



The Role of Implicit Learning in L2 Morphosyntax: An artificial-grammar language learning experiment

Yuqing Yang

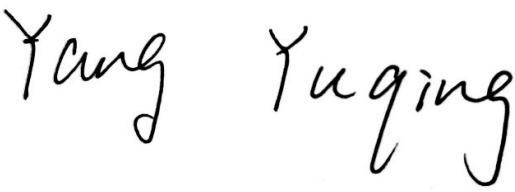
Note that some graphs/tables/images may be removed
in order to comply with copyright restrictions.

MSc in Applied Linguistics and Second Language Acquisition, 2024

DECLARATION BY THE CANDIDATE AS AUTHOR OF THE DISSERTATION



1. I understand that I am the owner of this dissertation and that the copyright rests with me unless I specifically transfer it to another person.
2. I allow the Department to deposit on my behalf a copy of this dissertation in the Oxford University Research Archive ('ORA') where it shall be freely available online for use in accordance with ORA's Terms and Conditions of Use [https://ora.ox.ac.uk/terms_of_use].
3. I understand that this dissertation should not contain material that can be used to personally identify individuals or specific groups of individuals (unless permission has been obtained from the individuals) and that such material should be removed before this dissertation is deposited in ORA.
4. I agree to be bound by the terms of the ORA Grant of Non-exclusive Licence [https://ora.ox.ac.uk/deposit_agreements] and I warrant that to the best of my knowledge, making my thesis available on the internet will not infringe copyright or any other rights of any other person or party, nor contain defamatory material.
5. I agree that my dissertation shall be available for download in ORA in accordance with paragraphs 2, 3 and 4 above.

Signed [an electronic signature is sufficient]:	
Date:	29 th August, 2024

**The Role of Implicit Learning in L2 Morphosyntax: An artificial-grammar
language learning experiment**



Yuqing Yang

Department of Education

Kellogg College

University of Oxford

Word Count: 19,892

Thesis submitted in partial fulfilment of the Degree of
Master of Science in Applied Linguistics and Second Language Acquisition

August 2024

Acknowledgements

My deepest gratitude goes first and foremost to Professor Victoria Murphy, my supervisor, for her constant encouragement, support and guidance. She carefully read the whole draft and offered painstaking and precious comments, which walked me through all the stages of this dissertation project. Her pursuits of academic excellence have impressed me deeply. Without her consistent and illuminating instructions, this dissertation could not have reached its present form. My research skills and critical thinking have improved a lot. I gradually pay more attention to asking myself 'so what' and remind myself to be a critical researcher, not a journalist. As always, I feel sincerely honoured to be Vicky's supervised student.

I am also greatly indebted to all the professors and teachers of the Department of Education at the University of Oxford, who have instructed and taught me a lot this academic year. When I was still a very ordinary student during my undergraduate study, I never imagined that I could study at the University of Oxford one day.

In addition, I would like to express my heartfelt gratitude to my beloved family for their loving consideration and great confidence in me during many difficult courses of this year. They always share my weal and woe. There were ups and downs this year. It's quite not easy but it's definitely a rewarding journey. Compared with my previous self who had not yet come to Oxford, I do feel that I'm growing up, like a tree, after getting through so many obstacles and puzzles.

Last but not least, thank you Sophie, Mr. Zhu, and Carl-Elias Goldberg.

Abstract

There is sustained interest in exploring implicit learning in second language acquisition (SLA). Previously, Williams and his colleagues (2004, 2005, 2009) demonstrated the involvement of implicit learning in grammatical form-meaning mappings. However, Hama and Leow (2010) revisited Williams' study, finding that participants failed to learn novel form-meaning connections implicitly. Additionally, Williams (2004) touched on the potential relationship between implicit learning and learners' gendered language background, but his later studies found no evidence for this relationship. In view of these conflicting results, the present study identified several methodological flaws of existing studies and modified the experimental design accordingly to probe into this topic in a more refined manner. The emphasis of this research lies in the role of implicit learning in the acquisition of L2 morphosyntax. Drawing on an artificial-determiner paradigm proposed by Williams (2005), this study worked with forty Chinese native speakers with English as their second language. All instructions and experimental materials were in English. Participants were introduced to four artificial articles: *gi*, *ro*, *ul*, and *ne*, which were taken as determiners to modify nouns. They were told that the determiner usage depended on whether the modified nouns referred to animals or humans. However, what was unknown to the participants was that *gi* was used to modify nouns related to predators, while *ul* was used to modify those associated with prey. Similarly, *ro* was accompanied by nouns of powerful roles, yet *ne* was for those denoting powerless roles (i.e. the hidden rule). The present study adopted a mixed method design to investigate the occurrence of implicit learning, L2 learners' consciousness of the hidden rule, and the relationship between consciousness and L2 learners' gendered language background. The results suggested that L2 learners could learn the hidden rule of the artificial-determiner system implicitly. Thirty-one of forty participants remained unaware of the hidden rule at the end of the experiment, but their accuracy rate of target items was significantly above the chance level. In general, the aware group outperformed the unaware group in the test task. L2 learners' consciousness of the hidden rule was found to be unrelated to their prior knowledge of gendered language. These findings supported the involvement of implicit learning in acquiring L2 morphosyntax, especially free grammatical morphemes. It would be advisable if L2 teachers could provide L2 learners with a supportive environment to promote implicit learning.

Table of Contents

Abstract	3
List of Tables	7
List of Figures	9
Chapter 1 Introduction	10
1.1 Research Background.....	10
1.2 Research Objectives	11
1.3 Research Questions	11
1.4 Research Significance	11
1.5 Structure of the Dissertation.....	12
Chapter 2 Literature Review	13
2.1 Implicit and Explicit Learning	13
2.1.1 Definition of Implicit Learning	13
2.1.2 Definition of Explicit Learning	14
2.2 Implicit and Explicit Knowledge	15
2.2.1 Definition of Implicit Knowledge	15
2.2.2 Definition of Explicit Knowledge	15
2.2.3 The Interface between Implicit and Explicit Knowledge	16
2.3 The Measurement of Implicit Learning.....	19
2.3.1 The Criteria for Implicit Learning	19
2.3.2 Artificial-grammar Learning Paradigm	20
2.3.3 Approach to Measure Implicit Learning: Verbal Reports.....	20
2.3.4 Approach to Measure Implicit Learning: Serial Reaction Time Task	21
2.4 Implicit Learning in Language Acquisition	22
2.5 Research Gap and Rationale for This Study	28
Chapter 3 Methodology	31
3.1 Sampling Frame	31
3.2 Pilot Study.....	32

3.2.1 The First Pilot Study	32
3.2.2 The Second Pilot Study.....	33
3.3 Participants	35
3.4 Materials	35
3.4.1 Determiners.....	35
3.4.2 Nouns Standardisation	36
3.4.3 Material Construction	36
3.5 Procedure	37
3.5.1 Consent Form.....	37
3.5.2 Demographic Information.....	38
3.5.3 Pretest.....	38
3.5.4 Determiner Pretraining.....	38
3.5.5 Training Task	39
3.5.6 Test Task: Forced Choice Test	40
3.5.7 Briefing Report	41
3.6 Ethical Considerations.....	42
3.7 Methodology Limitations	42
3.7.1 Inherent Limitations of the Artificial Grammar Paradigm	42
3.7.2 Potential Influence from Participants' Subjectivity	43
3.8 Analytical Strategy	43
Chapter 4 Results	45
4.1 Norming Study	45
4.2 Main Experiment.....	46
4.2.1 The Consciousness of the Hidden Rule	46
4.2.2 The Implicit Learning of the Hidden Rule.....	46
4.2.3 The Aware and Unaware Group's Performance Concerning Accuracy Rate.....	50
4.2.4 The Aware and Unaware Group's Performance Concerning Confidence Rate	51
4.2.5 The Aware and Unaware Group's Performance Concerning Reaction Time	57
4.2.6 The Relationship between Consciousness and Gendered Language Background.....	60

Chapter 5 Discussion62

5.1 The Implicit Learning of the Hidden Rule in the Artificial-determiner Experiment62

5.2 The Consciousness of the Hidden Rule.....65

5.3 The Differential Performance of the Aware and Unaware Group68

5.4 The Relationship between Consciousness and Gendered Language Background.....70

5.5 Pedagogical Implications70

5.6 Limitations71

5.7 Future Research Directions72

Chapter 6 Conclusion75

References78

Appendix A Statistical Power Calculation with G*Power.....94

Appendix B Recruitment Message95

Appendix C Demographic Information of Participants96

Appendix D The Experimental Materials Used in the First Pilot Study.....99

Appendix E Information Sheet and Consent Form for the Pilot Study100

Appendix F Information Sheet and Consent Form for the Norming Study.....104

Appendix G Information Sheet and Consent Form for the Main Experiment.....108

Appendix H Example of the Experiment.....110

Appendix I Ethical Approval113

Appendix J Results of the Norming Study114

List of Tables

Table 1 Key Characteristics of Implicit and Explicit Knowledge	16
Table 2 Demographic Information of Participants (The First Pilot Study)	96
Table 3 Demographic Information of Participants (The Second Pilot Study)	96
Table 4 Demographic Information of Participants (Main Experiment)	97
Table 5 Descriptive Statistics of Accuracy Rate (Unaware Group)	47
Table 6 Descriptive Statistics of Accuracy Rate (Aware Group)	48
Table 7 Paired Sample T-tests Results of Accuracy Rate (Unaware Group)	48
Table 8 No Correlation between the Accuracy Rate and Confidence Rate of Target Item	49
Table 9 Wilcoxon Signed-Rank Test Results of Accuracy Rate (Aware Group)	49
Table 10 Test of Homogeneity of Variances (Accuracy Rate)	50
Table 11 Mann-Whiney U Test Results of Accuracy Rate	51
Table 12 Descriptive Statistics of Confidence Rate (Unaware Group)	51
Table 13 Descriptive Statistics of Confidence Rate (Aware Group)	52
Table 14a, b Paired Sample T-test Results of Confidence Rate (Unaware Group)	52
Table 15a, b Pearson Correlation Test of Confidence Rate (Unaware Group)	53
Table 16a, b Paired Sample T-test Results of Confidence Rate (Aware Group)	54
Table 17a, b Pearson Correlation Test of Confidence Rate (Aware Group)	55
Table 18 Test of Homogeneity of Variances (Confidence Rate)	55
Table 19 Independent Sample T-test Results of Confidence Rate	56
Table 20 Descriptive Statistics of Reaction Time (Unaware Group)	57
Table 21 Descriptive Statistics of Reaction Time (Aware Group)	57
Table 22 Wilcoxon Signed-Rank Test Results of Reaction Time (Unaware Group)	58
Table 23a, b Spearman Test of Reaction Time (Unaware Group)	58
Table 24 Wilcoxon Signed-Rank Test Results of Reaction Time (Aware Group)	59

Table 25a, b Spearman Test of Reaction Time (Aware Group)60

Table 26 Chi-Square Test Result.....61

Table 27 Norming Study Results of Animal Word Items 114

Table 28 Norming Study Results of Human Word Items 115

List of Figures

Figure 1 A Sample Picture of Leung and Williams' Experiment.....	27
Figure 2 Flow Chart of the Experiment	37
Figure 3 Example of Practice before the Training Task.....	40
Figure 4 Percentage of Accuracy Rate.....	48
Figure 5 Percentage of Confidence Rate	52
Figure 6 Statistical Power Calculation with G*Power	94
Figure 7 Example of Pretest.....	110
Figure 8 Example of Pretraining Task	110
Figure 9 Example of Training Task.....	111
Figure 10 Example of Test Task.....	111
Figure 11 Example of Debriefing Report	112

Chapter 1 Introduction

1.1 Research Background

One can imagine a situation where skilled drivers are asked how to drive. They might find it difficult to describe such a complex set of motor skills in words. Despite having considerable driving experience, they are likely still unable to explain the exact physical movements and coordination necessary to accomplish this task (Hama & Leow, 2010). Scholars noticed this seemingly quasi-magical and inherently elusive phenomenon termed ‘implicit learning’ by Reber (1967). Implicit learning is not specific to motor skills. Children (seemingly) effortlessly acquire languages they are exposed to without awareness of grammar, but learning a second language for adults seems a notoriously time-consuming and complicated undertaking. In view of this, Dekeyser and Larson (2005: 34) stated that children seem ‘largely limited to implicit learning’, while adults may be ‘heavily limited to explicit learning’ (see also Mealor & Dienes, 2012). A long-standing debate has arisen about the rule of implicit learning in second language acquisition (SLA).

Schmidt (1990, 1994, 1995, 2001) proposed the Noticing Hypothesis with a contention that language features could be learnt only when they were consciously noticed. It also highlighted the facilitation of awareness in language learning. At the same time, Krashen (1981, 1982, 1985, 1992) argued that L2 development is primarily the result of unconscious acquisition processes, while conscious learning only monitors language outputs. Centred on this ongoing debate, a plethora of empirical studies have been conducted to examine the rule of implicit learning in SLA (e.g. Ellis, 2009; Erlam, 2024; Hulstijn, 2005; Yusuf, 2021). For example, Reber (1976, 1989, 1993; Reber et al., 1985, 1980) administered extensive experiments with artificial grammar, suggesting that individuals could learn the regularities underlying cooccurrence of forms (i.e., letter strings) without conscious effort. More recently, Williams and his coworkers (2004, 2005, 2009) provided positive evidence for the involvement of implicit learning in grammatical form-meaning mappings. However, Hama and Leow (2010) revisited Williams’ (2005) studies using think-aloud protocols, finding participants were incapable of implicitly acquiring form-meaning connections. It is not difficult to see that relevant

literature showed conflicting results on the function of implicit learning in SLA. Also, it remains to be determined what can and cannot be learnt implicitly and what factors might make some individuals more successful implicit learners than others (Williams, 2005).

1.2 Research Objectives

Under the aforementioned research background, the present study aims to investigate the involvement of implicit learning in L2 morphosyntax. The experiment draws on the artificial determiner paradigm developed by Williams (2005). A critical review of relevant literature has identified several methodological flaws in previous studies. Accordingly, this research implemented methodological improvements, in an attempt to experimentally reproduce the effects of implicit learning in SLA with more unambiguous evidence. Moreover, existing studies mainly focus on implicit learning of morphosyntax in native languages. This study sought to extend existing findings from the acquisition of native languages to second languages.

1.3 Research Questions

The specific research questions that motivated the present study were as follows:

- 1) Whether L2 learners can learn a hidden rule of an artificial-determiner system implicitly?
- 2) Whether L2 learners are aware of the hidden rule, and whether being aware has any differential impacts on their performance?
- 3) Whether L2 learners' consciousness of the hidden rule is related to their gendered language background?

1.4 Research Significance

Figuring out the role of implicit and explicit learning is essential to properly understand how L2 proficiency develops (Andringa & Rebuschat, 2015). Consequently, the present study potentially advances the knowledge of implicit learning in acquiring L2 morphosyntax, especially English

morphosyntax. With a mixed experiment design, the present study promoted a better understanding of the complex cognitive process of implicit learning. Also, it provides pedagogical insights on how to adjust instructional practices to maximise L2 learners' achievements.

1.5 Structure of the Dissertation

The Introduction Chapter presents the general research background and specifies the research objectives, research questions and research significance. Chapter 2 begins with definitions of the key constructs of implicit vs. explicit learning, implicit vs. explicit knowledge and their potential interface, followed by a critical review of closely related empirical studies. Methodological limitations of previous studies are pointed out and taken into full consideration in the experimental design of the present study. Chapter 3 elucidates the detailed methodology of the main experiment, in addition to reports on a stimuli norming study and two preliminary pilot studies. Chapter 4 presents qualitative and quantitative analyses of the gathered data. Chapter 5 discusses the results based on previous literature and highlights potential limitations, pedagogical implications, and future directions for further investigations.

Chapter 2 Literature Review

In this chapter, the oft-cited definitions of implicit and explicit learning as well as implicit and explicit knowledge will be introduced. Then, accounts are provided concerning debates on the interface between explicit and implicit knowledge, namely whether explicit knowledge can be converted into implicit knowledge and/or vice versa. Three positions will be discussed: non-interface position, strong-interface position, and weak-interface position. This is followed by elaborations on the measurement of implicit learning, covering the criteria for implicit learning, the introduction of artificial-grammar learning paradigm, and approaches to measure implicit learning (verbal reports and serial reaction time tasks). The last section mainly focuses on relevant studies on implicit learning in language acquisition. Williams' (2004, 2005, 2009) series of works and related studies will be critically reviewed in detail since the present study mainly draws on Williams' artificial determiner paradigm and implements several methodological adjustments to provide further compelling evidence on this topic.

2.1 Implicit and Explicit Learning

2.1.1 Definition of Implicit Learning

Arthur Reber (1967) first attempted to explain implicit learning as a process of acquiring complex knowledge through stimuli from environments in an unconscious and non-reflective way. He argued that the most distinctive characteristic of implicit learning is that learners are unaware of what they are actually learning. In other words, learners are likely unable to articulate the rules that control their behaviour but somehow nonetheless come to master them. Later, Ellis (1994, p.1) elaborated that implicit learning is the 'acquisition of knowledge about the underlying structure of a complex stimulus environment by a process which takes place naturally, simply, and without conscious operations.' Likewise, Frensch (1998, p.48) described implicit learning as the 'nonintentional automatic acquisition of knowledge about structural relations between objects or events'. Similarly, Saffran and his coworkers (1996) stressed the lack of explicit instructions or awareness when implicit learning occurred and an inability to articulate the learnt information. The term 'implicit learning'

then is commonly used to indicate the ability to extract regularities through automatic learning mechanisms without conscious awareness (Cleeremans et al., 1998).

2.1.2 Definition of Explicit Learning

As for the definition of explicit learning, Reber (1976) stated that explicit learning requires learners' intentional efforts in the learning process. Schmidt (1990) defined explicit learning as a learning approach that calls for selective attention to language rules and deals with the purposeful categorization of the rules. Ellis (1994, p.1) stated that explicit learning is 'a more conscious operation where the individual makes and tests hypotheses in a search for structure'. Dekeyser (1995) assumed that what made implicit learning different from explicit learning was the lack of awareness of what was being learnt by the learners. He pointed out that explicit learning involves explanations in instructions, or learners are required to make an effort to find out the rules by observing some particular forms (Dekeyser, 1995). Frensch and Runger (2003) later stressed that explicit learning is a learning process after which learners are conscious of what they have learnt. More recently, Hulstijn (2005, p. 131) defined explicit learning as 'input processing with the conscious intention to find out whether input information contains regularities and, if so, to work out the concepts and rules with which these regularities can be captured.' In contrast, implicit learning is 'input processing without such an intention, taking place unconsciously' (Hulstijn, 2005, p. 131). Generally, it is not difficult to see that most scholars distinguish implicit and explicit learning depending on whether subjects' awareness or consciousness are involved. It is important to note that implicit and explicit learning are not mutually exclusive. Mathews and his colleagues (1989) indicated that implicit and explicit learning are necessary to accomplish a complex task. Similarly, Ellis (2004, 2005b) and Dekeyser (2003) also reinforced the importance of combining explicit and implicit learning to promote language acquisition.

