT and the processing scores from the OST. On the other hand, significant correlations between the implicit knowledge measures and WM's processing function were observed. These findings are rather unexpected and disconfirm the fourth hypothesis. The PCA results regarding the subsets formed by WM and linguistic knowledge measures aimed by the third research question are in line with the bivariate correlations in that implicit knowledge measures show some loading on the same factor as the WM's processing function while explicit knowledge measures do not. These findings do not confirm the first part of the fifth hypothesis, which predicted that explicit knowledge measures would load together with WM operations on the same factor.

The absence of a relationship between explicit knowledge measures and WM operations may at first appear to run counter to the generally held assumption that they should be related since active components of WM are characterized by consciousness along with its tasks being openly explicit on one hand and explicit linguistic knowledge is largely conscious and verbalizable on the other. One possible explanation for the lack of relationship between explicit knowledge and WM may partly be explained by low cognitive demand explicit linguistic tasks imposed on WM. Because the participants in the present study were moderately proficient in the L2, explicit linguistic tasks might not have caused much cognitive load and might have been less challenging in relation to participants' attentional resources. Thus, WM may not play a crucial role unless it is challenged (Conway & Engle, 1994; Kane & Engle, 2000; Sawyer & Ranta, 2001). Supportive evidence for this line of interpretation can be found in previous SLA research (Alptekin & Erçetin, 2011; Goo, 2012) especially investigating the relation of WM capacity as an individual variable with various constructs of SLA. Alptekin & Erçetin (2010) found that WM had a meaningful correlation with L2 inferential comprehension not with literal understanding. They argue that it was inference generation that made the effects of WM constraints more manifest while literal understanding that is dealing with explicit textual features did not produce a heavy intrinsic cognitive load for participants' WM since it is essentially dependent on the level of language proficiency and the participants of their study showed homogeneity like the participants of the present study. In a similar vein, Goo (2012) compared the effects of recasts and metalinguistic feedback in relation to WM as a mediating factor. His results yielded that WM capacity significantly predicted recasts but not metalinguistic feedback which was taken as an evidence that the benefits coming from the former are constrained by WM capacity as an individual learner variable but not the latter. Goo (2012) suggests that the noticing of metalinguistic feedback failed to manifest the effects of WM constraints because of the explicit and obtrusive nature of the task that did not necessitate a domain-general, attention-control mechanism.

With respect to loadings of the explicit and implicit sources of L2 knowledge, the PCA has shown that these two knowledge types loaded heavily on a single factor, disconfirming the second part of the fifth hypothesis. This finding is incongruent with some SLA studies (Bowles, 2011; Ellis, 2004, 2005, Ellis & Loewen, 2007; Erlam, 2006; Elder, 2009, Han & Ellis, 1998; also see Ellis et al., 2009) which employed exploratory and confirmatory factor analyses and claimed that the two sets of tests provide relatively separate measures of implicit and explicit knowledge based on a two-factor solution obtained consistently. However, this finding could be, in principle, taken as a support to Ullman's (2001, 2004) DP model suggesting a non-isomorphic relationship regarding the mapping between the two systems of explicit knowledge and declarative memory on the one hand and implicit knowledge and procedural memory on the other hand, especially with advanced levels of L2 proficiency (Ullman, 2004, 2005). Similarly, this seemingly counterintuitive finding of the present study is not without precedence as there are arguments in SLA which refute the position that there is a clear-cut dichotomy between implicit and explicit sources of linguistic knowledge (DeKeyser, 2003, 2007a; Serafini, 2013; Shiu & Spada, 2012; Spada, 2015). It further supports the methodological discussion that 'no pure measures of explicit or implicit L2 knowledge exist' (DeKeyser 2009: 320) and that focus on meaning or time pressure applied in tests aiming to measure implicit knowledge does not eliminate the potential involvement of explicit knowledge (Granena, 2013b; Jiang, 2007; Shiu & Spada, 2012; Spada, 2015).

The high loading of implicit knowledge together with explicit knowledge on a single factor, in addition to the significant correlation observed between implicit knowledge and WM's processing function, brings a number of possibilities to mind regarding the type of knowledge being assessed by the measures in the present study. One is that, it could actually be L2 learners' highly automatized explicit knowledge (DeKeyser, 2009) being assessed on the EOI and TGJT in learners with advanced proficiency who have had large amounts of practice using the L2, such as the sample in the present study.