2.2 Implicit and Explicit Knowledge

2.2.1 Definition of Implicit Knowledge

Bialystok (1982) sketched implicit knowledge as an intuitive feeling about what is correct and acceptable, but the individual is unable to report freely the underlying rules. Following this, Mathews et al. (1989) emphasised that implicit knowledge was memory-based rather than rule-based since such kind of knowledge depended on memories of past experiences. Paradis (1994) stated that implicit knowledge was acquired occasionally, stored covertly, and used automatically. More recently, Ellis (2013, p. 36) defined it as ‘procedural, intuitive, automatic, and available in spontaneous or unplanned language use.’ He divided implicit knowledge into two types: formulaic knowledge and rule-based knowledge (Ellis, 2013, p. 37). Formulaic knowledge refers to internalized chunks, such as ‘good morning’ and ‘see you later,’ to name a few. Rule-based knowledge is internalized knowledge about rules, for example, adding -ed to verbs in the past tense or adding -s/-es to verbs in the third person.

2.2.2 Definition of Explicit Knowledge

Ellis (1993) stated that explicit knowledge is the learners’ conscious knowledge and learners know that knowledge. Similarly, Paradis (1994) indicated that individuals could learn and verbalise explicit knowledge when necessary. Roehr (2008) described it as declarative and conscious knowledge that can be accessed mainly through controlled cognitive processing. More recently, Ellis (2013) classified explicit knowledge into metalanguage and analysed knowledge. Metalanguage refers to L2 learners’ metalinguistic awareness of second language usage, while the analysed knowledge represents the knowledge to be learnt through instructions or observations (Ellis, 2013). In brief, explicit and implicit knowledge is commonly associated with effortful and automatic processing respectively (Hasher & Zacks, 1979; Segalowitz, 2003; Segalowitz & Hulstijn, 2005). Implicit knowledge is ‘intuitive and procedural’, which is accessed automatically, while explicit knowledge is ‘conscious and declarative’ and might be accessed via controlled processing (Roehr, 2008, p.69). Anderson and Lebiere (1998) emphasised that the distinctions between explicit and implicit

knowledge lie in the extent to which one has awareness of the underlying regularities and to what extent one can verbalise these regularities (see also Ellis, 2004), where lack of awareness or ability to verbalise is more associated with implicit knowledge while having awareness and ability to verbalise is more associated with explicit knowledge. Ellis (2005a, p.151) provided a more systematic summary of the key characteristics of implicit and explicit knowledge (see Table 1).

Table 1. Key Characteristics of Implicit and Explicit Knowledge (Ellis, 2005a, p.151).

The figure originally presented here cannot be made freely available via ORA because of copyright.
The figure was sourced at Ellis, R. (2005a). Measuring implicit and explicit knowledge of a second language: A psychometric study. *Studies in Second Language Acquisition*, 27(2), 141-172.

2.2.3 The Interface between Implicit and Explicit Knowledge

One of the heated debates in SLA concerns the interface between implicit and explicit knowledge. So far, no consensus has been reached concerning whether explicit knowledge can be transferred into implicit knowledge and/or vice versa. In general, there are three positions regarding the relationship between implicit and explicit knowledge: the non-interface position, the strong position, and the weak interface position.

The non-interface position argues that there is no relationship between explicit and implicit knowledge, and they cannot be converted to each other, in essence, there is no interface between the two. Krashen (1981) is one of the representatives of the non-interface position, who put forward a

distinction between ‘acquisition’ and ‘learning.’ He held that conscious learning and unconscious acquisition were independent mechanisms in the process of SLA. In other words, acquired implicit knowledge is separated from learnt explicit knowledge. It is not possible to realise transformations between implicit and explicit knowledge (Krashen, 1981). Krashen believed that explicit knowledge only served as a monitor in language production to check whether outputs were correct. Likewise, Zobl (1995) and Hulstijn (2002) supported the non-interface position, stating that implicit and explicit knowledge were different constructs and could not be influenced by each other. Later, Ullman (2001, 2004, 2016) proposed a declarative/procedural model, proposing that implicit and explicit knowledge were stored in different brain areas. Specifically, implicit knowledge works as ‘mental grammar subserved by procedural memory, rooted in left frontal/basal-ganglia structures’ (Ullman, 2001, p. 42). Nevertheless, explicit knowledge functions as a mental lexicon relying on ‘declarative memory, rooted in temporal lobe structures’ (Ullman, 2001, p. 105). Additionally, mental grammar involves acquiring motor and cognitive skills, whereas mental lexicon concerns the use of fact and experience (Ullman, 2004). This neuroscientific evidence lent support to the disassociation between implicit and explicit knowledge.

In contrast to the non-interface position, the strong interface position insists that the two kinds of knowledge are convertible to each other. Explicit knowledge can derive from implicit knowledge, while explicit knowledge can also be transferred into automatic and intuitive knowledge through considerable practice (DeKeyser, 1998). This position, based on Anderson’s Skill Acquisition Theory, asserts that language acquisition is fundamentally the same process as that of acquiring skills (Anderson, 1982). Anderson (1982) claimed that the acquisition of a skill follows a certain development process, from an initial representation of knowledge through changes in behaviour to eventual spontaneous and largely effortless habit (see also VanPatten & Williams, 2015). Dekeyser (2003, 2007), an advocate of the strong-interface position, claimed that language acquisition as a skill needs to go through three stages: declarative knowledge, procedural knowledge, and eventually transform to automatic acquisition of language. Declarative knowledge refers to knowledge about stating facts and rules, while procedural knowledge is about the ability to do something (Dekeyser,

2003, 2007). Declarative knowledge is additive, while procedural knowledge is integrative. For example, if someone has no idea about how to ride a bicycle, no matter how much declarative knowledge regarding riding, it will not be enough to acquire riding skills. What is needed is the ability to ride (namely procedural knowledge) through repeated practice. People might forget the declarative knowledge about riding more easily since it is additive, but the retention of procedural knowledge (i.e. the ability to ride a bicycle in this case) may remain in the long term due to its integrative properties. In addition to Dekeyser, Stevick (1974) and Bialystok (1985) are also proponents of the strong-interface positions, claiming that explicit and implicit knowledge can be mutually converted.

The language development of L2 learners does not always follow the expected path such as the strong-interface position states. Rod Ellis (1993) put forward the weak-interface position, declaring that explicit knowledge can be transformed into implicit knowledge under certain restrictive conditions. This position maintains that only when learners are developmentally ready to acquire linguistic form can their explicit knowledge possibly be converted into implicit knowledge through considerable practice. That is to say, learners need to monitor their language outputs to check errors, correct them, and then practice repeatedly. Only in this way does the explicit knowledge get consolidated and gradually evolve into implicit knowledge. The weak-interface position distinguishes between language input, language intake, and implicit knowledge (Ellis, 1993, p. 98). According to Ellis' model (1993), language input represents actual L2 utterances in communications, whereas language intake emphasises the linguistic features within language inputs that learners have noticed. Language intake, the extracted linguistic features, contributes to the acquisition of implicit language knowledge. Additionally, Ellis (1994, 2004) emphasised the complementary relationship between implicit and explicit knowledge. Explicit knowledge enables learners to pay more attention to the forms of language inputs, which is conducive for learners to notice the gap between the language inputs and their outputs. In this way, explicit knowledge indirectly facilitates the intake and acquisition of implicit knowledge.

2.3 The Measurement of Implicit Learning

2.3.1 The Criteria for Implicit Learning

Three criteria are generally used to assess implicit learning. The zero-correlation criterion posited that implicit learning occurred if participants' confidence rate in their answers was unrelated to their precision (Dienes & Berry, 1997). The guessing criterion upheld the occurrence of implicit learning if participants' accuracy rate in a grammaticality judgement test was significantly above the chance level, although they believed they were literally guessing at the answers randomly (Cheesman & Merikle, 1984). However, Dienes and Scott (2005) criticised the above two criteria that merely assessed the consciousness of judgment knowledge, that is, knowledge about whether particular test items share similarities with training items. Yet, they were not sensitive enough to tap into the conscious status of structural knowledge, that is the knowledge of the underlying rule governing the test items. Based on the distinction between judgment knowledge and structural knowledge, Dienes and Scott (2005) put forward a third measurement criterion called trial-by-trial structural knowledge attributions. It requires participants to reflect on their decision basis in every trial. There are four attributions: 'Guess' means that participants have no idea about the question, so they choose either option at random; 'Intuition' means that participants have some confidence but are unable to say why it is right; 'Memory' means that participants' judgements are based on a recollection of training items; 'Rules' means that participants make a judgement based on some rules they have found in the training task and can articulate the rule if asked. 'Guess' and 'intuition' attributions are treated as evidence for the unconsciousness of structural knowledge, whereas 'rule' and 'memory' attributions are in favour of consciousness of structural knowledge. Since proposed by Dienes and Scott (2005), numerous empirical studies have demonstrated the trial-by-trial knowledge attribution as a sensitive assessment of knowledge consciousness (e.g. Fu et al., 2010; Li et al., 2013; Norman et al., 2019; Rebuschat, 2008; Wan et al., 2008). In this regard, the present study integrates the three criteria to examine implicit learning in an artificial-grammar learning experiment, which has been extensively adopted in the relevant literature (e.g. Batterink et al., 2015a, b, Scott & Dienes, 2008; Tunney & Altmann, 2001).

2.3.2 Artificial-grammar Learning Paradigm

The artificial-grammar learning paradigm has been extensively used in previous studies to probe into implicit and explicit learning (e.g. Bovolenta & Marsden, 2024; Liu et al., 2023; Reber, 1967, 1978, 1989, see Fitch & Friederici, 2012 for a review). This paradigm commonly consists of two parts: an exposure phase and a testing phase (Holly, 2022). In the exposure phase, participants are presented with a series of stimuli, typically auditory or visual, and certain hidden rules govern these stimuli. Participants might be asked to interact with these stimuli but are not informed about the presence of any underlying rules. After that, a test task is conducted to measure participants' respective responses to 'grammatical' (i.e. following the same rules as in the exposure phase) or 'ungrammatical' (i.e. violating the rules as in the exposure phase) items to examine whether implicit learning has occurred (Knowlton & Squire, 1996, p. 170, see also Reber, 1993, p. 21). Different responses to the grammatical trials compared to ungrammatical ones may be taken as evidence that participants have acquired the hidden rule during the initial exposure phase. However, their inability to report the acquired rules further supports the idea that implicit learning works in this process, rather than explicit learning (Dienes & Berry, 1997). Taking a seminal study as an example, Saffran et al. (1996) utilised a preferential staring time task to demonstrate that 8-month-old infants could accomplish word segmentation within a fluent speech stream based solely on statistical regularities between neighbouring speech sounds. In this experiment, twenty-four 8-month-old infants were exposed to a 2-minute continuous speech stream comprising four three-syllable nonsense strings repeated randomly. As the infants habituated to these stimuli, they were presented with familiar and unfamiliar orderings of the three-syllable strings. It was found that infants showed significantly longer staring times for strings in the order that had not appeared before. This 'dishabituation effect' demonstrated that 8-month-old infants could extract the statistical serial-order information and implicit learning occurred (Saffran et al., 1996, p. 1927).

2.3.3 Approach to Measure Implicit Learning: Verbal Reports

The aforementioned criteria for implicit learning determine to what extent implicit learning can be

recognised, and then this section expounds on relevant approaches serving as vehicles to measure implicit learning. Verbal reports, as a predominant approach to testing the consciousness of learning, have been widely deployed in explorations on implicit learning (e.g. Frensch et al., 2003; Green & Shanks, 1993; Moroshkina et al., 2019). Generally, participants were asked to verbalise their cognitive processes during the training and test phase to examine their awareness of learning (Ericsson & Simon, 1993). Leow (1997) pioneered utilising verbal reports to tap into implicit learning. His studies focused on irregular (stem-changing) verbs in Spanish. Participants were exposed to exemplars in the context of crossword puzzle tasks and were asked to think aloud throughout the experiment. Half of the participants verbally reported noticing the peculiar form change in critical items, subsequently showing significantly higher accuracy rates in recognition and production posttest than in a pretest. On the contrary, without noticing the stem change in verbs, the remaining participants showed no significant difference between their pretest and posttest scores. Based on these findings, this research concluded that there was no learning in the absence of focal attention. More recently, Hama and Leow (2010) employed verbal reports (i.e. think-aloud protocols) to gather concurrent data at the encoding stage and measure participants' awareness of learning (This study will be further discussed in Chapter 5 Discussion). The concurrent data gathered showed no implicit learning occurred among unaware learners when exposed to determiner-noun combination trials. Nevertheless, it should be noted that verbal reports have also been criticised due to their potential influence on the alteration of learners' internal cognitive processes (Ellis, 2001).

2.3.4 Approach to Measure Implicit Learning: Serial Reaction Time Task

Another popular approach to measure implicit learning is the Serial Reaction Time task (e.g. Nissen & Bullemer, 1987; Fu et al., 2008; Jenkins et al., preprint). The serial reaction time task is a variant of the Contextual Cueing Paradigm developed by Chun and Jiang (1998) and the Derived Attention Paradigm of Lambert and his coworkers (Lambert & Sumich, 1996; Lambert, 2003). These paradigms claim that contextual regularities can facilitate the identification of a particular pattern by implicitly directing attention toward the target (Peterson & Kramer, 2001). A contextual cueing effect could be manifested by a significantly reduced reaction time to detect targets in a predictive

trajectory than those presented in a nonpredictive way. Subjects are rarely able to report having noticed contextual regularities, although contextual cueing effects can be observed. Another way to demonstrate the unconsciousness of learning is to let subjects perform a recognition task immediately after the target-searching task. Implicit learning is generally evident if subjects cannot differentiate between predictive and nonpredictive trials (Chun & Jiang, 1998, 2003). For example, Leung and Williams (2011, 2012) adopted the serial reaction time task to investigate implicit learning of grammatical form-meaning connections (which will be briefly introduced here and further reviewed in the next section). Thirty-three English native speakers engaged in a task to learn four novel articles but were not explicitly told the governing rule. They were asked to click a serial mouse to indicate which of the two displayed pictures was in line with an article-noun auditory description. Accuracy feedback would be provided. It was found that participants' response time significantly slowed when the agreement rule was violated despite no reported awareness of the regularity. These results lent support to the occurrence of implicit learning in grammatical form-meaning mappings. It is admitted that the serial reaction time task is a concurrent measure of implicit learning compared with post-training grammaticality judgment tests. However, caution should be exercised not to blindly overstate the adaptability of the serial reaction time task since it has been proven to be inflexible and context-specific (Vaquero et al., 2006). To some extent, this approach might not be well-suited to internet-based remote experiments where worldwide participants characterise diverse contexts.

2.4 Implicit Learning in Language Acquisition

It has been commonly recognised that most rules underlying native languages are learnt implicitly (Arciuli, 2018). When children acquire their mother tongue, they master the rules and characteristics of the language in an unconscious state. (Dienes, 2012). Relevant literature mostly revolves around three empirical questions (Andringa & Rebuschat, 2015). The first one concerns the role of awareness in language acquisition and the possibility of learning without awareness (e.g. Leow, 2000; Leow & Hama, 2013; Schmidt, 1990, 1995, 2001). The second question is about how to measure awareness. Previous studies mainly focus either on the process-based measurement of awareness (i.e.

while participants are exposed to a series of stimuli, e.g. Godfroid et al., 2015; Grey et al., 2014; Leow et al., 2014) or on the product-based measurement of awareness (i.e. what has been learnt, e.g. Hamrick & Rebuschat, 2012; Rebuschat, 2013). The third question deals with the implicit-explicit interface (i.e. whether explicit and implicit knowledge can be transformed mutually, e.g. Esteki, 2014, Kim & Godfroid, 2023; Valentin & Ellis, 2015, see Andringa & Rebuschat, 2015 for a review).

A pioneering study by Reber (1976) had participants learn complex letter strings (e.g. MXRMXT, VMTRRR) governed by an artificial grammar. These participants could distinguish between strings that accorded or broke the underlying grammar rules but were unable to verbalise their reasoning, demonstrating that they unconsciously acquired the underlying regularities during exposure. A following study by DeKeyser (1995) employed a miniature artificial language with rich inflectional morphology to shed light on the role of implicit learning in morphosyntax. In the training phase, 61 participants were asked to finish a sentence-picture matching task and indicate whether a given sentence correctly described a displayed picture. In the test phase, participants were presented with a series of pictures and required to type correct sentences to describe in the miniature artificial language. The results suggested that participants' performance was at chance in the production test, lending support to the necessity of attention to morphosyntactic form and meaning for learning. Up to now, a multitude of studies have explored the role of implicit learning in various aspects of language acquisition (e.g. Bell, 2017; Conway, 2020; Williams & Rebuschat, 2016; see VanPatten & Smith, 2022 for a review). Implicit learning appears to work in different levels of language processing (Romberg & Saffran, 2010). At a lower linguistic level, language learners implicitly apply transitional probabilities when dealing with speech sounds (e.g. Frost & Monaghan, 2016). At a higher level, implicit learning also contributes to the acquisition of syntactic structures (Thompson & Newport, 2007), the long-term storage of syntactic structure (Kidd, 2012), and the understanding of pragmatic utterances (Thothathiri & Rattinger, 2016).

Williams and his colleagues conducted a series of studies on the ability to acquire novel form-

meaning mappings implicitly (e.g. Williams, 2004, 2005; Leung & Williams, 2011). This section will critically review Williams' well-conceived studies since the present study mainly draws on his artificial determiner paradigm with methodological modifications. Williams (2005) exposed 41 participants to four artificial determiners (*gi*, *ro*, *ul*, and *ne*) and English word lists. Participants were instructed that the four determiners were used to modify nouns and encoded distance: *gi* and *ul* were used to represent near objects, while *ul* and *ne* were used for far objects. Unbeknownst to the participants, the usage of these four determiners also depended on the animacy of modified words: *gi* and *ul* were used with animate objects, whereas *ro* and *ne* were used with inanimate objects. In the training task, 24 nouns, which were clear cases of animate or inanimate objects, were built-in sentence contexts to clarify how far away the object was in the situation described. Participants were told to a) listen to each sentence with target words included and press the appropriate keys to indicate whether it means 'near' or 'far'; b) after listening to each sentence, repeat it exactly aloud; c) form a mental image of the general situation described by the sentence. A sentence completion task was employed in the testing phase which allowed participants to choose a noun phrase that seemed 'more familiar, better, or more appropriate' from two alternatives. At last, retrospective verbal reports were used to test participants' awareness of the hidden rule of animacy. It was found that participants were significantly more likely to select determiners according to the hidden rule of animacy even if they were completely unaware of its relevance to determiner usage.

It cannot be denied that Williams' (2005) seminal work provided valuable insights into the involvement of implicit learning in grammatical form-meaning mappings supported by robust empirical evidence. However, there are two notable limitations in his methodology meriting further consideration. Firstly, participants were not pre-screened on the experimental materials, that is the selected noun phrases and contextual sentences. This might bring a confounding effect that participants' mistaken choices or poor performance are possibly due to their unknowingness of the meaning of the presented words or sentences, rather than their failure to catch the hidden rule. In this way, implicit learning might have occurred but not been captured by the test task. The other limitation concerns participants' diverse language backgrounds. According to the researcher's report,

participants' L1s were 'Cantonese (n=1), Dutch (n=1), Greek (n=4), Mandarin Chinese (n=1), Portuguese (n=1), Serbian (n=4), Slovenian (n=1), and Taiwanese (n=1)'. Apart from English, the L2s known by the participants to an intermediate level or better include 'Cantonese (n=1), French(n=23), German (n=15), Greek (n=1), Ancient Greek (n=1), Hokkien (n=2), Italian (n=5), Japanese (n=1), Latin (n=6), Malay (N=1), Mandarin (n=3), Russian (n=1), Serbian (n=1), and Spanish (n=3)'. It is acknowledged that determiners are not necessary when communicating in Mandarin. Determiners in English, like 'the' or 'a/an' only serve as function words without carrying on categorical meanings. However, determiners in gendered languages like German, French or Russian are not only function words but also imply gender information for the following nouns. This means that participants with gendered language as their L1 or L2 are highly likely to have prior knowledge or at least a metalinguistic subliminal perception that the four novel determiners introduced in Williams' (2005) experiment might carry some potential semantic information, which is not in this case for their counterparts like English or Mandarin Chinese native speakers. Given this, prior knowledge of such gendered language systems possibly facilitates participants' implicit learning and leads to a greater possibility of detecting the hidden rule in Williams' (2005) experiment. Indeed, Williams (2005) reported that participants who spoke a gendered L1 or L2 did better than those who did not, and even implicit learning was weakly correlated with the number of gendered languages known. In a similar vein, the gendered L1 effect was also found in Williams' (2004, Experiment 1), and implicit learning was proved to be significantly correlated with the number of gendered languages known. All in all, the participants' diverse language backgrounds potentially exerted great influence on the research findings regarding implicit learning.

Later on, Chen (2011) confirmed Williams' (2005) findings with Chinese noun phrases as experimental materials. Also drawing on Williams' artificial determiner language paradigm, the researcher worked with forty Chinese native speakers with English as their second language. All experimental instructions and materials were changed into Chinese versions. The original four novel English determiners 'gi, ul, ro, ne' were modified into Chinese ones in this experiment, namely '丕, 央, 疋, 毛'. There were 48 training items and 32 test items, all of which were Chinese noun phrases.

Consistent with Williams' (2005) experimental design, participants were informed that the four determiners were used depending on the distance rule but unknown to the hidden rule of animacy. In the training phases, training items were presented in the context of sentences to indicate far or near situations. Participants were instructed to read each sentence aloud and press corresponding keys to respond regarding the distance of the given noun phrase as accurately as possible. After the training task, participants were tested on the hidden rule of animacy using a sentence completion task. Participants needed to choose one of two options that seemed more suitable for the sentence context and indicated the basis for their decision (guess, intuition, memory or rule) in every trial. The results showed that their performance was significantly better than the chance level while only one participant appeared to be aware of the hidden rule.

When reviewing Williams' (2005) study in the previous section, it is mentioned that the participants recruited in his study characterised diverse language backgrounds, serving as a potential confounding variable undermining the reliability of experimental results. Compared with Williams' (2005) study, Chen's (2011) study contributed to this topic with particular attention to unifying participants' language backgrounds, namely all are Chinese native speakers with English as their second language. Nevertheless, it would be more advisable if William and Chen conducted a stimuli norming study with an independent sample to ensure that the contextual sentences used exactly displayed the far/near situation to participants. For example, one of the sentences used by Williams is 'In the pub I asked my friend to get *ne* stool from the bar'. Another one used by Chen is 'A wolf wants to eat a *chu* (犬) bird on the tree'. Participants might have disputes regarding the distance of the '*ne* stool' or '*chu* bird' described in these sentences. This ambiguity perhaps turns out to be another confounding variable in the measurement of participants' explicit and implicit learning. Considering this, a norming study will ensure the validity of experimental materials and yield more compelling evidence.

A further study by Leung and Williams (2011) also supported Williams' (2005) findings. In this study,

participants were exposed to a similar artificial determiner system as Williams (2005) with minor changes in the usage of the four determiners (*gi*, *ro*, *ul*, and *ne*). Before the experiment, participants were told that *gi* and *ro* were used with personal names referring to adults, whereas *ul* and *ne* were accompanied by personal names referring to children. What was not told to participants was that the usage of determiners also depended on the thematic role of the noun phrase: *gi* and *ul* were for agents, while *ro* and *ne* were for patients. In the experiments, each trial consisted of a distinct picture displayed on screens in every trial with an auditory description. For example, Figure 1 shows a girl kissing a boy on the cheek with an accompanying auditory description like ‘Kiss *ul* Mary a boy on the face’. Participants needed to indicate the location of the named individual in the picture (left or right) by pressing the appropriate response key as soon as possible. There were 130 trials in total, consisting of 114 trials that followed the artificial determiner rules outlined above, and the following 16 trials violated the rules. Implicit learning was assessed by measuring participants’ reaction time in different trials. Finally, verbal reports were adopted to evaluate participants’ consciousness of potentially acquired knowledge. The results revealed that 80% of participants remained unaware of the hidden rule governing determiners at the end of the experiment. However, their response time to locate the named individual slowed significantly in the final 16 violation trials, suggesting that they implicitly acquired the relationship between the artificial determiners and the thematic roles.

Figure 1. A Sample Picture of Leung and Williams’ (2011) Experiment.

The figure originally presented here cannot be made freely available via ORA because of copyright.
The figure was sourced at Leung, J. H., & Williams, J. N. (2011). The implicit learning of mappings between forms and contextually derived meanings. *Studies in Second Language Acquisition*, 33(1), 33-55.

Indeed, Leung and Williams' (2011) study provided more solid evidence for the role of implicit learning in form-meaning mappings, given the researchers assessed participants' implicit learning by means of a novel process-based reaction time task. However, this experiment explicitly operationalised the four determiners based on whether the modified personal names represented adults or children. It seems controversial and greatly susceptible to participants' subjective preference on whether a personal name refers to adults or children. Buscholtz and Hall (2005) highlighted that the perception of a name could vary significantly depending on the listeners' cultural norms, personal experiences and social status. In this regard, this explicit rule of artificial determiners utilised seems not to be appropriate. It might be more plausible to employ a more objective criterion as the explicit rule to distinguish four determiners, such as *gi* and *ul* are used for nouns referring to animals and *ro* and *ne* are used for those referring to humans.

2.5 Research Gap and Rationale for This Study

After a critical review of existing studies, their methodological flaws have been clearly identified and will be fully considered in the present study. Furthermore, previous investigations are mainly devoted to shedding light on the role of implicit learning in native languages. Williams' significant studies worked with English native speakers with experimental materials in English. Similarly, Chen (2011) tested the implicit learning of Chinese native speakers when confronted with Chinese noun phrases as training and testing items. So far, few empirical studies have systematically investigated the implicit learning of L2 morphosyntax, and among these, the experimental results are mixed. The essential role of implicit learning in SLA has been repeatedly stressed (Pajak et al., 2016). It has been well established that native language acquisition mostly relies on implicit learning, whereas the SLA resorted to both explicit and implicit learning (Dekeyser, 2003; Krashen 1982). Considering this, it is imperative to pay more attention to the involvement of implicit learning in SLA. Thus, this research recruited Chinese native speakers with English as their L2 in an attempt to test the presence of implicit learning when they were exposed to L2 stimulus (i.e. English in this case).

This study draws on Williams' (2005) artificial determiner paradigm but characterises several methodological improvements. An important issue in all relevant literature on implicit learning concerns whether the tests of awareness adopted are sensitive enough (Leung & Williams, 2011). In experimental design, the researcher has comprehensively considered possible measures of implicit learning, including artificial-grammar learning paradigm, serial reaction time tasks, grammaticality judgement tasks, think-aloud protocols and post-task debriefing reports. As mentioned above, the sensitivity of serial reaction time tasks as a measurement largely relies on located contexts (Vaquero et al., 2006). Given this experiment was performed entirely online and the participants' surrounding contexts were out of control, the sensitivity of serial reaction time tasks is likely to decline in this case.

Moreover, this experiment requires participants to read sentences aloud in training tasks to consolidate their short-term memory, making it impossible for them to verbalise their cognitive process and read sentences aloud simultaneously. In brief, that is why serial reaction time tasks and think-aloud protocols, the seemingly more sensitive approaches, may not be the most optimal methodology in this research. Thus, this experiment follows the artificial grammar learning paradigm, a grammaticality judgment task and a debriefing report. Undeniably, debriefing reports have been criticised for sensitivity issues, as Berry and Dienes (1993) claimed that participants' glosses may not be accurate in detail when reporting their subjective states at the end of an experiment. This study combined trial-by-trial subjective measures with post-task debriefing reports to address this point. A multitude of empirical evidence has been presented in favour of combining them for better validity (e.g. Ziori & Dienes, 2006; Scott & Dienes, 2010a, 2010b). Also, this combination will make it possible to assess varying levels of participants' awareness, such as distinguishing their awareness at the level of 'noticing' from the level of 'understanding' (cf. Schmidt's Noticing Hypothesis, Schmidt, 1990, 1993, 2001).

Taken together, the present study sheds light on the role of implicit learning in L2 morphosyntax based on the artificial-grammar learning paradigm. After a critical review of relevant literature and comprehensive considerations of potential measures of implicit learning, a series of methodological changes have been implemented in this study to bear more robust empirical evidence on this topic. The mixed research design with both quantitative and qualitative analysis provided rich sources of data to elaborate on the presence or absence of implicit learning in L2 morphosyntax.

Chapter 3 Methodology

Drawing on the artificial-determiner paradigm of Williams (2004, 2005), this study employed a mixed method to shed light on the phenomenon of implicit learning of L2 morphosyntax. The entire experiment consisted of five parts: pretest, pretraining, training, testing and a debriefing report. In the quantitative data, the variables of interest include accuracy rate, confidence rate, and reaction time. The variables involved in qualitative data are consciousness of the hidden rule and prior knowledge of gendered languages (i.e. gendered language background). Based on quantitative and qualitative evidence, this experiment attempts to investigate whether L2 learners can implicitly learn a hidden rule of an artificial-determiner system, whether L2 learners being aware of the hidden rule has any differential impacts on their performance in the test task, and whether L2 learners' consciousness of the hidden rule is related to their gendered language background.

3.1 Sampling Frame

A statistical power calculation was conducted using G*Power 3.1 to decide the sample size of this study. According to Cohen (1977), a threshold of power should be set to forestall rejecting the null hypothesis incorrectly (type I error, α), or falsely accepting the null hypothesis (type II error, β). The power analysis suggested that a minimum of 37 participants would be required to achieve 95% power at the $\alpha = .05$ level [$(1-\beta) = .95$] for the main effects (see Appendix A). Forty participants were therefore invited to the main experiment

The present study comprised two pilot studies, a stimuli norming study and a main experiment. There were 40 participants involved in the two pilot studies (20 participants each). These participants were recruited through the social media of WeChat (see Appendix B). The researcher noticed that the disappointing results of pilot studies to some extent attributed to some participants' not serious attitude to the experiment. In addition, there seems to be a potential sample bias since all these participants were postgraduate students from the University of Oxford community. Considering this,

the participants for the following norming study and main experiment were recruited through Prolific (<https://www.prolific.com>), an online platform for participant recruitment. This platform allows the researcher to monitor and review gathered data so as to exclude unreliable responses. Under the premise of inclusion criteria, recruiting participants through Prolific ensures that the sample is more representative of broader populations which enhances the generalisability of experimental findings (Cook & Campbell, 1979).

3.2 Pilot Study

3.2.1 The First Pilot Study

Twenty participants were recruited in the first pilot study (6 males and 14 females, average age=23, SD=1.95, demographic information displayed in Appendix C, Table 2). The inclusion criteria for recruitment were the same as those in the main experiment (see Section 3.3. Participants). Originally, the present study aimed to investigate whether L2 learners could implicitly acquire word form-metaphorical meaning mappings. Participants were instructed to learn four artificial articles: *gi*, *ro*, *ul*, and *ne*. They were told that the four artificial articles were used as determiners to modify nouns and the usage depended upon the animacy of the accompanying noun: *gi* and *ul* were used for animate objects (e.g. cat), while *ro* and *ne* were used for inanimate objects (e.g. door). Unbeknownst to the participants, however, *gi* and *ro* were used to modify high objects in space (e.g. sky), while *ul* and *ne* were used before spatially low objects (e.g. ground). The experimental procedure was similar to the main experiment except for the pretest phase (see Section 3.5 Procedure). It was expected to test whether participants would unconsciously tend to use *gi* and *ro* (articles for high objects) before nouns referring to powerful social rules, while *ul* and *ne* (articles for low objects) before nouns referring to powerless social rules. If so, the participants' accuracy rate of test items would be significantly above the chance level (50%) although they believed that they were guessing to make a choice all the time. Unexpectedly, the results showed that no one became aware of the hidden rule and the accuracy rate of these unaware participants was significantly below the chance level ($p < .05$).

The surprising results are perhaps ascribed to the complexity of the test task. Ideally, participants were not only required to implicitly acquire the hidden rule about highness but also to apply this implicitly acquired hidden rule in a metaphorical context. In addition, the selected nouns were metaphors in the participants' second language. It has been acknowledged that it took some time for L2 learners to learn more figurative aspects of second languages, like metaphors (e.g. Boers, 2000; Danesi, 1995; Lazar, 1996; Littlemore & Low, 2006). Indeed, even L1 metaphors emerge later in children's linguistic development (Gardner, 1974; Gentner, 1988; Gibbs, 1994; Winner, 1979; Vosniadou & Ortony, 1983). Therefore, it seemed not surprising that the participants were struggling to make these connections after limited exposure in such a short time. Moreover, it was found that disputes existed among participants with respect to whether a referent was a high object or not, such as a ceiling or tower (see Appendix D for experimental materials utilised in the first pilot study). To make it more feasible and manageable, this study was simplified to focus on the implicit learning of L2 literal form-meaning mappings.

3.2.2 The Second Pilot Study

Later, the second pilot study was carried out with a streamlined experiment. Another twenty participants were invited for the second pilot study (1 male and 19 females, average age=25.55, SD=2.72, demographic information displayed in Appendix C, Table 3). Participants involved in the first pilot study were not included in the second pilot study. The inclusion criteria of recruitment remained unchanged (see Section 3.3. Participants). The purpose of the updated experiment is to narrowly investigate the role of implicit learning in the acquisition of L2 morphosyntax. Drawing on a similar artificial-determiner paradigm, the participants were still introduced to four novel articles used as determiners to modify nouns: *gi*, *ro*, *ul*, and *ne*. Notwithstanding, participants were informed that the determiner usage depended on whether the referents of modified nouns were animals or human: *gi* and *ul* were used for nouns referring to animals, while *ro* and *ne* were used for human referents. The hidden rule was that *gi* was used for nouns of predators, while *ul* was used for those of prey. Likewise, *ro* modified nouns of powerful social roles, yet *ne* was for those representing powerless social roles. The experimental procedure was the same as the main experiment apart from

the pretest phase (see Section 3.5 Procedure). Similar to the first pilot study, it was expected that even if participants remained unaware of the hidden rule, their accuracy rate in the test task was significantly above the chance level. Indeed, the results were consistent with the predictions ($p < .05$).

The experimental design has been fine-tuned for more robust evidence. In the questionnaire to collect demographic information, the question ‘knowledge of any other language’ used to be required to be filled in, which changed into an optional question since some participants may only know English as their second language. Apart from that, participants were not only asked to specify languages but also needed to report proficiency in the updated version. A pretest was added before pretraining to review all selected nouns which would be used as training and test items later. This was to guarantee participants fully understood the meaning of all items in case they showed poor performance because they were unknown of the word meaning rather than they did not grasp the hidden rule. In the training task, participants would be clearly informed that they would not be recorded as they read aloud the words. In the test task, the confidence rating was changed from a discrete scale (i.e. 50%, 60%, 70%, 80%, 90%, 100%) to a continuous scale (i.e. 50%-100%) for statistical analysis. The decision basis question was changed to accept multiple choices in that several participants from the second pilot study reflected that they probably had two or more decision bases when making a judgement. In the pretraining and test tasks, the position of correct answers from two alternatives used to be fixed (on the left side or the right side) across participants. It was changed to be entirely randomised across trials and participants. What’s more, there used to be only one practice trial in the pretraining, training and test tasks. Participants generally expressed that one practice trial was seemingly not enough for them to get on track. Thus, two more practice trials were added (three in total) in the pretraining, training, and test tasks independently. In brief, the foregoing adjustments in experimental design hopefully enhanced the reliability and validity of the findings drawn from the ensuing main experiment.

3.3 Participants

There were 40 participants included in the main experiment (15 males and 25 females, average age=24.05, SD=3.37, demographic information displayed in Appendix C, Table 4). Participants in the two pilot studies were not included in the subsequent main experiment. Inclusion criteria stipulated that the participants needed to be Chinese native speakers aged between 18 and 30 years old, sequential bilinguals with English as their second language (L2), with advanced English proficiency (C1 level and above) according to participants' self-report overall scores of IELTS/TOFEL tests. Exclusion criteria are any prior experience of English immersive learning. Empirical studies found that L2 learners with immersive experience showed greater sensitivity to detect and internalise underlying language patterns compared to non-immersed learners (Llanes & Munoz, 2009). Additionally, participants should not be in a linguistic- or education-relevant major since this cohort with advanced linguistic knowledge might be more attuned to detecting underlying patterns in language, which potentially skew the outcomes of this artificial-determiner experiment (Ellis, 2006). Moreover, an independent sample (N=10) was included in a stimuli norming study to test the validity of experimental materials, the inclusion criterion of which was English native speakers.

3.4 Materials

3.4.1 Determiners

Drawing on Williams' (2004, 2005) paradigm, participants were introduced to four artificial articles: *gi*, *ro*, *ul*, and *ne*, which were taken as determiners to modify nouns. The four artificial determiners were pronounced as 'g, r, u, n' respectively according to their letter name so that their pronunciation would not influence participants' understanding of how to use them. Participants were instructed that the determiner usage depended upon whether modified nouns' referents were animals or humans. That is, *gi* and *ul* were used for nouns referring to animals (e.g. cat), while *ro* and *ne* were used for human referents (e.g. children). However, what was unknown to participants was that *gi* was used to modify nouns related to predators (e.g. tiger), while *ul* was used to modify those associated with

prey (e.g. rabbit). Similarly, the article *ro* is accompanied by nouns of powerful social roles (e.g. president), yet *ne* is for those denoting powerless social roles (e.g. refugee).

3.4.2 Nouns Standardisation

A total of 60 English nouns were selected, consisting of 15 clear cases of predatory animals, 15 prey animals, 15 powerful social roles, and 15 powerless social roles. To ensure this is the case, the present research invited an independent sample (N=10) to rate ‘To what extent do you agree that A means a kind of animal/human?’, ‘To what extent do you agree that A means a kind of predator/prey’ and ‘To what extent do you agree that B means a powerful/powerless social role?’ on a 5-point Likert scale (i.e. 1 point-strongly disagree, 2 points-disagree, 3 points-neutral, 4 points-agree, and 5 points-strongly agree). The average of each agreement rating was calculated. It was expected that the mean value of corresponding ratings would be above 3 (i.e. neutral). For example, the word ‘bear’ would be a qualified experimental item if its mean values in animal rating and predator rating were above 3 (i.e. neutral), while its mean value in prey rating was below 3 (i.e. neutral). This stimuli norming study guaranteed the validity of experimental materials.