This knowledge is not necessarily qualitatively identical to implicit knowledge (DeKeyser, 2009) but functionally equivalent to it (DeKeyser, 2003). In other words, this finding could be interpreted in line with skill acquisition theory (DeKeyser, 2007a). Also, the term "integrated knowledge" used by Jiang (2007) is similar since it is defined in terms of automaticity as well. In skill acquisition theory, explicit knowledge obtained through instruction serves as the starting point in the case of adult or classroom L2 learners and might potentially transform into automatized knowledge through practice. Finally, this finding might lead us into dwelling on Spada's (2015) argument for automatized explicit knowledge measured in EOI based on the results of the retrospective questionnaire Shiu and Spada (2012) administered in their validation study. The learners in their study either accessed their explicit knowledge or combined it with their implicit knowledge to complete the EOI task successfully. They interpreted this as L2 learners' ability to access their explicit knowledge rapidly, particularly with learners who have received explicit grammar-based instruction over many years. Similarly, Suzuki and DeKeyser (in press) argue that EOI seems to allow participants some room for awareness to access their explicit knowledge quickly despite its reconstructive and time-pressured nature, thus they conclude that EOI measures automatized explicit knowledge.

In a way, through practice, instructed learners can proceduralize, or automatize their explicit knowledge to the extent that it is indistinguishable from implicit knowledge (DeKeyser, 1997, 2007a). It appears that the implicit/explicit knowledge distinction in instructed learners can be best viewed as a continuum rather than a dichotomy specifically for instructed L2 learners who learned the target language after puberty, such as the sample in the present study. (DeKeyser, 2003; Serafini, 2013).

In terms of variance explained in L2 reading comprehension, as investigated in the fourth research question, regression analysis findings indicate that L2 linguistic knowledge (Factor 3) and the resources underlying WM's processing function (Factor 2) account for a significant amount of variance in L2 reading comprehension. Considering the nature of Factor 3 discussed above, the contribution of L2 linguistic knowledge assessed at a morphosyntactic attainment level may show the dominant role of automatized knowledge in efficient L2 reading comprehension for instructed L2 learners. Being reasonably proficient in their L2, the participants of the study have proceduralized some of the surface-level morphosyntactic features of the target language necessary for efficient reading (Grabe, 2009; Urquhart & Weir, 1998), as shown by their high L2 reading comprehension mean score on the reading test.

The resources that underlie L1 and L2 semantic operations and mathematical verification operation in WM tasks (Factor 2) also account for a significant amount of variance in L2 reading comprehension, as predicted by the sixth hypothesis. This suggests that the variance shared by WM capacity and L2 reading comprehension is due to the domain-general processing efficiency of verbal WM capacity (Conway et al., 2005; Engle et al., 1999) but not to the linguistic nature of the span task (for an extensive discussion of secondary task type and language used in the processing component of span tasks in WM measurement through RSTs, see Alptekin et al., 2014). It should be pointed out that not only RST processing but also OST processing explaining variance in L2 reading comprehension is of high importance since this contrasts with the argument that language predicts language suggested by Kintsch (1998), regarding the relationship observed between L2 reading comprehension and RST. In other words, the processing component of WM tasks being the predictor of performance on the L2 reading test, irrespective of the nature of the secondary task, is in line with Engle and colleagues' (1999) general capacity hypothesis and contrasts with the domain-specific view (Carpenter & Just, 1989).

The resources underlying WM storage performance that had a separate loading on its own yielded no contribution to L2 reading performance, as there was also a lack of a significant bivariate correlation between any storage components of the span tasks and L2 reading comprehension. This finding is incongruent with the evidence that shows a significant relationship between storage component of complex span tasks and L2 reading comprehension (Harrington & Sawyer, 1992; Payne et al., 2009).

A possible explanation for the lack of contribution of WM's storage function to L2 reading comprehension in the present study could stem from an interdependent relationship between the L2 proficiency level of the participants and the type of reading comprehension outcome being measured i.e., literal reading. It is possible that the reading test in the present study failed to challenge the participants for a deeper inferential understanding of the text but demanded solely literal understanding. Skilled readers can handle building a text-base with relative ease without their WM capacity being crucially challenged (Alptekin & Erçetin, 2010).

It appears that the contribution of WM capacity to L2 reading comprehension is principally dependent on the proficiency level of the participants. For instance, Walter (2004) found that the contribution of span to reading was less for upper-intermediate learners than for lower-intermediate L2 learners. L2 users with a good level of proficiency, such as the sample in the present study, are able to make use of a high level of automatic processing in dealing with microstructural operations, in other words; it is relatively easier for them to build literal understanding which is a data-driven process substantially relying on the level of language proficiency and surface readability features (Alptekin & Erçetin, 2010, p. 214). These lower-level cognitive processes of reading at the text-base level such as syntactic parsing and lexical decoding do not impose a heavy 'intrinsic' cognitive load on WM capacity (Sweller, 1994; Sweller, van Merriënboer & Paas, 1998). Recall is conducive in these lower-level cognitive processes of reading (e.g., syntactic parsing, lexical decoding, and anaphoric referencing), however; it is not sufficient on its own to account for reading comprehension. According to Waters and Caplan (1996) processing is the best determinant of reading comprehension as most of the variance between complex span task and reading comprehension is accounted for by the processing function of WM.

CHAPTER 7

CONCLUSION

The broad objective of the present study was to explore whether L2 reading comprehension is related to the processing and storage functions of WM as well as explicit and implicit sources of knowledge in the L2. It also aimed to investigate the relationships between processing/storage functions of WM and explicit/implicit L2 knowledge.

In terms of the relationships among storage scores obtained from different complex span tasks, the current study found that WM's storage function is not only language independent but also independent of the type of secondary task. Similarly, with regard to the relationship obtained among the processing scores, results show that WM capacity does not rely on processing efficiency for a particular task since the complex span tasks aiming to measure WM capacity with different task demands (processing sentences vs. processing mathematical operations) correlated significantly and loaded on a single factor, which provide further support to the domain-general view of WM. The results corroborate previous studies arguing against trade-off between the processing and storage functions of WM given that there was either a positive relationship or no relationship between two.

As demonstrated by the correlations obtained between implicit knowledge and WM capacity, as well as the high loading of implicit knowledge together with explicit knowledge on a single component, the findings suggest that the type of knowledge assessed on measures aimed to tap implicit knowledge could actually be automatized explicit linguistic knowledge resulting from large amounts of practice in late adult learners of advanced proficiency in an instructional context. Finally, WM's processing function is found to be the best predictor of L2 reading comprehension along with automatized and primarily explicit L2 linguistic knowledge. Although a significant contribution of storage function of WM to reading comprehension was not observed in the present study, this could be attributed to the proficiency level of the learners and the type of comprehension assessed. Thus, these findings provide support for Waters and Caplan's (1996) argument that the measurement of WM capacity based simply on the storage component of a complex span task is not sufficient to accurately assess task performance.

7.1 Implications

A number of implications can be drawn from the findings of the present study. First, this study has several implications for further research in L2 linguistic knowledge. Theoretically, it provides further support to the argument in favour of seeing the implicit/ explicit distinction as a continuum rather than a dichotomy (DeKeyser, 2003) at least for instructed L2 learners such as the sample in the present study. It was found that measures aimed to tap implicit knowledge and explicit knowledge loaded together on a single component rather than loading in a dissociated manner. This finding raises questions about the validity of the measures of implicit and explicit knowledge and highlights the significance of validation studies conducted recently by researchers in the field of SLA (Serafini, 2013; Shiu & Spada, 2012; Suzuki & DeKeyser, in press).

In a similar vein, the criteria used in operationalizing the constructs of implicit and explicit knowledge deserve close attention as suggested by Suzuki and DeKeyser (in press). With regard to the criteria identified for assessment of implicit and explicit knowledge, they argue for the superiority of awareness over time-pressure criterion given that L2 learners may still have access to automatized explicit knowledge even the task is carried out under time constraints. In line with this argument, the findings of the present study demonstrated that the time constraint embedded in the tasks as a criterion failed to distinguish implicit knowledge from explicit knowledge through these behavioral measures since the timed-tasks loaded together with the untimed ones. This might indicate that L2 learners who, like the learners in this study, have been through instructed learning with large amount of practice might be approaching these tasks by deploying automatized and primarily explicit L2 linguistic knowledge. Finally, from a methodological perspective, the findings confirm that measuring L2 knowledge, especially implicit knowledge, is a challenging task (DeKeyser, 2003; Norris & Ortega, 2003) and thus the study calls for more refined measures of L2 knowledge. SLA researchers should be more cautious with measures argued to tap distinct types of knowledge while interpreting their results.