3.4.3 Material Construction

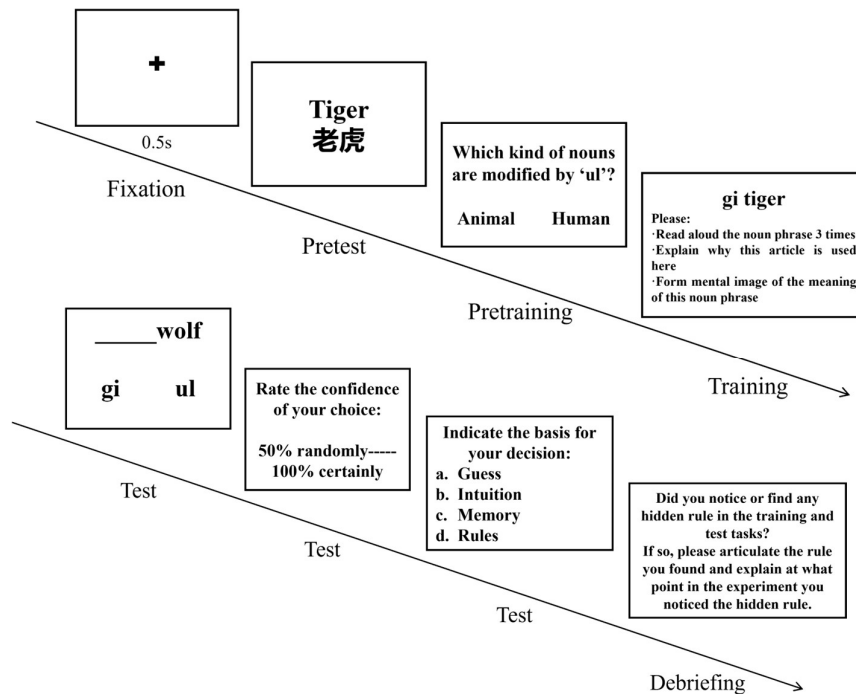
Among the 60 English nouns, 20 noun phrases were assigned as training items, which comprised five ‘*gi* + predators’, five ‘*ul* + preys’, five ‘*ro* + powerful social roles’, and five ‘*ne* + powerless social roles. The remaining 40 nouns without determiners were used in a forced-choice test task. None of the test items had been presented during the training task. Specifically, the 40 nouns are representations of predators (N=10), prey (N=10), powerful social roles (N=10) and powerless social roles (N=10).

3.5 Procedure

3.5.1 Consent Form

The pilot studies, norming study and main experiment were all administered online through Gorilla (<https://gorilla.sc>), an experiment programming platform. Participants conducted corresponding experiments remotely in their own spaces. Before the experiment, the whole experiment procedure was introduced to the participants. Participants were informed that they would complete a series of computer-based tasks remotely, which took about 30 minutes. The experiment consisted of five phases: a pretest, determiner pretraining, a training task, a test task (forced-choice test) and a briefing report (see Figure 2 Flow Chart of the Experiment). All instruction languages were in English. An electronic information sheet and consent form for the pilot study, norming study or main experiment were presented to participants (see Appendix E for the pilot study, Appendix F for the norming study, and Appendix G for the main experiment). The information sheets and consent forms were in English. They ticked the box ‘I have read and understood the above and hereby give my consent to take part in this experiment in full knowledge that data is being recorded’ to declare their willingness to participate.

Figure 2. Flow Chart of the Experiment.



3.5.2 Demographic Information

After signing the consent form, participants were asked to finish an online questionnaire to gather their demographic information. The collected demographic information included age, gender, nationality, education level, native language, English Proficiency (IELTS/TOEFL overall score), and knowledge of any other language.

3.5.3 Pretest

In the pretest, participants reviewed all the 60 nouns in advance, which were used in the following training and test tasks. The nouns and their corresponding Chinese translations in black were displayed one by one at the centre of a screen against a white background (see Appendix H, Figure 7). The Chinese translations used were from the second edition of the Oxford English-Chinese Dictionary (Manser, 2010). Even though participants possibly had known the meaning of the displayed nouns, the Chinese translations were still provided. This is because content words are very likely to attach with multiple semantic meanings and can change their syntactic categories in different contexts (Bauer, 1983). For example, the word ‘chief’ can be used as an adjective like ‘a chief problem’, or as a noun like ‘a union chief’ (sources from Online Oxford English Dictionary, retrieved from <https://www.oed.com>). At the same time, the word ‘chief’, when serving as an adjective, might mean ‘most important (e.g. a chief reason)’ or ‘highest in rank (e.g. the Chief Education Officer)’ (sources from Online Oxford English Dictionary, retrieved from <https://www.oed.com>). The pretest was performed to ensure that the participants fully understood the meaning of training and test items in avoidance of potential ambiguities. Otherwise, their poor performance in test tasks might be attributable to their ignorance about the semantic meaning of some nouns rather than unawareness of the hidden rule.

3.5.4 Determiner Pretraining

After filling in the online questionnaire about demographic information, participants were told that

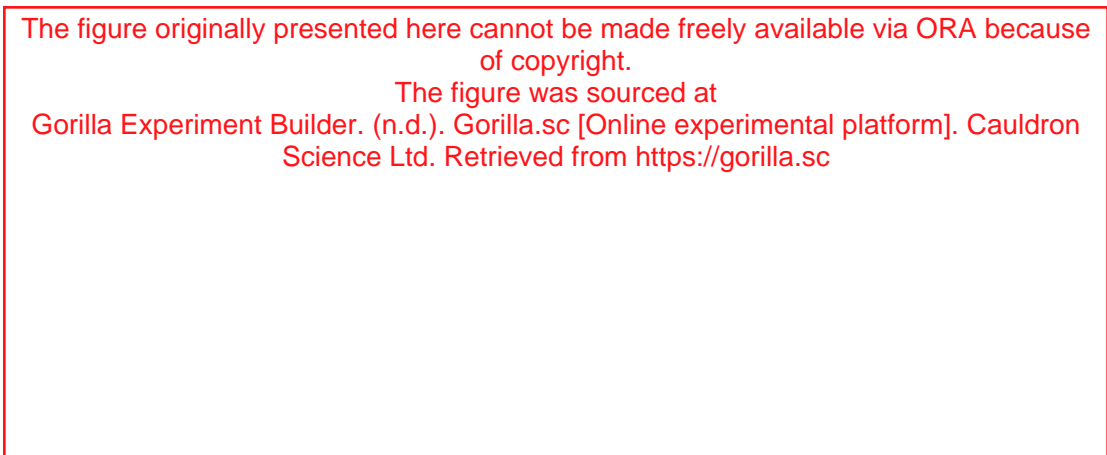
they would learn four novel articles as determiners to modify nouns: *gi*, *ul*, *ro* and *ne*. They needed to remember the usage of these four articles: *gi* and *ul* are used before nouns denoting animals (e.g. cat), while *ro* and *ne* are used before nouns referring to humans (e.g. student). However, a hidden rule of the four novel articles was unknown to the participant: *gi* is used before predator referents, while *ul* is used before prey counterparts. Likewise, *ro* is used to modify nouns implying powerful social roles, yet *ne* is used for those representing powerless social roles. Additionally, participants were required to acquire the pronunciation of these four articles, which were ‘g, u, r, and n’ respectively (namely the pronunciation of their initial letter names). These four articles were pronounced the same as the pronunciation of their initials to minimize potential influences from pronunciation on participants’ understanding of the hidden rule. A subsequent forced-choice task was administered to test whether participants had grasped the usage of the four novel articles. Specifically, four similar questions ‘Which kind of nouns are modified by *gi/ul/ro/ne*?’ in black were displayed at the centre of a computer screen against a white background. Two alternatives were presented below the questions: ‘animal’ versus ‘human’ (see Appendix H, Figure 8). The correct answer being on the left or right side was entirely random across trials and participants. Participants indicated their responses by clicking the corresponding buttons and accuracy feedback would be provided so they could infer whether their responses were correct or not. Participants passed the pretraining task only if all their responses to the four questions were correct, otherwise, the pretraining task would be recycled until they went through the four questions correctly. This accuracy criterion was set to ensure that participants fully mastered how to use the four novel articles. There was no time limit for participants to respond. The presentation order of the four questions was independently randomised in every cycle across participants.

3.5.5 Training Task

In the training task, participants were shown 20 noun phrases (article + noun, e.g. *gi* tiger) as training items. There was a fixation point ‘+’ with a duration of 500ms, and then, each noun phrase in black was presented one at a time on a computer screen against a white background. Participants were instructed to a) read the noun phrase aloud three times which would not be recorded, b) explain why

the novel article was used in the noun phrase, and c) form a mental image of the meaning of the noun phrase (see Appendix H, Figure 9). Participants were clearly informed that they would not be recorded as they read aloud the nouns. It was also stressed that participants should pay more attention to understanding the general meaning described by these noun phrases, rather than remembering their precise forms. Given the complexity of the training task, the task instruction was presented accompanying each noun phrase in every trial for participants' reference (see Figure 3). Three noun phrases were used for practice with answers provided before the main training task. For example (see Figure 3), 'ro manager' was displayed on the screen with task instructions. Participants needed to read aloud 'r manager' three times and explained that 'ro' was used in this noun phrase because a manager is human. Then, they imagined the image of a manager in their mind. There was no time limit for any given trial. The three noun phrases used for practice were not included in the main training task. The presentation order of the training items was randomised across participants. All nouns appeared in singular form with corresponding articles to avoid confounding effects caused by varying word forms.

Figure 3. Example of Practice before the Training Task.



3.5.6 Test Task: Forced Choice Test

After the training task, participants were examined on the hidden rule of these four novel articles by means of a forced choice test. Participants were shown 40 nouns as testing items, among which 10

nouns were representations of powerful animals (predators), 10 of powerless animals (prey), 10 of human powerful social roles, and 10 of human powerless social roles. At the beginning of each trial, there was a fixation point ‘+’ with a duration of 500ms. Then, each noun without a determiner (e.g. _____ king) in black was displayed one at a time at the centre of a screen against a white background and two alternative options below the noun (see Appendix H, Figure 10). In particular, the two alternative articles provided were used for animals or humans but indicate different powerfulness (e.g. *gi* and *ul* are both used for animals, but *gi* indicates predators and *ul* indicates prey). In each trial, participants were asked a) to choose one of the articles that seemed more appropriate to modify the given noun based on their experience in the training task; b) to rate their confidence in their choice on a continuous scale from 50% to 100% (where 50% suggests at chance, 100% suggests complete certainty); c) choose from four options (guess, intuition, memory or rules) to indicate what they believed to be the basis for their decisions (multiple choices were permitted). These four decision strategies were defined as follows: Guess-you have no idea so you chose either option at random, Intuition-you have some confidence but are unable to say why it is right, Memory-your choice is based on a recollection of training items, Rules-your choice is based on some rules you found in the training task and can state if asked (Dienes & Scott, 2005). The above working definitions were provided along with four options (see Appendix H, Figure 10). There was no time limit in each trial. The presentation order of trials was independently randomised across participants. The correct answer being on the left side or right side was entirely random across trials and participants. The test order (animal test items first or human test items first) was counterbalanced across participants. All nouns appeared in singular forms in case participants mistakenly attributed the hidden rule to differences in word forms.

3.5.7 Briefing Report

After the forced choice test, there was a debriefing report regarding the question ‘‘Did you notice or find any hidden rule in the training and test tasks? If so, please articulate the rule you found and explain at what point in the experiment you noticed the hidden rule’’ (see Appendix H, Figure 11). Any reference to the relationship between predators and prey or powerfulness was regarded as

evidence of awareness of the hidden rule and was noted by the experimenter. In such cases, participants were further required to expound (if they could) at what point in the experiment they had noticed the hidden rule and how they found that powerfulness was relevant in the choice of novel articles.

3.6 Ethical Considerations

The present search followed the British Educational Research Association Ethical Guidelines for Educational Research (University of Oxford Central University Research Ethics Committee, 2023). The participants were contacted to participate in the online experiment after receiving ethical approval from the Department of Education's Research Ethics Committee (see Appendix I). Participants were informed that they could withdraw themselves from this research at any time without giving a reason. If they withdrew from the study, any data collected up to that point would not be used in the following analysis. Participants had opportunities to ask the experimenter any clarifying questions directly by email. All collected data and research outputs were pseudonymized with an ID to link the data with specific individuals. The files that recorded participants' IDs were stored on a password-protected laptop and OneDrive for business. Participants were not identifiable from the collected data and research outputs. To the best of the researcher's knowledge, there are no potential disadvantages or risks in taking part in this experiment.

3.7 Methodology Limitations

3.7.1 Inherent Limitations of the Artificial Grammar Paradigm

This experiment mainly draws on the artificial grammar paradigm, while this paradigm is by no means free from its inherent limitations. One of the main criticisms of the artificial grammar paradigm is its lack of ecological validity. The experiment involves artificial and simplified language structures that may not accurately reflect the complexity and richness of natural languages (Jamieson & Mewhort, 2005; Christiansen & Chater, 2001). Moreover, critics also argue that learning a miniature linguistic system in a laboratory differs greatly from classroom language learning and

naturalistic language learning (DeKeyser, 2008). The findings drawing on the artificial grammar paradigm may not apply to real-world language learning scenarios (Gomez & Gerken, 2000). The researcher has fully recognised the abovementioned criticisms. However, this online experiment is conducted remotely, and participants are within various contexts worldwide. The artificial grammar paradigm allows a highly controlled environment in which the researcher can systematically manipulate variables and study the implicit learning effect without confounding factors present in natural languages (Reber, 1967). Forkstam and Petersson (2005) also emphasised that the artificial grammar paradigm is particularly useful for exploring the process of implicit learning. Despite criticisms, this paradigm characterises advantages that make it a valuable tool for exploring the complex cognitive phenomenon of implicit learning in a simplified and controlled setting.

3.7.2 Potential Influence from Participants' Subjectivity

There seems to be a vague boundary between word referents of predators or prey as well as powerful or powerless social roles, which are susceptible to participants' subjectivity. In other words, one might believe that birds are a kind of predator, but others possibly regard them as a kind of prey. To minimize the potential influence caused by participants' subjectivity, an aforementioned stimuli norming study has been carried out with 10 English native speakers involved to ensure the experimental materials were treated as expected.

3.8 Analytical Strategy

Participants would be divided into the aware group and the unaware group depending on their consciousness of the hidden rule. To address the first research question, if the collected data was normally distributed, Paired Sample T-tests would be performed on SPSS to analyse whether the accuracy rate and confidence rate of unaware participants were significantly above the chance level (50%). If not normally distributed, nonparametric Wilcoxon Signed-Rank Tests would be used in this regard. To deal with the second research question, it was expected to use Independent Sample T-tests (with normal distribution) or Mann-Whiney U Test (without normal distribution) to analyse

whether the aware group and the unaware group performed differently concerning accuracy rate, confidence rate and reaction time. At the same time, the Pearson Correlation Test and Spearman Test would be administered to check if there were any potential correlations between variables. For the last research question, participants who were aware of the hidden rule were coded as '1' while the others without consciousness were coded as '0'. Similarly, participants who knew any gendered languages were recorded as '1' no matter their proficiency, while those who had no previous knowledge of gendered languages were coded as '0'. A subsequent Chi-Square Test would be employed to examine the relationship between participants' consciousness of the hidden rule and their gendered language background.

Chapter 4 Results

This chapter will address the research questions by analysing gathered quantitative and qualitative data. It starts with reporting the results of a stimuli norming study to ensure the validity of experimental materials, followed by accounts of the main experiment results. In line with the three research questions, the report of the main experiment results develops from the following aspects: the consciousness of the hidden rule, the implicit learning of the hidden rule, the aware and unaware groups' performance concerning accuracy rate, confidence rate and reaction time, as well as the relationship between participants' consciousness of the hidden rule and their gendered language background. Within-group analysis combines with between-group analysis to provide more comprehensive evidence for the research topic.

4.1 Norming Study

To test the validity of designed experimental materials, a norming study was conducted with an independent sample of English native speakers (N=10). They were asked to rate three questions on a 5-point scale (i.e. strongly disagree, disagree, neutral, agree, and strongly agree): 'To what extent do you agree that A means a kind of animal/human?', 'To what extent do you agree that A means a kind of predator/prey?', and 'To what extent do you agree that B means a powerful/powerless social role?'. Based on this 5-point scale, 'strongly disagree' was counted as 1 point, while 'disagree' was as 2 points, 'neutral' as 3 points, 'agree' as 4 points and 'strongly agree' as 5 points. The average agreement rating was calculated respectively. For a predator word item like 'tiger', it was expected that its mean value in animal rating and predator rating would be above 3 (i.e. neutral), while its mean value in prey rating would be below 3 (i.e. neutral). In contrast, a prey word item like 'rabbit' would associate with 3-plus mean values in animal and prey ratings, but below-3 mean values in predator ratings. The same idea can also be applied to human word items. For example, a human word item like 'chancellor' was expected to be rated above 3 (i.e. neutral) in human rating and powerfulness rating whereas below 3 in powerlessness rating. In a similar manner, a human word item like 'refugee' was expected to be rated above 3 (i.e. neutral) in human rating and powerless

rating yet below 3 in powerfulness rating. All word items utilised in this experiment met the abovementioned criteria, which suggested that the experimental materials would be interpreted as intended in this study (shown in Appendix J for details).

4.2 Main Experiment

4.2.1 The Consciousness of the Hidden Rule

As recorded in the debriefing report, any reference to relationships between predators and prey or powerfulness and powerlessness would be regarded as evidence of awareness of the hidden rule. Nine of forty participants expressed awareness of the hidden rule and were able to articulate the rule (i.e. the aware group). The rest of the participants remained unaware of the hidden rule at the end of the experiment (i.e. the unaware group). Four participants had become aware during the training phase, and the remaining five reported that they noticed the rule during the test phase. The nine participants were treated as the aware group while the others were the unaware group, paving the way for the following between-subject data analysis. A participant mistakenly suspected the hidden rule was relevant to word length, reporting that ‘I think the longer the word of animals is *ul* and *ne* for human. The word is 5 (length) or above to apply the rule’. Another one had suspicions about word pronunciation, documenting ‘I had suspicions about *ro* being used for words ending in consonants or something along those lines, but I don’t think I had anything concrete’. Also, a participant had a vague impression that ‘maybe it is based on positive and negative things’.

4.2.2 The Implicit Learning of the Hidden Rule

The first research question concerns whether L2 learners could implicitly learn the hidden rule of the artificial-determiner system. To address this question, there were 50 test items in the test task consisting of 40 items to test whether participants learnt the hidden rule (called ‘target items’ below) and 10 items to test whether participants learnt the explicit rule (called ‘generalisation items’ below). According to the guessing criterion and zero-correlation criterion of measuring implicit learning (see Chapter 2 Literature Review, Section 2.3.1 for details), it was expected that the accuracy rate of

target items was significantly above the chance level (50%) though participants believed that they were unaware of the hidden rule. At the same time, the accuracy rate of target items was anticipated not to be correlated with the confidence rate of target items. As for the explicit rule, the accuracy rate of generalisation items should be significantly above the chance level (50%) to demonstrate that participants had mastered the explicit rule.