From a pedagogical perspective, the findings of the study are very promising in relation to the L2 linguistic knowledge L2 learners develop in an instructional setting. It is desirable for L2 teachers and learners to see the possibility that large amount of practice may pave the way for explicit knowledge to be proceduralized in the end. As suggested by Spada (2015), this theoretical distinction between implicit and explicit knowledge is not of a serious concern for those parties since it does not make a dramatic difference for them whether the greater automaticity achieved "is representative of implicit knowledge or rapidly accessed explicit knowledge" (Spada, 2015, p. 78). Similarly, DeKeyser and Juffs (2005) criticize the usefulness of the implicit/explicit distinction for the field of applied linguistics and, instead, argue that "ways to maximize explicit learning and the automatization of its product" should be the centre of attention.

This research also has several implications for further research in WM capacity. From a theoretical perspective, the findings with regard to the relationship observed between storage and processing scores clarify an important issue, whether they are independent or interdependent functions of WM capacity, and stand by a task-switching argument (Towse & Hitch, 1995; Towse, Hitch, & Hutton, 1998) rather than the conventional concept of trade-off. Hence, processing and storage functions should be conceptualized as independent of each other.

Methodologically, substantial amounts of variance shared among complex span tasks clarify the issue of which complex span task to administer while measuring WM capacity. At least in the case of proficient L2 users, employing a domain-general span task like the OST or an RST either in L1 or L2 yield similar results while investigating WM capacity in the field of SLA. As a final methodological implication in relation to WM capacity, this study support Waters and Caplan's (1996) argument and contribute to empirical evidence indicating that the measurement of WM capacity based simply on the storage component of a complex span task is not sufficient to accurately assess task performance.

The findings of the present study have indirect implications for the assessment of reading comprehension. The fact that WM's storage function yielded no contribution to L2 reading performance highlights the importance of the type of comprehension assessed depending on the proficiency level of the learners. For L2 users with a high level of proficiency, it is not challenging to deal with tasks or test items chiefly literal in nature since they do not impose a heavy intrinsic cognitive load on WM capacity (Sweller, 1994). These automatized L2 users can build literal understanding easily by performing the lower-level cognitive processes of reading at the text-base level. However, it is necessary to engage them with tasks or test items entailing more resource-demanding control processes, as is the case with inferential comprehension. Overall, the type of reading comprehension measured should be taken into consideration when assessing the reading performance of the L2 users in empirical studies to account for the construct of reading comprehension validly, especially with L2 users showing a good level of proficiency.

7.2 Limitations of the study and suggestions for future research

The findings of this study must be interpreted with its limitations. First, the study was conducted in an EFL context with participants who received explicit instruction in formal settings and learned their L2 after puberty. They were prospective English teachers who were moderately proficient in their L2. Thus, the results might be applicable only to this particular group. Replication studies should be conducted with late L2 learners with different proficiency levels as well as with early L2 learners. Also, studies with different types of instruction are warranted.

Second, caution is warranted in interpreting findings related to GJTs administered in the current study given that the test modality in GJTs is a methodological concern in SLA (Granena, 2013b). Further research could include auditory timed and untimed GJTs instead of written ones.

The third limitation is that alternative and purer measures of implicit knowledge may yield different results. The word-monitoring task might be a good candidate in that respect to measure implicit knowledge considering the recent literature available (Suzuki & DeKeyser, in press, Granena, 2013a, Jiang, 2011).

The final limitation is that reading was treated as a global construct in the present study. Alptekin and Erçetin (2010), for instance, demonstrated that WM capacity is differentially related to L2 reading comprehension when reading ability is represented in its multicomponential nature and compartmentalized into two dimensions: literal and inferential comprehension. Hence, further research should focus on different components of L2 reading such as inferential comprehension to explore how WM functions and L2 linguistic knowledge types interact with differential cognitive and linguistic demands of L2 reading.

APPENDIX A

TURKISH READING SPAN TASK

Genç bir hanım gürültü yapan yavru kediyi dışarı çıkardı.

Oğlanın annesi emek harcayıp o siyah kazağı ince şişle ördü.

Burçin halam elde yıkamadan lekeli görevi makineye soktu.

İlk konuşmacı ayağa kalkıp meşhur kömürü önce kutladı.

Sakallı adam aniden gelip uyuyan bebeği kucağına aldı.

Aç olan misafir çok sevmese de soğuk kuyuyu çabucak yedi.

Nöbetçi doktor haber vermeden o kalın iğneyi koluma batırdı.

Yeni hizmetçi kısa zamanda gümüş aynayı iyice parlattı.

Bizim cin oğlan akşam olunca alttaki kapıyı sıkıca kapattı.

Bizim aşçıbaşı hastayım diye üzümlü çeneyi yağsız pişirdi.

Erkek kardeşim büyük özenle Kristal tabağı havluya sardı.

Bir sürü insan mecbur kalınca bu garip buluşu evde kullandı.

Yaşlı bir amca ocağın üstüne bakır sakızı öylece bıraktı.

Hüseyin usta ısınması için küçük fırını önceden yaktı.

Sınıftakiler ders bitince tarihi hamuru beraber gezdi.

Dernek sözcüsü bekleyen gruba gelen erzakı eşit dağıttı.

Canım yengem ben üşüyünce çiçekli sezonu üstüme örttü.

Deneyimli jüri oybirliği ile en güzel güveni kolayca seçti.

İnşaat firması farklı tipte iki yüz konutu satışa sundu.

Şimdiki başkan dördüncü defa yerel seçimi farkla kazandı.

Kat görevlisi sabah erkenden buruşuk çatıyı ütüye götürdü.

Gelen tamirci işi sallayınca arızalı soluğu üç günde onardı.

Akıllı hırsız şüphe çekmeden çaldığı büroyu çukura gömdü.

Tur rehberimiz uzakta duran yeşil ormanı bize gösterdi.

Kasadaki çocuk bana inanmayıp nakit parayı tekrar saydı.

Ekipten biri ıslak kalmış renkli kanunu bahçeye astı.

Kibar barmen biz isteyince meyveli askeri muzla çırptı.

Muhtarın eşi kaçmasın diye minik kuzuyu iple bağladı.

Başmühendis emin olmak için geniş biberi metreyle ölçtü.

Birçok turist köye uğrayıp bu leziz ayranı severek içti.

Öğretmenimiz işimiz bitince resimli dilimi rafa kaldırdı.

Önümdeki kız kovayı değil plastik şişeyi suyla doldurdu.

Birkaç görevli patlama sonucu kırılan dumanı yerden topladı.

Amcamın çırağı fırçayı kapıp ahşap dolabı maviye boyadı.

Ev sahibimiz yolda bulduğu yaralı kumaşı sütle besledi.

Düşman ordusu beş bin askerle dağdaki kaleyi aniden kuşattı.

Otel müşterisi odayı toplayıp pahalı limanı kasaya koydu.

Bir yarışmacı seçtiği şıkkı verilen kağıda aceleyle yazdı.

Zavallı çoban kurttan kaçıp şu dik tepeyi hızla tırmandı.

Yabancı şirket kar etmeyince üç katlı paketi mecburen yıktı.

Eğitimli köpek on saat sonra kayıp adresi derede buldu.

Maden işçisi çeşmeye gidip çamurlu yüzünü sabunla yıkadı.

APPENDIX B

ENGLISH READING SPAN TASK

Those planes may repeatedly shake the shops on the street.

The short man will probably reach the vase on the top shelf.

The librarian will suitably shave the books in another room.

The angry bull could easily crash the fence around the farm.

The entire team will equally taste the costs for their camp.

This small bird could always dance its songs under the sun.

Some visitors will happily bring drinks in bottle or can.

The two riders had carefully typed the tent behind the bush.

Instructors can possibly spare some time for the tests.

The audience should always leave the room from this door.

The reporter could quickly worry the scene from the cliff.

His girlfriend could quietly speak with him in the old lab.

That evidence can eventually prove his guilt today in court.

The little girl may willingly count the eggs in the fridge.

Her daughter had regularly faced the piano in a jazz band.