The normal distribution of the accuracy rate was tested as the absolute values of skewness and kurtosis were between -2 and +2 (George & Mallery 2010). Histograms and Q-Q plots were also used to check the normal distribution of the variable visually. It suggested that the accuracy rate of the unaware group was normally distributed as shown in Table 5, whereas that of the aware group was not as shown in Table 6. The assumptions of a Paired T-test have been fully met for the unaware group: a) the measurements of subjects are independent of one another, b) each of the paired measurements is obtained from the same subjects, c) the dependent variable (accuracy rate in this case) is continuous, d) the dependent variable is approximately normally distributed (Field, 2013). Then, a Paired Samples T-test was conducted on SPSS to analyse the accuracy rate of the unaware group. Indeed, it was found that their accuracy rate of target items (to test the hidden rule) was significantly above the chance level (50%), although they reported that they found no hidden rule and almost guessed to make a choice across trials (M=54.677%, SD=0.117, t(30)=2.218, p=.034). The accuracy rate of generalisation items (to test the explicit rule) was also significantly above the chance level (50%) (M=86.8%, SD=0.1996, t(30)=9.537, p<.001, see Table 7 and Figure 4). The Pearson Correlation Test revealed no correlation between the accuracy rate of target items and the confidence rate of target items (r=.104, p=.578, see Table 8).

Table 5. Descriptive Statistics of Accuracy Rate (Unaware Group).

	N	Min	Max	Mean	S. D.	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Explicit Rule Accuracy Rate	31	.3	1.0	.868	.1996	-1.364	.427	1.129	.833
Implicit Rule Accuracy Rate	31	.375	.950	.54677	.117392	.414	.427	.195	.833

Table 6. Descriptive Statistics of Accuracy Rate (Aware Group).

	N	Min	Max	Mean	S. D.	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Explicit Rule Accuracy Rate	9	.9	1.0	.9556	.0527	-.271	.717	-2.571	1.400
Implicit Rule Accuracy Rate	9	.475	1.000	.76389	.231541	-.339	.717	-2.272	1.400

Table 7. Paired Sample T-test Results of Accuracy Rate (Unaware Group).

	Mean	S. D.	S. E. M	95% CI		t	df	p (2-tailed)
				Lower	Upper			
Pair 1 Explicit Rule Accuracy Rate vs Chance Level	.34194	.19962	.03585	.26871	.41516	9.537	30	<.001
Pair 2 Implicit Rule Accuracy Rate vs Chance Level	.046774	.117392	.021084	.003714	.089834	2.218	30	.034

Figure 4. Percentage of Accuracy Rate.

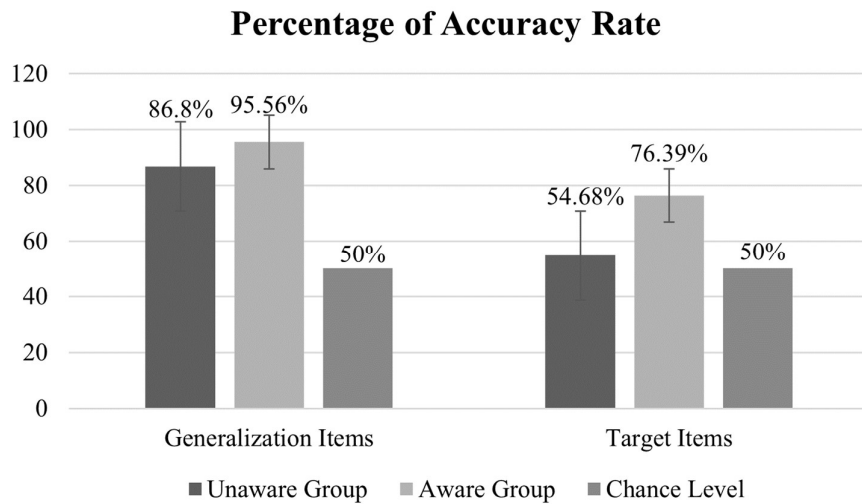


Table 8. No Correlation between the Accuracy Rate and Confidence Rate of Target Items.

		Accuracy Rate of Target Items	Confidence Rate of Target Items
Accuracy Rate of Target Items	Pearson Correlation	1	.104
	Sig. (2-tailed)		.578
	N	31	31
Confidence Rate of Target Items	Pearson Correlation	.104	1
	Sig. (2-tailed)	.578	
	N	31	31

The accuracy rate of the aware group was not normally distributed, which failed to meet the assumptions of a Paired T-test. Consequently, a nonparametric Wilcoxon Signed-Rank Test was used to analyse the accuracy rate of the aware group. All assumptions of a Wilcoxon Signed-Rank Test were met, including 1) the dependent variable is measured at the ordinal or continuous level, b) the independent variable involves matched pairs with the same subjects in both groups, c) the distributions are symmetrical in shape (Field, 2013). Consistent with the unaware group, the aware group showed significantly higher accuracy rates of target items above the chance level ($M=76.39\%$, $SD=0.232$, $Z=-2.201$, $p=.028$). This is unsurprising given that the aware group has been aware of the hidden rule and is able to articulate it. Likewise, their accuracy rate of generalisation items related to the explicit rule was also significantly above the chance level (50%) ($M=95.56\%$, $SD=0.0527$, $Z=-2.739$, $p=.006$, see Table 9).

Table 9. Wilcoxon Signed-Rank Test Results of Accuracy Rate (Aware Group).

	Explicit Rule Accuracy Rate vs Chance Level	Implicit Rule Accuracy Rate vs Chance Level
Z	-2.739 ^b	-2.201 ^b
Asymp. Sig. (2-tailed)	.006	.028

4.2.3 The Aware and Unaware Group's Performance Concerning Accuracy Rate

The second research question was to shed light on any particular differences in performance between those aware of the hidden rule and those not. There were three variables of great interest: accuracy rate, confidence rate and reaction time. The accuracy rates of the aware and unaware groups were not in equal homogeneity of variances (as shown in Table 10), which failed to meet the assumptions of the Independent Sample T-test. Thus, a nonparametric Mann-Whiney U Test was conducted to compare the performance of the aware and unaware groups. The assumptions of the Mann-Whiney U Test have been fully met, namely: a) the observations in each group are independent, b) the independent variable consists of two independent and categorical groups, c) the dependent variable is measured on an ordinal or a continuous level, d) the distributions in two groups have the similar shape (Field, 2013). The results suggested that the aware group outperformed the unaware group with a significantly higher accuracy rate of target items ($U=74$, $Z=-2.129$, $p=.033$), but a similar accuracy rate of generalisation items ($U=96.5$, $Z=-1.475$, $p=.14$, see Table 11 for details).

Table 10. Test of Homogeneity of Variances (Accuracy Rate).

		Levene Statistic	df1	df2	Sig.
Explicit Rule Accuracy Rate	Based on Mean	6.568	1	38	.014
	Based on Median	3.611	1	38	.065
	Based on Median and with adjusted df	3.611	1	31.877	.066
	Based on trimmed mean	5.407	1	38	.025
Implicit Rule Accuracy Rate	Based on Mean	19.739	1	38	<.001
	Based on Median	6.298	1	38	.016
	Based on Median and with adjusted df	6.298	1	20.714	.020
	Based on trimmed mean	19.216	1	38	<.001

Table 11. Mann-Whiney U Test Results of Accuracy Rate.

	Explicit Rule Accuracy Rate	Implicit Rule Accuracy Rate
Mann-Whitney U	96.500	74.000
Wilcoxon W	592.500	570.000
Z	-1.475	-2.129
Asymp. Sig. (2-tailed)	.140	.033
Exact Sig. [2*(1-tailed Sig.)]	.167 ^b	.034 ^b

4.2.4 The Aware and Unaware Group's Performance Concerning Confidence Rate

The confidence rate of the aware and unaware group was tested to be normally distributed according to the value of skewness and kurtosis (shown in Table 12 and 13). For the unaware group, the confidence rate of target items (M=76.12, SD=13.971, $t(30)=30.334$, $p<.001$) and generalisation items (M=87.9, SD=10.692, $t(30)=45.257$, $p<.001$) were both significantly above 50% (i.e. guessing). Their confidence rate of correct-answered items (M=79.87, SD=11.034, $t(30)=40.299$, $p<.001$) and confidence rate of incorrect-answered items (M=75.24, SD=13.352, $t(30)=31.375$, $p<.011$) were also significantly above 50% (see Table 14a and Figure 5). Further, the confidence rate of target items was significantly different from that of generalisation items ($p<.001$). The confidence rate of correct-answered items was significantly different from that of incorrect-answered items ($p<.001$, see Table 14b). Surprisingly, there is a strong correlation between the confidence rate of correct-answered items and incorrect-answered items ($r=.921$, $p<.001$), whereas no correlation was found between the confidence rate of target items and generalisation items ($r=.192$, $p=.301$, see Table 15a, b for details).

Table 12. Descriptive Statistics of Confidence Rate (Unaware Group).

	N	Min	Max	Mean	S. D.	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Explicit Rule Confidence Rate	31	59.9	100.00	87.406	10.692	-.805	.421	-.098	.821
Implicit Rule Confidence Rate	31	50.1	98.95	76.618	13.971	-.061	.421	-1.041	.821
Correct Item Confidence Rate	31	60.706	99.355	80.366	11.034	.135	.421	-.946	.821
Incorrect Item Confidence Rate	31	50.0	98.0	75.741	13.352	-.028	.421	-.976	.821

Table 13. Descriptive Statistics of Confidence Rate (Aware Group).

	N	Min	Max	Mean	S. D.	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Explicit Rule Confidence Rate	9	61.70	100.00	89.87	13.64	-1.345	.717	.951	1.400
Implicit Rule Confidence Rate	9	65.025	95.875	84.13	9.987	-.925	.717	.017	1.400
Correct Item Confidence Rate	9	63.233	97.069	85.90	10.898	-1.366	.717	1.321	1.400
Incorrect Item Confidence Rate	9	64.00	93.810	76.62	9.515	.526	.752	.498	1.481

Table 14a. Paired Sample T-test Results of Confidence Rate (Unaware Group).

		Mean	S. D.	S. E. M.	95% CI		t	df	p (2-tailed)
					Lower	Upper			
Pair 1	Explicit Rule Confidence Rate vs Guessing Level	87.9	10.692	1.920	82.984	90.827	45.257	30	<.001
Pair 2	Implicit Rule Confidence Rate vs Guessing Level	76.12	13.971	2.509	70.993	81.243	30.334	30	<.001
Pair 3	Correct Item Confidence Rate vs Guessing Level	79.87	11.034	1.982	75.818	83.913	40.299	30	<.001
Pair 4	Incorrect Item Confidence Rate vs Guessing Level	75.24	13.35	2.398	70.343	80.138	31.375	30	<.001

Figure 5. Percentage of Confidence Rate.

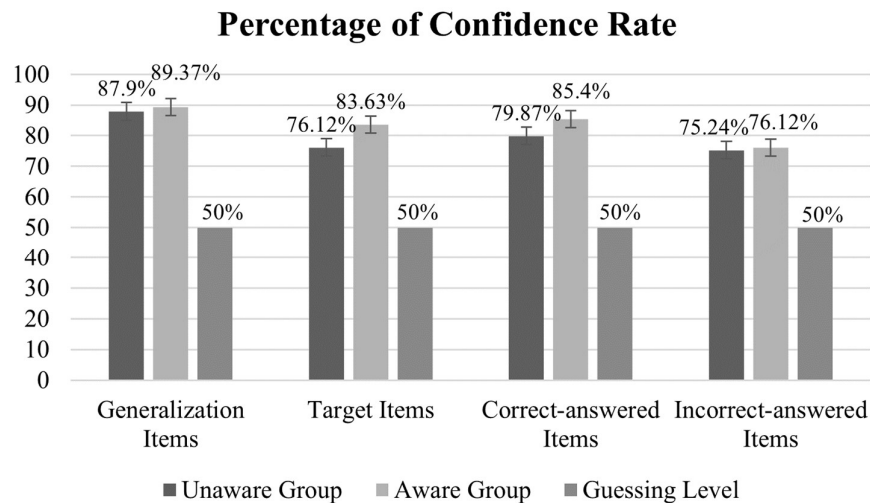


Table 14b. Paired Sample T-test Results of Confidence Rate (Unaware Group).

		Mean	S. D.	S. E. M.	95% CI		t	df	p (2-tailed)
					Lower	Upper			
Pair 1	Explicit Rule Confidence Rate vs Implicit Rule Confidence Rate	10.788	15.879	2.852	4.963	16.612	3.782	30	<.001
Pair 2	Correct Item Confidence Rate vs Incorrect Item Confidence Rate	4.625	5.366	.964	2.657	6.593	4.799	30	<.001

Table 15a. Pearson Correlation Test of Confidence Rate (Unaware Group).

		Correct Item Confidence Rate	Incorrect Item Confidence Rate
Correct Item Confidence Rate	Pearson Correlation	1	.921**
	Sig. (2-tailed)		<.001
	N	31	31
Incorrect Item Confidence Rate	Pearson Correlation	.921**	1
	Sig. (2-tailed)	<.001	
	N	31	31

** . Correlation is significant at the 0.01 level (2-tailed).

Table 15b. Pearson Correlation Test of Confidence Rate (Unaware Group).

		Implicit Rule Confidence Rate	Explicit Rule Confidence Rate
Implicit Rule Confidence Rate	Pearson Correlation	1	.192
	Sig. (2-tailed)		.301
	N	31	31
Explicit Rule Confidence Rate	Pearson Correlation	.192	1
	Sig. (2-tailed)	.301	
	N	31	31

Similar to the unaware group, the confidence rate of the aware group was significantly above the guessing level of 50% (confidence rate of generalisation items: $M=89.37$, $SD=13.637$, $t(8)=19.660$, $p<.001$; confidence rate of target items: $M=83.63$, $SD=9.987$, $t(8)=25.123$, $p<.001$; confidence rate

of correct-answered items: $M=85.4$, $SD=10.898$, $t(8)=23.510$, $p<.001$; confidence rate of incorrect-answered items: $M=76.12$, $SD=9.515$, $t(8)=22.626$, $p<.001$, see Table 16a for details). Unlike the unaware group, however, the differences between the confidence rate of target and generalisation items were not statistically significant for the aware group ($p>.05$). The confidence rate of correct-answered items was also not significantly different from that of incorrect-answered items for the aware group ($p>.05$, see Table 16b for details). Contrary to the results of the unaware group, the aware group showed a strong correlation between the confidence rate of target items and generalisation items ($r=.764$, $p=.017$), but a relatively weak correlation between the confidence rate of correct-answered items and incorrect-answered items ($r=.433$, $p=.284$, see Table 17a, b).

Table 16a. Paired Sample T-test Results of Confidence Rate (Aware Group).

		Mean	S. D.	S. E. M.	95% CI		t	df	p (2-tailed)
					Lower	Upper			
Pair 1	Explicit Rule Confidence Rate vs Guessing Level	89.37	13.637	4.546	78.884	99.849	19.660	8	<.001
Pair 2	Implicit Rule Confidence Rate vs Guessing Level	83.63	9.987	3.329	75.957	91.310	25.123	8	<.001
Pair 3	Correct Item Confidence Rate vs Guessing Level	85.40	10.898	3.633	77.024	93.778	23.510	8	<.001
Pair 4	Incorrect Item Confidence Rate vs Guessing Level	76.12	9.515	3.364	68.162	84.072	22.626	8	<.001

Table 16b. Paired Sample T-test Results of Confidence Rate (Aware Group).

		Mean	S. D.	S. E. M.	95% CI		t	df	p (2-tailed)
					Lower	Upper			
Pair 1	Explicit Rule Confidence Rate vs Implicit Rule Confidence Rate	5.733	8.808	2.936	-1.037	12.503	1.953	8	.087
Pair 2	Correct Item Confidence Rate vs Incorrect Item Confidence Rate	8.299	11.130	3.935	-1.006	17.604	2.109	8	.073

Table 17a. Pearson Correlation Test of Confidence Rate (Aware Group).

		Explicit Rule Confidence Rate	Implicit Rule Confidence Rate
Explicit Rule Confidence Rate	Pearson Correlation	1	.764*
	Sig. (2-tailed)		.017
	N	9	9
Implicit Rule Confidence Rate	Pearson Correlation	.764*	1
	Sig. (2-tailed)	.017	
	N	9	9

*. Correlation is significant at the 0.05 level (2-tailed).

Table 17b. Pearson Correlation Test of Confidence Rate (Aware Group).

		Correct Item Confidence Rate	Incorrect Item Confidence Rate
Correct Item Confidence Rate	Pearson Correlation	1	.433
	Sig. (2-tailed)		.284
	N	9	9
Incorrect Item Confidence Rate	Pearson Correlation	.433	1
	Sig. (2-tailed)	.284	
	N	9	9

Given the confidence rate of the two groups was equal in variances (shown in Table 18), an Independent Sample T-test was carried out to compare the confidence rate of the unaware group with that of the aware group. As displayed in Table 19, no significant differences were found in this regard ($p > .05$ in all cases).

Table 18. Test of Homogeneity of Variances (Confidence Rate).

		Levene Statistic	df1	df2	Sig.
Explicit Rule Confidence Rate	Based on Mean	.889	1	38	.352
	Based on Median	.108	1	38	.744

	Based on Median and with adjusted df	.108	1	30.791	.745
	Based on trimmed mean	.645	1	38	.427
Implicit Rule Confidence Rate	Based on Mean	2.367	1	38	.132
	Based on Median	2.867	1	38	.099
	Based on Median and with adjusted df	2.867	1	37.970	.099
	Based on trimmed mean	2.517	1	38	.121
Correct Item Confidence Rate	Based on Mean	.260	1	38	.613
	Based on Median	.421	1	38	.520
	Based on Median and with adjusted df	.421	1	34.978	.521
	Based on trimmed mean	.320	1	38	.575
Incorrect Item Confidence Rate	Based on Mean	2.981	1	37	.093
	Based on Median	3.044	1	37	.089
	Based on Median and with adjusted df	3.044	1	36.941	.089
	Based on trimmed mean	3.041	1	37	.089

Table 19. Independent Sample T-test Results of Confidence Rate.

	t	df	p (2-tailed)	Mean Difference	S.E. Difference	95% CI	
						Lower	Upper
Explicit Rule Confidence Rate	-.571	38	.571	-2.461	4.307	-11.180	6.258
	-.499	11.017	.628	-2.461	4.935	-13.32	8.398
Implicit Rule Confidence Rate	-1.500	38	.142	-7.515	5.010	-17.659	2.628
	-1.803	18.114	.088	-7.515	4.169	-16.270	1.239
Correct Item Confidence Rate	-1.328	38	.192	-5.536	4.167	-13.972	2.90
	-1.338	13.160	.204	-5.536	4.138	-14.464	3.393
Incorrect Item Confidence Rate	-.174	37	.863	-.876	5.042	-11.093	9.341
	-.212	15.017	.835	-.876	4.131	-9.681	7.929

4.2.5 The Aware and Unaware Group's Performance Concerning Reaction Time

Based on the absolute value of skewness and kurtosis, the unaware group's reaction time of target items and correct-answered items, as well as the aware group's reaction time of incorrect-answered items were attested not to be normally distributed (see Table 20 and 21 for details). The other variables followed a normal distribution. In view of this, the nonparametric Wilcoxon Signed-Rank Test was used for data analysis. For the unaware group, the reaction time of target items and generalisation items as well as the reaction time of correct-answered items and incorrect-answered items appeared not to significantly differ from each other ($p > .05$ in both cases, see Table 22 for details). A Spearman Test indicated that there was a strong correlation between the reaction time of target items and generalisation items ($r = .925$, $p < .001$), as well as between the reaction time of correct-answered items and incorrect-answered items ($r = .896$, $p < .001$, see Table 23a, b).