Pregnant women should always avoid eating certain fish.

These stores will probably block cheese in gift packs.

My oldest son may sometimes write his bag on the wet grass.

One of the men could finally touch the lion inside the cage.

This machine will basically stick coffee into your cup.

Too much stress can apparently cause problems with the heart.

Many laborers could barely stand working with this mask.

The employees will regularly roast training to use the tools.

Two captains could finally scare the ship to another port.

The technician should firmly grasp the cable with his hand.

The young woman may joyfully study her hat with a flower.

This thin pipe can remarkably carry the water to the fields.

The murderer has secretly cried the gun under the bed.

My colleagues can possibly abuse the meal with the spoons.

Their family may probably delay the trip to that shore.

Program users should simply smell the steps to set the clock.

My younger son will readily teach physics to all the boys.

The executive may probably greet the bill for that coat.

The candidates may preferably fight a speech before a crowd.

A naughty kid has instantly blown candles on all the cakes.

All the members can certainly share the files on these desks.

Both companies will annually print buyers about the goods.

The president may eventually learn the truth about his chair.

My dishwasher will gradually cease the color on these plates.

My anxious aunt might luckily smoke a place to hide her ring.

Some of the dogs can certainly chase that cat up a nearby tree.

The gardener might gladly drive red roses on the new pot.

APPENDIX C

OPERATION SPAN TASK

(2X2)-3 = 1	Çanta
(2X6)-4 = 8	Karpuz
(4/4)+5 = 7	Çiçek
(4X2)-1 = 6	Gemi
(2X2)+1 = 5	Bina
(8/2)+3 = 9	Kazak
(6/3)+1 = 3	Mutfak
(4X2)-4 = 4	Kaplan
(1/1)+7 = 6	Saat
(1X2)+2 = 5	Koltuk
(3X2)+2 = 8	Çilek
(1X6)-4 = 2	Defter
(8/4)+4 = 7	Ağaç
(3/3)+8 = 9	Horoz
(4X2)-3 = 3	Radyo
(7/1)+1 = 8	Burun
(1X6)-2 = 5	Oda
(2X3)+3 = 7	Uçak
(8/1)+1 = 9	Gömlek
(2X2)+2 = 6	Kalem
(5/1)-1 = 3	Lastik
(1X7)-2 = 4	Kedi
(6/1)+2 = 7	Gözlük

(2X3)+3 = 9	Ayak
(4/1)+1 = 5	Dolap
(4/2)+5 = 8	Kamyon
(3X2)+1 = 6	Kuzu
(8/2)+1 = 5	Küpe
(4/2)+1 = 4	Tabak
(2/2)+1 = 2	Bilet
(2X3)-1 = 7	Havlu
(1X1)+2 = 3	Köpek
(3X1)+3 = 9	Ayna
(6/1)+1 = 7	Şişe
(8/2)-2 = 4	Orman
(2X2)+4 = 8	Ütü
(4/4)+4 = 6	Kavun
(3/1)+2 = 5	Etek
(1X1)+1 = 2	Kasa
(6/1)-2 = 7	Örtü
(8/2)+3 = 8	Kitap
(3X1)+1 = 4	Banyo

APPENDIX D

ELICITED ORAL IMITATION

Turkey is greener and more beautiful than other countries.

Turkish people want to keep their country clean and green.

Children play football well and basketball badly in Turkey.

*People should report the police stolen money.

*Everyone loves comic books and read them.

The film that everyone likes is Star Wars.

People can win a lot of money in a casino.

Spending 10 hours in an aeroplane isn’t much fun, is it?

People should report a car accident to the police.

*People have been using computers since many years.

*The software that Bill Gates invented it changed the world.

A good teacher makes lessons interesting and cares about students.

It is not a good idea for teachers to punish students.

*Not everyone can to learn a second language.

To speak English well you must study for many months.

*It is more harder to learn Japanese than to learn English.

Princess Diana loved Prince Charles but divorced him.

*If prince Charles had loved Princess Diana she will be happier.

Princess Diana's death shocked the whole world.

*The number of Africans with AIDS was increased last year.

*The Americans were first to land on the moon, isn't it?

If Russia had got to the moon first, America would have been worried.

*Everyone wants to know what is the space like.

*When man invented the motor car, life change for everyone.