Table 20. Descriptive Statistics of Reaction Time (Unaware Group).

	N	Min	Max	Mean	S. D.	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Explicit Rule Reaction Time	31	908.399	11051.25	3289.158	2433.807	1.955	.421	3.676	.821
Implicit Rule Reaction Time	31	1038.508	8863.013	3481.474	1867.495	1.017	.421	.799	.821
Correct Item Reaction Time	31	997.0	10263.164	3373.309	2024.080	1.665	.421	3.392	.821
Incorrect Item Reaction Time	31	1029.263	10328.7	3625.89	2122.186	1.235	.421	1.914	.821

Table 21. Descriptive Statistics of Reaction Time (Aware Group).

	N	Min	Max	Mean	S. D.	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
Explicit Rule Reaction Time	9	1669.55	6789.1	4492.64	2105.19	-.217	.717	-2.155	1.4
Implicit Rule Reaction Time	9	1441.15	5359.82	3161.36	1201.11	.601	.717	.177	1.4
Correct Item Reaction Time	9	1821.62	5671.18	3368.45	1238.16	.653	.717	-.262	1.4
Incorrect Item Reaction Time	9	1478.43	19321.65	5540.74	5813.26	2.4	.752	6.077	1.481

Table 22. Wilcoxon Signed-Rank Test Results of Reaction Time (Unaware Group).

	Correct Item Reaction Time vs Incorrect Item Reaction Time	Explicit Rule Reaction Time vs Implicit Rule Reaction Time
Z	-1.254 ^b	-1.548 ^c
Asymp. Sig. (2-tailed)	.210	.122

Table 23a. Spearman Test of Reaction Time (Unaware Group).

			Implicit Rule Reaction Time	Explicit Rule Reaction Time
Spearman's rho	Implicit Rule Reaction Time	Correlation Coefficient	1.000	.925**
		Sig. (2-tailed)	.	<.001
		N	31	31
	Explicit Rule Reaction Time	Correlation Coefficient	.925**	1.000
		Sig. (2-tailed)	<.001	.
		N	31	31

** . Correlation is significant at the 0.01 level (2-tailed).

Table 23b. Spearman Test of Reaction Time (Unaware Group).

			Correct Item Reaction Time	Incorrect Item Reaction Time
Spearman's rho	Correct Item Reaction Time	Correlation Coefficient	1.000	.896**
		Sig. (2-tailed)		<.001
		N	31	31
	Incorrect Item Reaction Time	Correlation Coefficient	.896**	1.000
		Sig. (2-tailed)	<.001	
		N	31	31

** . Correlation is significant at the 0.01 level (2-tailed).

The aware group shared similar results as the unaware group. There were no significant differences between the reaction time of target items and generalisation items, as well as between the reaction

time of correct-answered items and incorrect-answered items ($p > .05$ in both cases, see Table 24 for details). A strong correlation was obtained between the reaction time of target items and generalisation items ($r = .783$, $p = .013$), yet no significant correlation was detected between the reaction time of correct-answered items and incorrect-answered items ($r = .619$, $p = .102$, see Table 25a, b).

Table 24. Wilcoxon Signed-Rank Test Results of Reaction Time (Aware Group).

	Implicit Rule Reaction Time vs Explicit Rule Reaction Time	Correct Item Reaction Time vs Incorrect Item Reaction Time
Z	-1.955	-.420
Asymp. Sig. (2-tailed)	.051	.674

Table 25a. Spearman Test of Reaction Time (Aware Group).

			Explicit Rule Reaction Time	Implicit Rule Reaction Time
Spearman's rho	Explicit Rule Reaction Time	Correlation Coefficient	1.000	.783*
		Sig. (2-tailed)		.013
		N	9	9
	Implicit Rule Reaction Time	Correlation Coefficient	.783*	1.000
		Sig. (2-tailed)	.013	
		N	9	9

*. Correlation is significant at the 0.05 level (2-tailed).

Table 25b. Spearman Test of Reaction Time (Aware Group).

		Correct Item Reaction Time	Incorrect Item Reaction Time
Spearman's rho	Correct Item Reaction Time	Correlation Coefficient	1.000
		Sig. (2-tailed)	.619
		N	9
	Incorrect Item Reaction Time	Correlation Coefficient	.619
		Sig. (2-tailed)	1.000
		N	9

4.2.6 The Relationship between Consciousness and Gendered Language Background

The third research question pertained to the potential relationship between participants' consciousness of the hidden rule and their prior knowledge of gendered languages. In the debriefing report, any reference to the relationship between predators and prey or powerfulness and powerlessness was regarded as evidence of awareness of the hidden rule. Participants who were aware of the hidden rule (i.e. the aware group) were operationalized as '1' for statistical analysis, while the others without consciousness (i.e. the unaware group) were operationalized as '0'. Similarly, participants who knew any gendered languages like French or German were coded as '1' no matter their proficiency, while those with no previous knowledge of gendered languages were coded as '0' for statistical analysis. The data met the assumptions of a Chi-Square Test: a) both variables are categorical, b) all observations are independent, and c) cells in the contingency table are mutually exclusive (Field, 2013). Therefore, a Chi-Square Test was employed to examine whether participants' consciousness of the hidden rule was related to their gendered language background. The results revealed no relationship between them ($\chi^2=0.455$, $p=.5$, as shown in Table 26).

Table 26. Chi-Square Test Results.

	Value	df	Asymptotic Significance (2-tailed)
Pearson Chi-Square	.455 ^a	1	.500
Continuity Correction ^b	.077	1	.781
Likelihood Ratio	.445	1	.505
Fisher's Exact Test			
Linear-by-Linear Association	.444	1	.505
N of Valid Cases	40		

a. 1 cells (25.0%) have an expected count of less than 5. The minimum expected count is 3.15.

b. Computed only for a 2x2 table.

Chapter 5 Discussion

The discussion unfolds around three research questions: 1) whether L2 learners can learn the hidden rule of the artificial-determiner system implicitly, 2) whether L2 learners are aware of the hidden rule and whether being aware of the hidden rule exerts any differential impacts on their performance, 3) whether L2 learners' consciousness of the hidden rule is related to their prior knowledge about gendered language. The findings indicated that participants did learn the hidden rule of the artificial-determiner system implicitly. The ensuing discussion centres on participants' conscious status of judgement knowledge and structural knowledge reflected by their self-reported decision basis. This is followed by comparing the aware group and unaware group's performance concerning accuracy rate, confidence rate and reaction time. After this, the next section revolves around the finding that no relationship was observed between participants' consciousness of the hidden rule and gendered language background. This chapter ends with elaborations on pedagogical implications, potential limitations and navigating directions for future studies.

5.1 The Implicit Learning of the Hidden Rule in the Artificial-determiner Experiment

In the test task, there were 10 generalisation items used to examine whether participants mastered the explicit rule and 40 target items to determine whether participants implicitly acquired the hidden rule. As predicted, participants' accuracy rate of the generalisation items reached 86.8%, and their confidence rate of the generalisation items reached 87.9% on average, which were both significantly above the chance level ($p < .05$). This was regarded as positive evidence of participants' mastery of the explicit rule and their serious attitude to this experiment. The results resonated with DeKeyser's (1995) seminal study where participants were explicitly taught a set of grammatical rules in a short time frame. It was found that participants could rapidly acquire explicit knowledge of the rules, demonstrating the effectiveness of explicit instructions and the speed at which explicit learning could occur. In a similar manner, Rod Ellis (1994) also noted that when L2 learners were given clear and concise explanations of language rules and structures, they could commonly take in this knowledge quickly. More recently, Nick Ellis (2005), in his systematic review of the interface between explicit

and implicit knowledge, highlighted that L2 learners could quickly learn explicit rules about an artificial grammar system and the knowledge could be applied to tasks shortly after learning. This was closely akin to the results of the present study.

Of great interest was whether the hidden rule was implicitly learnt by the L2 learners, namely the first research question. According to the records in the debriefing, nine of forty participants declared that they were aware of the hidden rule and were capable of articulating it at the end of the experiment. However, the remaining thirty-one participants were also able to select the correct determiner-noun combinations significantly above the chance level (50%) even though they expressed being unaware of the hidden rule. Based on the guessing criterion of measuring implicit learning (Cheesman & Merikle, 1984, cf. the Chapter 2 Literature Review, Section 2.3.1 for details about the criterion), this result validated the idea that the hidden rule had been implicitly learnt by the L2 learners. Another supporting evidence was from no correlation between the unaware group's accuracy rate of target items and their confidence rate in their answers. This met the zero-correlation criterion in favour of the occurrence of implicit learning (Dienes & Berry, 1997, cf. the Chapter 2 Literature Review, Section 2.3.1 for details about the criterion). The findings were consistent with the contention that learning could occur incidentally (Reber, 1976). It seemed unnecessary for L2 learners to be aware of targets for learning to acquire language structures (Knoelton & Squire, 1996; Mathews et al., 1989). Notwithstanding, these findings appeared to counter the assumption that the L2 grammatical form-meaning mappings require the intervention of explicit learning to be acquired (Ellis, 1994).

The results aligned with previous findings Williams (2004, 2005) reported, supporting the occurrence of implicit learning in the artificial-determiner experiment. However, this countered against Hama and Leow's (2010) study where they revisited Williams' (2005) study with a hybrid design to gather concurrent data via think-aloud protocol as well as nonconcurrent data via debriefing report. Thirty-four participants engaged in Hama and Leow's (2010) experiment which consisted of a pretraining task, a training task, a multiple-choice test and a production test. The procedure

generally followed that of Williams (2005) except that participants were asked to think aloud reasoning for their choice during the training and test tasks. Additionally, sentences were auditorily presented in the test task whereas they were visually presented in the test task of Williams' (2005) study and the present study. Different from the product-based results of the present study, the processing-based results of Hama and Leow's (2010) work revealed that unaware learners failed to learn the hidden rule implicitly.

The discrepancy in findings may be attributed to the think-aloud method used in Hama and Leow's (2010) study. The think-aloud protocols appeared not to be a more sensitive approach to measure implicit learning than verbal reports, as it was reported that two out of eight participants who were classified as aware learners via think-aloud protocols failed to report awareness in the debriefing report. At the same time, one participant who was regarded as an unaware learner in think-aloud but did report the hidden rule in later verbal reports. It was undeniable that debriefing as a method was by no means free from limitations (see Nisbett & Wilson, 1977). Nevertheless, the think-aloud protocols had been critiqued for the issue of reactivity, that is the act of verbalisation was likely to alter participants' internal cognitive processes (Ellis, 2001). Given this, it would be plausible if another non-think-aloud control group was set up to address the potential reactivity effect.

Another possible reason for the contradicting results may be the lack of pretesting and controlling participants' proficiency in English listening skills. All stimuli were visually displayed in the present experiment, but auditorily displayed in Hama and Leow's (2010) study. This means that participants' varying listening skills could be a confounding variable that potentially influenced their performance in the test task. In other words, participants' poor performance in the test task might be ascribed to the fact that they did not comprehend the meaning of the auditory stimulus rather than the nonexistence of implicit learning in the artificial-determiner experiment. Based on the findings of the present study, it is possible for L2 learners to learn the hidden rule of the artificial-determiner system implicitly. In this sense, implicit learning appears to be involved in the acquisition of L2

morphosyntax.

5.2 The Consciousness of the Hidden Rule

The second research question sought to examine participants' consciousness of knowledge related to the hidden rule. What is different from the findings of Williams' studies (2004, 2005) is that most unaware participants in this experiment reported 'intuition' as their basis of decision, and their confidence rate was significantly above the guessing level (50%). In this regard, Williams assumed that the participants were guessing across the trials. However, this study indicated that the participants were likely to employ their subliminal perception (i.e. intuition) to make judgements, rather than guess purely.

The differential findings might be explained by a third subjective measure adopted in the present experiment, the trial-by-trial knowledge attributions. Dienes and Scott (2005) pointed out the distinctions between judgment knowledge and structural knowledge. Judgment knowledge foregrounds the knowledge to judge whether particular test items share similarities with training items. Yet, structural knowledge lies in the knowledge of the underlying rule governing the training and test items (Dienes & Scott, 2005). Given this, Williams' (2004, 2005) study mainly tapped into the consciousness of structural knowledge with a mere reliance on debriefing reports. Based on the trial-by-trial knowledge attribution measurement, participants were asked not only to make a choice in the forced-choice test but also to report their confidence rate and decision basis in every trial. In regard to decision basis, there were four options to choose from (multiple choice available): guessing, intuition, memory and rules. Reporting decision basis measures the conscious status of participants' structural knowledge and judgment knowledge individually. According to the notion of Dienes and Scott (2005), if participants choose 'intuition' as their basis for decision-making and give the right answer, they possibly have conscious judgment knowledge but unconscious structural knowledge. 'Guessing' as a decision basis may reflect that individuals have unconscious judgement knowledge and unconscious structural knowledge. Nevertheless, they might have conscious judgement

knowledge and conscious structural knowledge if they choose ‘rules’ as their basis for decision-making. Indeed, the nine aware participants tended to choose ‘rules’ as their basis of decision, which indicated their consciousness of both judgement knowledge and structural knowledge.

It was noticed that all four options for decision basis were selected by different unaware participants. Further, the majority of participants preferred to choose multiple choices, which suggested that they commonly resorted to multiple decision bases when making a judgment in the test task. Caution should be exercised that this decision-basis report is not adequate to shed light on how much each attribution contributed during the process of decision-making. At least, to some extent, it revealed that the unaware participants showed significantly above-chance accuracy rates in the test, not with a mere reliance on guessing, but involving judgement knowledge like intuition and memory as well. This is a discrepancy between Williams’ study (2004, 2005) and the present study. This assumption coincides with the seminal work by Kahneman and Tversky (1974), stating that individuals often resort to intuition and implicit understanding when making judgments under certainty. It is further endorsed by a retrospection report from a participant in this experiment. When asked ‘Did you notice or find any hidden rule in the training and test tasks’, he/she answered ‘No, but I strongly feel that there is one, for example, *gi* and *ul* could be used before different kinds of animals. I don’t know the exact rule though.’ In spite of the unconsciousness of the hidden rule (i.e. unconsciousness of the structural knowledge), this participant’s accuracy rate of target items reached 95% in the test task. To some extent, this finding seems coherent with the view that knowledge can be used implicitly (Berry, 1987). In other words, subjects do not need to be aware that they are accessing implicit knowledge at the time of testing (see also Dienes & Perner, 1999).

A surprising finding was that a participant who clearly articulated the hidden rule in the debriefing, however, just showed an accuracy rate of target items at the average level of 47.5%. A possible explanation could be his/her mixing up of the rule governing the four artificial determiners, as reported by the participant ‘I thought that *ro* was used for lesser positions in society and *ne* was used

for higher positions or more authority. I noticed during the training task but I might have switched the rules in my mind so now I'm not sure.' To deal with the mixing-up dilemma, L2 learners perhaps need more exposure and engagement to strengthen their grasp of the hidden rule in the process of implicit learning. Sutton and Barto (1998) proposed the Reinforcement Learning Model which highlighted the importance of strengthening the association between a stimulus and a response during implicit learning. This view is shared by Hebb (1949) from the perspective of neuroscience, stating that exposure made learners build an initial connection, while subsequent reinforcement led to repeated activation of neural circuits, which was foundational for implicit learning.

The report on decision basis is also informative to differentiate participants' awareness at the level of noticing or at the level of understanding. To be more specific, the selection of 'rules' as a decision basis might manifest individuals' awareness at the level of understanding. In contrast, the selection of 'intuition' or 'memory' as a decision basis possibly indicates subjects' awareness at the level of noticing. The results of the decision basis accord with the Noticing Hypothesis proposed by Richard Schmidt (1990), positing that noticing is a necessary condition for language learning, but understanding might not be. As Schmidt (2001) pointed out, noticing only determined whether specific instances of linguistic inputs were encoded in memory. Once this has occurred, generalisations across instances could be formed even if learners were unaware of what the generalisations were or how they were acquired (see also Robinson, 1995). Nevertheless, it is worth mentioning that this study is not sure to what extent the unaware participants took advantage of their judgment knowledge in the decision process, which merits further investigations. Also, it is impossible to make definitive claims about whether the nine aware participants became aware of the hidden rule after they had learnt it implicitly or they became aware of the hidden rule first before learning it. They may have learnt the hidden rule implicitly but then developed an explicit awareness of it, whereas more compelling evidence is warranted.

5.3 The Differential Performance of the Aware and Unaware Group

Regarding the second research question, this study further explores whether being aware of the hidden rule has any differential impacts on their performance. Participants' performances are measured in three aspects: accuracy rate, confidence rate and reaction time. Caution should be exercised to interpret the results of comparing the aware (N=9) and unaware group (N=31), given the big discrepancy in numbers across the two groups. As predicted, the aware group showed a significantly higher accuracy rate regarding the hidden rule than the unaware group, while a similar accuracy rate regarding the explicit rule with the unaware group. Such a better performance could be explained by the fact that the nine participants were aware of the hidden rule at the end of the experiment.

There is a difference in their confidence rate of target items, generalisation items, correct-answered items and incorrect-answered items. In general, the aware group was inclined towards a higher confidence rate of both generalisation and target items as well as correct-answered and incorrect-answered items than the unaware group, but this was not statistically significant. For the unaware group, these types of confidence rates were significantly different from each other, but the differences were not statistically significant for the aware group. This result is perhaps not surprising in light of the aware group who obtained the consciousness of the hidden rule possibly tended to express higher confidence rates of both generalisation items and target items. Compared with the aware group, the unaware group incapable of freely explicating the hidden rule showed a higher confidence rate concerning the explicit rule but a relatively lower confidence rate regarding the implicit rule.

Moreover, an unexpectedly strong correlation was detected between the confidence rate of correct-answered items and incorrect-answered items among the unaware group. Another strong correlation was observed between the confidence rate of target items and generalisation items among the aware group. The results might be attributable to participants' individual differences in personal

characteristics. That is to say that some more radical participants seemingly preferred giving a higher confidence rate across all test items, whereas other more conservative participants possibly leaned toward a lower confidence rate across all test items. This assumption is supported by psychological literature. For instance, Judge and Bono (2001) touched on individuals with high self-esteem and high self-efficacy tended to exhibit higher confidence in their decisions. Similarly, Kleitman and Stankov (2007) found that individuals who were high in openness to experience and conscientiousness tended to be more confident in their decisions.

When it comes to the reaction time, the aware group's reaction time to target items was less than the unaware group's despite not reaching statistical significance. This result may be due to the aware group's consciousness of the hidden rule. Participants who grasped the hidden rule might be less reliant on intuition or rote memory of individual items in the posttest, facilitating their quicker decisions. However, the unaware group was likely to spend more time hesitating about their answers. This pertinently resonated with Evan's study (2008), arguing that explicit knowledge, involving clear rules, was consciously accessible and likely to be applied quickly in decision-making. Also, Kahneman (2011) claimed that explicit knowledge led to faster decisions with well-understood rules, whereas intuition or rote memory demanded more time for pattern recognition and memory retrieval.