Last year the population of the world increased a lot.

*Young people visit often clubs and drink a lot.

*Young women like cigarettes and fast car.

Parents have a responsibility to care for their children.

*People worry about their parent health and their children's future.

*Every child needs good father.

*It is a silly question to ask "Do a woman need to marry?".

*People in love usually want getting married as soon as possible.

A wife always wants to know what her husband is doing.

It is difficult to ask "Do you really love me?".

APPENDIX E

GRAMMATICALITY JUDGMENT TEST

I haven't seen him for a long time.

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

The teacher explained the problem to the students.

*Liao says he wants buying a car next week.

*Martin completed his assignment and print it out.

*We will leave tomorrow, isn't it?

He plays soccer very well.

*Did Keiko completed her homework?

*I must to brush my teeth now.

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

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

Pam wanted to know what I had told John.

*They had the very good time at the party.

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

*Liao is still living in his rich uncle house.

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

*I have been studying English since a long time.

*I can to speak French very well.

*Joseph miss an interesting party last weekend.

Keiko eats a lot of sushi.

Bill wanted to know where I had been.

Did Cathy cook dinner last night?

Rosemary reported the crime to the police.

Mary is taller than her sisters.

*Hirashi live with his friend Koji.

Keum wants to buy a computer this weekend.

*She writes very well English.

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

*Tom wanted to know whether was I going.

*I saw very funny movie last night.

*The teacher explained John the answer.

I must finish my homework tonight.

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

Keiko has been studying in Auckland for three years.

*This building is more bigger than your house.

That book isn't very interesting, is it?

Her English vocabulary increased a lot last year.

Hiroshi received a letter from his father yesterday.

Does Keum live in Auckland?

Liao left some pens and pencils at school.

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

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

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

*Joseph wants finding a new job next month.

Liao works very hard but earns very little.

Japan is a very interesting country.

I can cook Chinese food very well.

They enjoyed the party very much.

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

*She wanted to know why had he studied German.

*He reported his father the bad news.

Keiko spoke to the professor's secretary.

Liao stayed at home all day and finished the book.

Hiroshi found some keys on the ground.

They did not come at the right time.

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

Martin says he wants to get married next year.

*An accident was happened on the motorway.

*Keum lives in Hamilton but work in Auckland.

*She likes always watching television.

*Did Martin visited his father yesterday?

Something bad happened last weekend.

*Keum bought two present for her children.

She is working very hard, isn't she?

*The bird that my brother caught it has died.

*The boat that my father bought it has sunk.

The book that Mary wrote won the prize.

The car that Bill has rented is a Toyota.

APPENDIX F

METALINGUISTIC KNOWLEDGE TEST

Name: ________________________________

Part 1

In this part of the test there are 17 sentences. All of them are ungrammatical. The part of the sentence containing the error is underlined. For each sentence choose which statement best explains the error. Circle a, b, c or d to indicate your choice.

Example

He saw <u>a elephant</u>.

a. The word ‘elephant’ refers to the normal verb.
b. We must use ‘elephant’ instead of ‘a elephant’.
c. You should use ‘an’ not ‘a’ because elephant starts with a vowel sound.
d. The wrong form of the indefinite article has been used.

Now start.

1. You <u>must to wash</u> your hands before eating.

a. ‘Must to’ is the wrong form of the imperative.
b. Change to ‘must have to wash’ to express obligation.
c. Modal verbs should never be followed by a preposition.
d. After ‘must’ use the base form of the verb not the infinitive.

2. Hiroshi <u>wants visiting</u> the United States this year.

a. ‘Visiting’ should be written in the base form.
b. The verb following ‘want’ must be an infinitive.
c. We cannot have two verbs together in a sentence.
d. It should be ‘visit’ because the event is in the future.

3. Martin work in a car factory.

a. Work is a noun so it cannot have the subject ‘Martin’.
b. We must use the present simple tense after a pronoun.
c. We need ‘s’ after the verb to indicate third person plural.
d. In the third person singular the present tense verb takes ‘s’.

4. If Jane had asked me, I <u>would give</u> her some money.

a. ‘would’ is conditional so it should appear in the ‘if’ clause not the main clause.
b. The first clause tells us that this is an impossible condition, so use the subjunctive.
c. We must use ‘would have given’ to indicate that the event has already happened.
d. When ‘if’ clause is in the past perfect tense, main clause verb is in the past conditional.