Similar to the confidence rate, there is a strong correlation between the reaction time of target items and generalisation items, and between the reaction time of correct-answered items and incorrect-answered items in the unaware group. The aware group shares similar results but with a moderate correlation between the reaction time of correct-answered items and incorrect-answered items. Individual differences like personality traits may also account for the correlation results. Some more decisive subjects are likely to make rapid decisions while those more indecisive might need more time for hesitation. In this vein, Matthews and Deary (1998) illustrated that individuals with higher levels of assertiveness and impulsivity seemed to make quicker decisions. Conversely, those prone to overthinking and second-guessing possibly made a decision more slowly.

5.4 The Relationship between Consciousness and Gendered Language Background

The third research question deals with whether L2 learners' consciousness of the hidden rule is related to their prior knowledge of gendered languages. The present study found no relationship between participants' consciousness of the hidden rule and their gendered language background. The result was consistent with Hulstijn's (2002) foundational work on implicit learning, arguing that the implicit learning process was driven by exposure to language inputs and was less influenced by prior explicit knowledge of previously learnt language structures. However, this finding seems to counter Williams' (2004, 2005) previous findings. Williams (2005) indicated that participants whose native languages were gendered languages performed better in the generalisation test. Williams (2004) also pointed out that implicit learning correlated with the number of gendered languages known by participants, and there was also a gender L1 effect. Notably, one must be cautious in interpreting the results of this experiment because of the limited sample size and participants' varying proficiency in gendered languages. Therefore, even though it is claimed here that L2 learners' consciousness of the hidden rule was unrelated to their gendered language background, this topic still awaits future close investigations.

5.5 Pedagogical Implications

The present study might provide some insights into L2 teaching and learning. In general, the findings of this research support the involvement of implicit learning in SLA, especially the acquisition of L2 morphosyntactic structures. Stakeholders relevant to SLA generally pay more attention to explicit learning in classroom settings, while understating the significance of implicit learning or statistical learning in L2 development (Rebuschat & Williams, 2012). Numerous scholars have repeatedly highlighted the potential contributions of implicit learning to multiple aspects of SLA (e.g. for vocabulary see Rebuschat et al., 2021, Yu & Smith, 2007; for phonology see Ge et al., 2024, Thiessen & Erickson, 2013, Brooks et al., 2017; for syntax see Hamrick 2014, Lee, 2023; for grammar see Chen et al., 2022; see also Hu & Plonsky, 2021 for a review). It would be plausible if L2 educators

could provide more opportunities to promote L2 learners' implicit learning or statistical learning in class or after class. For example, Dizon and Thanyawatpokin (2021) advocated L2 language learning with Netflix with an emphasis on the benefits of dual subtitles on vocabulary learning and listening comprehension. Furthermore, it is imperative to underline the necessity of adequate exposure and reinforcement to consolidate implicitly learnt information (Ellis, 2002). It is well-documented that repeated exposure and reinforcement can make the outcomes of implicit learning more accessible and durable over time (Hulstijn, 2001). Apart from that, strengthening implicit learning also enables the acquired knowledge to be applied flexibly across different contexts (Curran & Keele, 1993). Therefore, as L2 teachers attempt to promote learners' implicit learning effects, equal importance should be given to sufficient exposure and consequent reinforcement for learners' long-term retention of acquired language knowledge.

5.6 Limitations

The findings of this study should be interpreted with caution considering the following limitations. The first point lies in the participants' demographic background. This experiment did not let participants self-report their potential history of psychiatric disorders or language disorders due to the absence of relevant ethical approval. Nevertheless, it is perhaps more advisable if this aspect could be given more attention in future studies.

Secondly, the results of this experiment were possibly influenced by self-report bias. In the test task, participants were asked to self-report their confidence rate and decision basis. However, Nisbett and Wilson (1977) pointed out that individuals were often unaware of the cognitive processes that underlay their thoughts and behaviour. As a result, self-reports to some extent may be inaccurate since respondents may not have introspective access to the true causes of their behaviour. In addition, Bradburn and Shevell (1987) mentioned that respondents often reconstructed their past experiences based on later beliefs or feelings, which could comprise the reliability and validity of self-report data. In this experiment, participants self-reported their confidence rate and decision basis after they had

made a decision. In this way, potential memory deviation may distort the data.

Thirdly, the debriefing report was adopted in this experiment to examine participants' awareness of the hidden rule, which was associated with inherent limitations. Fincham and Hewstone (2001) highlighted that debriefing sometimes led participants to reinterpret their experiences in a way that aligned with the experimenter's expectations, rather than their true initial reactions. Similarly, Ross (1984) found that participants often provided socially desirable responses and failed to accurately recall their thoughts during the experiment, which potentially resulted in incomplete debriefing results. These inherent limitations of debriefing potentially exerted impacts on final findings.

Fourth, this experiment seems to be not sensitive enough to determine whether participants implicitly learnt the hidden rule first and then developed the awareness of it, or they became aware of the hidden rule first and then learnt the hidden rule. Additionally, participants' subjective responses in the debriefing appear to be insufficient to specify at what point in the experiment the L2 learners became aware of the hidden rule or at what point in the experiment they implicitly learnt the hidden rule. Further research is still needed to elucidate these aspects.

Fifth, this experiment was performed entirely online. Although the experimenter had closely reviewed the gathered data, it is still possible that some participants did not pay enough attention to the training items during the exposure phase which undermined implicit learning effects. What's more, participants completed this experiment remotely on their own, which means that their located settings were perhaps hugely varied and out of control. Presumably, this also affected their performance during the experiment and the ensuing results of the present study.

5.7 Future Research Directions

Having discussed the findings and limitations of the present study, some suggestions can be given

for future studies. The ‘reflection-based’ test task adopted in this experiment might virtually assess the final outcomes of the complex cognitive process underlying implicit learning but provide limited information about how implicit learning occurred during the exposure phase (Jenkins, 2022, p. 34). In addition, as discussed in Section 5.2, participants were asked to make explicit decisions in the ‘reflection-based’ test tasks that required conscious reflections about what had been learnt. In this way, this approach largely measured learning that individuals could explicitly access but may not be applicable to check the implicit knowledge that had been acquired (Christiansen, 2019). In further work, it would be interesting to employ the ‘process-based’ test task, such as the Serial Reaction Time task or Serial Recall task, to provide more insights into the role of implicit learning in SLA. Nonetheless, it is worth reiterating that the present study chose to utilise the ‘reflection-based’ test task since the sensitivity of ‘processing-based’ test tasks heavily relied on located experimental contexts (Vaquero et al., 2006), whereas this experiment was administered entirely online and participants’ surrounding contexts were out of control. This is likely to undermine the reliability of results drawn from ‘processing-based’ test tasks.

In terms of statistical analysis methods, Bayes Factor Analysis serves as a promising statistical tool that can tap closer into implicit learning in SLA. Unlike traditional hypothesis testing, which only provides a binary decision (i.e. reject or fail to reject the null hypothesis), Bayes Factor Analysis characterises a continuous measure of evidence for one model over another (Kass & Raftery, 1995, Hoijtink et al., 2008). This allows for more nuanced findings. Considering the unconscious nature of implicit learning, which is intricate to detect and measure, Bayes Factor Analysis is likely to offer a more refined manner to analyse collected data than traditional p-value tests.

Besides, it has been acknowledged that the transfer of knowledge acquired in receptive modalities to the use of knowledge in productive modalities seems weak (Hulstijn, 2002). So far, existing studies mostly focus on implicit learning effects through passive exposure to training items and check the learning outcomes in posttest. Future research could combine comprehension and

production test tasks to examine whether receptive knowledge can be transferred to productive knowledge in the process of implicit learning. Apart from that, this study primarily checks whether implicit learning effects can be obtained at the retrieval phase. Further empirical studies are necessary to monitor the presence of implicit learning and the conscious status of knowledge at both the encoding and recalling stages. Generally speaking, it is still unclear what aspects of L2 can and cannot be acquired as a mere result of exposure without explicit treatments. Considerably more empirical evidence is desperately needed before the precise role of implicit learning in SLA can be fully determined.

Chapter 6 Conclusion

The present study aimed to investigate the role of implicit learning in the acquisition of L2 morphosyntax drawing on an artificial-determiner paradigm developed by Williams (2005). Williams and his coworkers provided positive evidence supporting the involvement of implicit learning in grammatical form-meaning mappings. Chen et al. (2011) confirmed Williams' (2005) findings with Chinese phrases as experimental materials. Nevertheless, Hama and Leow (2010) revisited Williams' (2005) study utilising think-aloud protocols, finding participants could not learn novel form-meaning connections implicitly. Regarding the mixed results, this study first critically reviewed Williams' (2004, 2005) series of studies and pointed out several existing methodological flaws. Given this, the present study implemented corresponding methodological improvements to provide more robust evidence on this topic.

In addition, these existing studies mostly focus on implicit learning effects in native languages. For example, Williams' seminal studies (2004, 2005, 2009) tested the performance of English native speakers with English experimental materials. Likewise, Chen et al. (2011) worked with Chinese native speakers utilising Chinese experimental materials. However, this study revolved around implicit learning in SLA, especially the L2 morphosyntactic structures. Forty participants recruited in this experiment were therefore Chinese native speakers with English as their L2, while all instructions and experimental materials were in English. It was expected to examine whether previous findings by Williams and his colleagues (2004, 2005, 2009) can be extended from native language to second language.

Another point is that Williams' (2005) work mentioned the potential interaction between implicit learning and learners' gendered language background. It is reported that subjects' prior knowledge of gendered languages seems to facilitate implicit learning, no matter whether their L1 or L2 is a gendered language. However, this effect is not obtained in his more recent research. Considering this, the present study also inquired into the relationship between L2 learners' consciousness of the hidden

rule and their gendered language background. In view of the aforementioned research background, this research centred on three research questions: 1) Whether L2 learners can learn a hidden rule of an artificial-determiner system implicitly, 2) Whether L2 learners are aware of the hidden rule and whether being aware has any differential impacts on their performance, 3) Whether L2 learners' consciousness of the hidden rule is related to their prior knowledge of gendered languages.

A mixed method was employed to address the above three research questions. As for the first question, the present study conceptually replicated and extended prior work by Williams (2004, 2005), Leung and Williams (2011) and Chen et al. (2011), lending support to the occurrence of implicit learning in acquiring L2 morphosyntactic structures. Thirty-one out of forty participants remained unaware of the hidden rule at the end of the experiment, but their accuracy rate of target items was significantly above the chance level. Simultaneously, there was no correlation between the accuracy rate and confidence rate of target items. According to the zero-correlation criterion (Dienes & Berry, 1997) and the guessing criterion (Cheesman & Merikle, 1984), the unaware participants implicitly learnt the hidden rule of the artificial-determiner system. With regard to the second question, the aware participants showed a significantly higher accuracy rate of target items than the unaware participants. Also, the aware group generally exhibited a higher confidence rate of generalisation and target items compared with the unaware group. In terms of the third question, no relationship was found between participants' consciousness of the hidden rule and their gendered language background.

Taken together, these findings may contribute to a better understanding of implicit learning in SLA, especially the acquisition of L2 morphosyntax. Regarding the open-ended questions that which language aspects can or cannot be learnt implicitly, the present study provided positive evidence for the assumption that L2 morphosyntactic structures, free grammatical morphemes in particular, were likely to be learnt implicitly by L2 learners. L2 teachers, apart from explicit instructions, could pay more attention to L2 learners' implicit learning effect in classroom settings or outside of class. All in

all, this exploratory study serves as a preliminary attempt to shed light on the role of implicit learning in SLA. There is still ample room for further progress in determining the precise role of implicit learning in SLA.

References

- Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological Review*, 89(4), 369.
- Anderson, J. R., & Lebiere, C. (1998). *The Atomic Components of Thought*. Lawrence Erlbaum Associates Publishers.
- Andringa, S., & Rebuschat, P. (2015). New directions in the study of implicit and explicit learning: An introduction. *Studies in Second Language Acquisition*, 37(2), 185-196.
- Arciuli, J. (2018). Reading as statistical learning. *Language, Speech, and Hearing Services in Schools*, 49(3), 634-643.
- Bauer, L. (1983). *English Word-formation*. Cambridge University Press.
- Batterink, L. J., Reber, P. J., Neville, H. J., & Paller, K. A. (2015a). Implicit and explicit contributions to statistical learning. *Journal of Memory and Language*, 83, 62-78.
- Batterink, L. J., Reber, P. J., & Paller, K. A. (2015b). Functional differences between statistical learning with and without explicit training. *Learning & Memory*, 22(11), 544-556.
- Berry, D. C. (1987). The problem of implicit knowledge. *Expert Systems*, 4(3), 144-151.
- Berry, D. C., & Dienes, Z. (1993). *Implicit Learning: Theoretical and Empirical Issues*. Lawrence Erlbaum Associates.
- Bell, P. K. (2017). Explicit and implicit learning: Exploring their simultaneity and immediate effectiveness. *Applied Linguistics*, 38(3), 297-317.
- Bialystok, E. (1982). On the relationship between knowing and using linguistic forms¹. *Applied Linguistics*, 3(3), 181-206.
- Bialystok, E., & Ryan, E. B. (1985). Toward a definition of metalinguistic skill. *Merrill-Palmer Quarterly*, 31(3), 229-251.
- Bucholtz, M., & Hall, K. (2005). Identity and interaction: A sociocultural linguistic approach. *Discourse Studies*, 7(4), 585-614.

- Boers, F. (2000). Metaphor awareness and vocabulary retention. *Applied Linguistics*, 21(4), 553-571.
- Bovolenta, G., & Marsden, E. (2024). The effect of verb surprisal on the acquisition of second language syntactic structures in adults: An artificial language learning study. *Applied psycholinguistics*, 45(1), 110-137.
- Bradburn, N. M., Rips, L. J., & Shevell, S. K. (1987). Answering autobiographical questions: The impact of memory and inference on surveys. *Science*, 236(4798), 157-161.
- Brooks, P. J., Kwoka, N., & Kempe, V. (2017). Distributional effects and individual differences in L2 morphology learning. *Language Learning*, 67(1), 171-207.
- Christiansen, M. H., & Chater, N. (2001). Connectionist psycholinguistics: Capturing the empirical data. *Trends in Cognitive Sciences*, 5(2), 82-88.
- Christiansen, M. H. (2019). Implicit statistical learning: A tale of two literatures. *Topics in Cognitive Science*, 11(3), 468-481.
- Chun, M. M., & Jiang, Y. (1998). Contextual cueing: Implicit learning and memory of visual context guides spatial attention. *Cognitive Psychology*, 36(1), 28-71.
- Chun, M. M., & Jiang, Y. (2003). Implicit, long-term spatial contextual memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 29(2), 224.
- Chen, W., Guo, X., Tang, J., Zhu, L., Yang, Z., & Dienes, Z. (2011). Unconscious structural knowledge of form-meaning connections. *Consciousness and Cognition*, 20, 1751-1760.
- Chen, Y., Li, L., Wang, M., & Wang, R. (2022). Which cognitive factors predict L2 grammar learning: Cognitive control, statistical learning, working memory, or attention. *Frontiers in Psychology*, 13, 943988.
- Cheesman, J., & Merikle, P. M. (1984). Priming with and without awareness. *Perception & Psychophysics*, 36(4), 387-395.
- Cintrón-Valentín, M., & Ellis, N. C. (2015). Exploring the interface: Explicit focus-on-form instruction and learnt attentional biases in L2 Latin. *Studies in Second Language*

Acquisition, 37(2), 197-235.

Cleeremans, A., Destrebecqz, A., & Boyer, M. (1998). Implicit learning: News from the front. *Trends in Cognitive Sciences*, 2(10), 406-416.

Cohen, J. (1977). *Statistical Power Analysis for the Behavioral Sciences*. Lawrence Erlbaum Associates.

Cook, T. D., Campbell, D. T., & Day, A. (1979). *Quasi-experimentation: Design & Analysis Issues for Field Settings*. Boston: Houghton Mifflin.

Conway, C. M. (2020). How does the brain learn environmental structure? Ten core principles for understanding the neurocognitive mechanisms of statistical learning. *Neuroscience & Biobehavioral Reviews*, 112, 279-299.

Curran, T., & Keele, S. W. (1993). Attentional and nonattentional forms of sequence learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 19(1), 189-202.

Danesi, M. (1995). Learning and teaching languages: The role of “conceptual fluency”. *International Journal of Applied Linguistics*, 5(1), 3-20.

DeKeyser, R. M. (1995). Learning second language grammar rules: An experiment with a miniature linguistic system. *Studies in Second Language Acquisition*, 17(3), 379-410.

DeKeyser, R. M. (1998). Beyond focus on form: Cognitive perspectives on learning and practicing second language grammar. In C. Doughty & J. Williams (Eds.), *Focus on Form in Classroom Second Language Acquisition* (pp. 42-63). Cambridge University Press.

DeKeyser, R. (2003). Explicit and implicit learning. In C. Doughty, & M. H. Long (Eds.). *The Handbook of Second Language Acquisition* (pp. 313-348). Blackwell.

DeKeyser, R., & Larson-Hall, J. (2005). What does the critical period really mean?. In J. F. Kroll & A. M. B. de Groot (Eds.), *Handbook of Bilingualism: Psycholinguistic Approaches* (pp. 88-108). Oxford University Press.

DeKeyser, R.M. (2007) *Practice in a Second Language: Perspectives from Applied Linguistics and*

Cognitive Psychology. Cambridge University Press.

- Dienes, Z., & Berry, D. (1997). Implicit learning: Below the subjective threshold. *Psychonomic Bulletin & Review*, 4, 3-23.
- Dienes, Z., & Perner, J. (1999). A theory of implicit and explicit knowledge. *Behavioral and Brain Sciences*, 22(5), 735-808.
- Dienes, Z., & Scott, R. (2005). Measuring unconscious knowledge: Distinguishing structural knowledge and judgment knowledge. *Psychological Research*, 69, 338-351.
- Dienes, Z. (2012). Conscious versus unconscious learning of structure. *Statistical Learning and Language Acquisition*, 1, 337-364.
- Dizon, G., & Thanyawatpokin, B. (2021). Language learning with Netflix: Exploring the effects of dual subtitles on vocabulary learning and listening comprehension. *Computer-Assisted Language Learning Electronic Journal*, 22(3), 52-65.
- Ellis, N. (1993). Rules and instances in foreign language learning: Interactions of explicit and implicit knowledge. *European Journal of Cognitive Psychology*, 5(3), 289-318.
- Ellis, R. (1994). *The Study of Second Language Acquisition*. Oxford University Press.
- Ellis, R. (2001). Introduction: Investigating form-focused instruction. *Language Learning*, 51, 1-46.
- Ellis, N. C. (2002). Frequency effects in language processing: A review with implications for theories of implicit and explicit language acquisition. *Studies in Second Language Acquisition*, 24(2), 143-188.
- Ellis, R. (2004). The definition and measurement of L2 explicit knowledge. *Language Learning*, 54(2), 227-275.
- Ellis, R. (2005a). Measuring implicit and explicit knowledge of a second language: A psychometric study. *Studies in Second Language Acquisition*, 27(2), 141-172.
- Ellis, N. C. (2005b). At the interface: Dynamic interactions of explicit and implicit language knowledge. *Studies in Second Language Acquisition*, 27(2), 305-352.