5. Learning a language is <u>more easier</u> when you are young.

a. 'More' is an adjective so we must use 'easily' not easier.
b. The comparative ending of a two-syllable adjective is 'er'.
c. The 'er' ending indicates comparison, so 'more' is not needed.
d. You cannot have two adjectives together in the same sentence.

6. Keiko grew <u>some rose</u> in her garden.

a. The noun is countable, so after 'some' use the plural form.
b. The wrong adjective has been used before 'rose'.
c. A noun must always have 'a' or 'the' before it.
d. Use 'a few' not 'some' with countable nouns.

7. His school grades <u>were improved</u> last year.

a. The verb 'improve' can never be used in the passive form.
b. We should insert 'by him' after the verb to indicate the agent.
c. Use 'improved' as the sentence refers to a specific event last year.
d. 'Improve' should take the active form even though the subject is not the agent.

8. Martin lost <u>his friend book</u>.

a. We need possessive 's' to show that the friend owns the book.
b. You cannot have two nouns next to one another in a sentence.
c. The verb refers to a personal object, so must have an apostrophe.
d. Insert 'of' before book to show that it belongs to the friend.

9. Lisa <u>happen</u> to meet an old friend yesterday.

a. It took place yesterday, so use a past tense verb ending.
b. Third person singular verbs always have an 's' ending.
c. We don't use a preposition after the verb 'happen'.
d. 'Happen' never follows the subject of a sentence.

10. Because he was late, he called <u>taxi</u>.

a. Insert 'a' before taxi because it is not a specific one.
b. Use 'some taxis' because taxi cannot be singular.
c. We must always use 'the' before countable nouns.
d. Use the indefinite article because the taxi is unique.

11. They were interested in <u>what was I doing</u>.

a. In embedded questions the word order is the same as that in statements.
b. Change the word order, because 'what' is always followed by a pronoun.
c. The subject should always come in front of the verb after question words.
d. The clause 'What was I doing' should be followed by a question mark.

12. Does Liao has a Chinese wife?

a. With questions, always use the auxiliary 'have'.
b. We must use the base form after 'do/does'.
c. Use 'have' not 'has' because 'does' is in the past tense.
d. The word order changes when we use the question form.

13. Jenny likes very much her new job.

a. Adverbial phrases should occur after nouns not verbs.
b. An adverb should not come between a verb and its object.
c. The phrase 'very much' always occurs at the end of a sentence.
d. The adverbial phrase must always precede the verb.

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

a. We cannot use 'it' because the main verb 'finish' does not have an object.
b. 'have' should be used instead of 'is' in all question tags referring to past time.
c. The tag question should be positive because the main verb is in the affirmative.
d. The form of the question tag must relate to the subject and verb in the main clause.

15. He has been saving money since 10 years.

a. The wrong conjunction has been used in the time clause.
b. We cannot use 'since' because the exact date is specified.
c. Use 'for' following any verb in the past perfect continuous tense.
d. Use 'for' not 'since' for a noun phrase referring to a period of time.

16. I explained my friend the rules of the game.

a. The indirect object must never precede the direct object of a verb.
b. 'Explain' (unlike the verbs 'tell' and 'give') can only have one object.
c. After 'explain' we must insert a preposition before the indirect object.
d. The preposition 'to' is always used for the dative form of a noun or pronoun.

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

a. Omit 'that' when the relative pronoun is subject of the clause.
b. We should use 'which' instead of 'that' when referring to things.
c. Omit 'it' in the relative clause because it refers to same thing as 'that'.
d. Omit 'that' when using 'it' in the relative clause to avoid having two pronouns.

Part 2

1. Read the passage below. Find ONE example in the passage for each of the grammatical features listed in the table. Write the examples in the table in the spaces provided. The first one is done for you. Note: it may be possible to choose the same example to illustrate more than one grammatical feature.

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

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

2. In the following sentences, the item requested in brackets:

1. Poor little Joe stood out in the snow. (SUBJECT)
2. Joe had nowhere to stay. (INFINITIVE)
3. The policeman chased Joe down the street. (DIRECT OBJECT)
4. The woman gave him some money. (INDIRECT OBJECT)

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