- Ellis, N. C. (2006). Selective attention and transfer phenomena in L2 acquisition: Contingency, cue competition, salience, interference, overshadowing, blocking, and perceptual learning. *Applied Linguistics*, 27(2), 164-194.
- Ellis, R. (2009). Implicit and explicit learning, knowledge and instruction. In R. Ellis, S. Loewen, C. Elder, H. Reinders, R. Erlam & J. Philp (Eds.). *Implicit and Explicit Knowledge in Second Language Learning, Testing and Teaching* (pp. 3-26). Multilingual Matters.
- Ellis, N. C. (2013). Second language acquisition. In P. Robinson (Ed.), *The Routledge Encyclopedia of Second Language Acquisition* (pp. 36-37). Routledge.
- Ericsson, K. A., & Simon, H. A. (1993). *Protocol Analysis: Verbal Reports as Data*. The MIT Press.
- Erlam, R. (2024). Implicit and explicit knowledge in English language learning. In A. Cirocki, B. Indrarathne & S. McCulloch (Eds.). *Cognitive and Educational Psychology for TESOL: A Guide for Practitioners* (pp. 109-127). Springer Nature Switzerland.
- Esteki, B. (2014). The relationship between implicit and explicit knowledge and second language proficiency. *Theory and Practice in Language Studies*, 4(7), 1520-1525.
- Evans, J. St. B. T. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology*, 59, 255-278.
- Fincham, F. D., & Hewstone, M. (2001). Attribution theory and research: From basic to applied. In M. Hewstone, & W. Stroebe (Eds.). *Introduction to Social Psychology: A European Perspective* (pp.197-238). Blackwell Publishing.
- Fitch, W. T., & Friederici, A. D. (2012). Artificial grammar learning meets formal language theory: an overview. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 367(1598), 1933-1955.
- Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics*. SAGE Publications.
- Forkstam, C., & Petersson, K. M. (2005). Towards an explicit account of implicit learning. *Current Opinion in Neurology*, 18(4), 435-441.

- Frensch, P. A. (1998). *One Concept, Multiple Meanings: On How to Define the Concept of Implicit Learning*. Sage Publications.
- Frensch, P. A., & Runger, D. (2003). Implicit learning. *Current Directions in Psychological Science*, *12*(1), 13-18.
- Frensch, P. A., Haider, H., Runger, D., Neugebauer, U., Voigt, S., & Werg, J. (2003). The route from implicit learning to verbal expression of what has been learnt: Verbal report of incidentally experienced environmental regularity. In L. Jimenez (Ed.). *Attention and Implicit Learning* (pp. 335-366). John Benjamins Publishing Company.
- Frost, R. L., & Monaghan, P. (2016). Simultaneous segmentation and generalisation of non-adjacent dependencies from continuous speech. *Cognition*, *147*, 70-74.
- Fu, Q., Fu, X., & Dienes, Z. (2008). Implicit sequence learning and conscious awareness. *Consciousness and Cognition*, *17*(1), 185-202.
- Fu, Q., Dienes, Z., & Fu, X. (2010). Can unconscious knowledge allow control in sequence learning?. *Consciousness and Cognition*, *19*(1), 462-474.
- Gardner, H. (1974). Metaphors and modalities: How children project polar adjectives onto diverse domains. *Child Development*, *45*(1), 84-91.
- Gentner, D. (1988). Metaphor as structure mapping: The relational shift. *Child Development*, *59*(1), 47-59.
- George, D. and Mallery, P. (2010) *SPSS for Windows Step by Step: A Simple Guide and Reference* (10th ed.). Pearson.
- Ge, Y., Monaghan, P., & Rebuschat, P. (2024). The role of phonology in non-native word learning: Evidence from cross-situational statistical learning. *Bilingualism: Language and Cognition*, 1-16.
- Gibbs, R. W. (1994). *The Poetics of Mind: Figurative Thought, Language, and Understanding*. Cambridge University Press.

- Gigerenzer, G., & Gaissmaier, W. (2011). Heuristic decision making. *Annual Review of Psychology*, 62, 451-482.
- Gomez, R. L., & Gerken, L. (2000). Infant artificial grammar learning: Reconsidering the evidence. *Developmental Science*, 3(3), 359-382.
- Godfroid, A., Loewen, S., Jung, S., Park, J. H., Gass, S., & Ellis, R. (2015). Timed and untimed grammaticality judgments measure distinct types of knowledge: Evidence from eye-movement patterns. *Studies in Second Language Acquisition*, 37(2), 269-297.
- Green, R. E., & Shanks, D. R. (1993). On the existence of independent explicit and implicit learning systems: An examination of some evidence. *Memory & Cognition*, 21, 304-317.
- Grey, S., Williams, J. N., & Rebuschat, P. (2014). Incidental exposure and L3 learning of morphosyntax. *Studies in Second Language Acquisition*, 36(4), 611-645.
- Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. *Journal of Experimental Psychology: General*, 108(3), 356-388.
- Hama, M., & Leow, R. P. (2010). Learning without awareness revisited: Extending Williams (2005). *Studies in Second Language Acquisition*, 32(3), 465-491.
- Hamrick, P. & Rebuschat, P. (2011). How implicit is statistical learning?. In P. Rebuschat & J. Williams (Eds.). *Statistical Learning and Language Acquisition* (pp. 365-382). De Gruyter Mouton.
- Hamrick, P. (2014). A role for chunk formation in statistical learning of second language syntax. *Language Learning*, 64(2), 247-278.
- Hebb, D. O. (1949). *The Organization of Behavior: A Neuropsychological Theory*. New York: Wiley.
- Hogarth, R. M. (1987). *Judgement and Choice: The Psychology of Decision* (2nd ed.). John Wiley & Sons.
- Hojtink, H., Klugkist, I., & Boelen, P. A. (2008). *Bayesian Evaluation of Informative Hypotheses*. Springer.

- Hulstijn, J. H. (2001). Intentional and incidental second language vocabulary learning: A reappraisal of elaboration, rehearsal, and automaticity. In P. Robinson (Ed.), *Cognition and Second Language Instruction* (pp. 258-286). Cambridge University Press.
- Hulstijn, J. (2002). Towards a unified account of the representation, processing and acquisition of second language knowledge. *Second Language Research*, 18(3), 193-223.
- Hulstijn, J. H. (2005). Theoretical and empirical issues in the study of implicit and explicit second-language learning: Introduction. *Studies in Second Language Acquisition*, 27(2), 129-140.
- Hu, Y., & Plonsky, L. (2021). Statistical assumptions in L2 research: A systematic review. *Second Language Research*, 37(1), 171-184.
- Jamieson, R. K., & Mewhort, D. J. K. (2005). On the theory and data for implicit learning. *Behavioral and Brain Sciences*, 28(1), 23-24.
- Jenkins, H. E. (2022). *Processing-based measures of implicit statistical learning of artificial grammars* [Unpublished doctoral dissertation]. University of Newcastle.
- Jenkins, H., Riches, N. G., Wilson, B., & de Graaf, Y. (preprint). Assessing serial recall as a measure of artificial grammar learning. OSF.
- Judge, T. A., & Bono, J. E. Individuals commonly resorted to multiple decision bases when making a judgment in the test task. *Journal of Applied Psychology*, 86(1), 80-92.
- Kass, R. E., & Raftery, A. E. (1995). Bayes factors. *Journal of the American Statistical Association*, 90(430), 773-795.
- Kahneman, D. (2011). *Thinking, Fast and Slow*. Farrar, Straus and Giroux.
- Kim, K. M., & Godfroid, A. (2023). The interface of explicit and implicit second-language knowledge: A longitudinal study. *Bilingualism: Language and Cognition*, 26(4), 709-723.
- Kidd, E. (2012). Implicit statistical learning is directly associated with the acquisition of syntax. *Developmental Psychology*, 48(1), 171.
- Kleitman, S., & Stankov, L. (2007). Self-confidence and metacognitive processes. *Learning and*

Individual Differences, 17(2), 161-173.

Knowlton, B. J., & Squire, L. R. (1996). Artificial grammar learning depends on implicit acquisition of both abstract and exemplar-specific information. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 22(1), 169-181.

Krashen, S. (1981). Second language acquisition. *Second Language Learning*, 3(7), 19-39.

Krashen, S. D. (1982). *Principles and Practice in Second Language Acquisition*. Oxford: Pergamon Press.

Krashen, S. (1985). *The Input Hypothesis: Issues and Implications*. Longman.

Krashen, S. (1992). The input hypothesis: An update. In J. Alatis (Ed.). *Linguistics and Language Pedagogy: The State of the Art* (pp. 409-431). Georgetown University Press.

Lazar, G. (1996). Using figurative language to expand students' vocabulary. *ELT Journal*, 50(1), 43-51.

Lambert, A. J., & Sumich, A. L. (1996). Spatial orienting controlled without awareness: A semantically based implicit learning effect. *The Quarterly Journal of Experimental Psychology Section A*, 49(2), 490-518.

Lambert, T. (2003). Visual orienting, learning and conscious awareness. In L. Jiménez (Ed.). *Attention and Implicit Learning* (pp. 253-275). John Benjamins Publishing Company.

Leow, R. P. (1997). Attention, awareness, and foreign language behavior. *Language Learning*, 47(3), 467-505.

Leow, R. P. (2000). A study of the role of awareness in foreign language behavior: Aware versus unaware learners. *Studies in Second Language Acquisition*, 22(4), 557-584.

Leow, R. P., & Hama, M. (2013). Implicit learning in SLA and the issue of internal validity: A response to Leung and Williams's (2011) "The implicit learning of mappings between forms and contextually derived meanings". *Studies in Second Language Acquisition*, 35(3), 545-557.

Leow, R. P., Grey, S., Marijuan, S., & Moorman, C. (2014). Concurrent data elicitation procedures,

- processes, and the early stages of L2 learning: A critical overview. *Second Language Research*, 30(2), 111-127.
- Leung, J. H., & Williams, J. N. (2011). The implicit learning of mappings between forms and contextually derived meanings. *Studies in Second Language Acquisition*, 33(1), 33-55.
- Leung, J. H., & Williams, J. N. (2012). Constraints on implicit learning of grammatical form-meaning connections. *Language Learning*, 62(2), 634-662.
- Lee, O. S. (2023). Implicit statistical learning in L2 sentence processing: Individual cognitive differences. *Journal of Psycholinguistic Research*, 52(4), 1037-1060.
- Littlemore, J., & Low, G. (2006). *Figurative Thinking and Foreign Language Learning*. Palgrave Macmillan.
- Li, F., Guo, X., Zhu, L., Yang, Z., & Dienes, Z. (2013). Implicit learning of mappings between forms and metaphorical meanings. *Consciousness and Cognition*, 22(1), 174-183.
- Liu, Y., Gao, C., Wang, P., Friederici, A. D., Zaccarella, E., & Chen, L. (2023). Exploring the neurobiology of merge at a basic level: Insights from a novel artificial grammar paradigm. *Frontiers in Psychology*, 14, 1151518.
- Llanes, À., & Muñoz, C. (2009). A short stay abroad: Does it make a difference?. *System*, 37(3), 353-365.
- Mathews, R. C., Buss, R. R., Stanley, W. B., Blanchard-Fields, F., Cho, J. R., & Druhan, B. (1989). Role of implicit and explicit processes in learning from examples: A synergistic effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15(6), 1083.
- Matthews, G., Deary, I. J., & Whiteman, M. C. (2009). The trait concept and personality theory. In G. Matthews, I. J. Deary, & M. C. Whiteman (Eds.). *Personality Traits* (pp. 3-41). Cambridge University Press.
- Manser, M. H. (2010). *Concise English-Chinese Chinese-English Dictionary*. Commercial Press.
- Mealor, A. D., & Dienes, Z. (2012). Conscious and unconscious thought in artificial grammar

learning. *Consciousness and Cognition*, 21(2), 865-874.

Moroshkina, N. V., Ivanchei, I. I., Karpov, A. D., & Ovchinnikova, I. (2019). The verbalization effect on implicit learning. In A. Cleeremans, V. Allakhverdov, & M. Kuvaldina (Eds.). *Implicit Learning: 50 years on* (pp. 189-207). Routledge.

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review*, 84(3), 231-259.

Nissen, M. J., & Bullemer, P. (1987). Attentional requirements of learning: Evidence from performance measures. *Cognitive Psychology*, 19(1), 1-32.

Norman, E., Scott, R. B., Price, M. C., Jones, E., & Dienes, Z. (2019). Can unconscious structural knowledge be strategically controlled? In A. Cleeremans, V. Allakhverdov, & M. Kuvaldina (Eds.). *Implicit Learning: 50 Years on* (pp. 159-173). Routledge.

Online Oxford English Dictionary, retrieved on 27th August 2024 from <https://www.oed.com>.

Paradis, M. (1994). Neurolinguistic aspects of implicit and explicit memory: Implications for bilingualism. In N. Ellis (Ed.). *Implicit and Explicit Learning of Second Languages* (pp. 393-419). London Academic Press.

Pajak, B., Fine, A. B., Kleinschmidt, D. F., & Jaeger, T. F. (2016). Learning additional languages as hierarchical probabilistic inference: Insights from first language processing. *Language Learning*, 66(4), 900-944.

Peterson, M. S., & Kramer, A. F. (2001). Attentional guidance of the eyes by contextual information and abrupt onsets. *Perception & Psychophysics*, 63(7), 1239-1249.

Pelucchi, B., Hay, J. F., & Saffran, J. R. (2009). Statistical learning in a natural language by 8-month-old infants. *Child Development*, 80(3), 674-685.

Reber, A. S. (1967). Implicit learning of artificial grammars. *Journal of Verbal Learning and Verbal Behavior*, 6(6), 855-863.

Reber, A. S. (1976). Implicit learning of synthetic languages: The role of instructional set. *Journal*

of Experimental Psychology: Human Learning and Memory, 2(1), 88-94.

Reber, A. S., & Allen, R. (1978). Analogic and abstraction strategies in synthetic grammar learning: A functionalist interpretation. *Cognition*, 6(3), 189-221.

Reber, A. S., Kassin, S. M., Lewis, S., & Cantor, G. (1980). On the relationship between implicit and explicit modes in the learning of a complex rule structure. *Journal of Experimental Psychology: Human Learning and Memory*, 6(5), 492.

Reber, A. S., Allen, R., & Regan, S. (1985). Syntactical learning and judgment, still unconscious and still abstract: Comment on Dulany, Carlson, and Dewey. *Journal of Experimental Psychology: General*, 114(1), 17-24.

Reber, A. S. (1989). Implicit learning and tacit knowledge. *Journal of Experimental Psychology: General*, 118(3), 219.

Reber, A. S. (1993). *Implicit Learning and Tacit Knowledge: An Essay on the Cognitive Unconscious*. Oxford University Press.

Rebuschat, P. (2008). *Implicit learning of natural language syntax* [Unpublished doctoral dissertation]. University of Cambridge.

Rebuschat, P., & Williams, J. N. (2012). Implicit and explicit knowledge in second language acquisition. *Applied Psycholinguistics*, 33(4), 829-856.

Rebuschat, P. (2013). Measuring implicit and explicit knowledge in second language research. *Language Learning*, 63(3), 595-626.

Rebuschat, P., Monaghan, P., & Schoetensack, C. (2021). Learning vocabulary and grammar from cross-situational statistics. *Cognition*, 206, 104475.

Ross, B. H. (1984). Reminders and their effects in learning a cognitive skill. *Cognitive Psychology*, 16, 371-416.

Robinson, P. (1995). Attention, memory, and the “noticing” hypothesis. *Language Learning*, 45(2), 283-331.

- Roehr, K. (2008). Linguistic and metalinguistic categories in second language learning. *Cognitive Linguistics*, 19(1), 67-106.
- Romberg, A. R., & Saffran, J. R. (2010). Statistical learning and language acquisition. *Wiley Interdisciplinary Reviews: Cognitive Science*, 1(6), 906-914.
- Saffran, J. R., Aslin, R. N., & Newport, E. L. (1996). Statistical learning by 8-month-old infants. *Science*, 274(5294), 1926-1928.
- Schmidt, R. W. (1990). The role of consciousness in second language learning. *Applied Linguistics*, 11(2), 129-158.
- Schmidt, R. (1993). Awareness and second language acquisition. *Annual Review of Applied Linguistics*, 13, 206-226.
- Schmidt, R. (1994). Deconstructing consciousness in search of useful definitions for applied linguistics. *Consciousness in Second Language Learning*, 11, 237-326.
- Schmidt, R. (1995). Consciousness and foreign language learning: A tutorial on the role of attention and awareness in learning. In R. Schmidt (Ed.). *Attention and Awareness in Foreign Language Learning* (pp. 1-63). University of Hawaii Press.
- Schmidt, R. (2001). Attention. In P. Robinson (Ed.), *Cognition and Second Language Instruction* (pp. 3-32). Cambridge University Press.
- Scott, R. B., & Dienes, Z. (2008). The conscious, the unconscious, and familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 34(5), 1264.
- Scott, R. B., & Dienes, Z. (2010a). Knowledge applied to new domains: The unconscious succeeds where the conscious fails. *Consciousness and Cognition*, 19(1), 391-398.
- Scott, R. B., & Dienes, Z. (2010b). Fluency does not express implicit knowledge of artificial grammars. *Cognition*, 114(3), 372-388.
- Segalowitz, N. (2003). Automaticity and second languages. In C. Doughty, & M. H. Long (Eds.). *The Handbook of Second Language Acquisition* (pp. 382-408). Blackwell.

- Segalowitz, N., & Hulstijn, J. (2005). Automaticity in bilingualism and second language learning. In J. F. Kroll & A. M. B. de Groot (Eds.), *Handbook of Bilingualism: Psycholinguistic Approaches* (pp. 371-388). Oxford University Press.
- Stevick, E. W. (1974). Language instruction must do an about-face. *The Modern Language Journal*, 58(8), 379-384.
- Sutton, R. S., & Barto, A. G. (1998). *Reinforcement Learning: An Introduction*. Cambridge: MIT Press.
- Thompson, S. P., & Newport, E. L. (2007). Statistical learning of syntax: The role of transitional probability. *Language learning and development*, 3(1), 1-42.
- Thothathiri, M., & Rattiner, M. G. (2016). Acquiring and producing sentences: Whether learners use verb-specific or verb-general information depends on cue validity. *Frontiers in Psychology*, 7, 404.
- Thiessen, E. D., & Erickson, L. C. (2013). Beyond word segmentation: A two-process account of statistical learning. *Current Directions in Psychological Science*, 22(3), 239-243.
- Tunney, R. J., & Altmann, G. (2001). Two modes of transfer in artificial grammar learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 27(3), 614.
- Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases in judgments reveal some heuristics of thinking under uncertainty. *Science*, 185(4157), 1124-1131.
- Ullman, M. T. (2001). The declarative/procedural model of lexicon and grammar. *Journal of Psycholinguistic Research*, 30(1), 37-69.
- Ullman, M. T. (2004). Contributions of memory circuits to language: The declarative/procedural model. *Cognition*, 92(1), 231-270.
- Ullman, M. T. (2016). The declarative/procedural model: A neurobiological model of language learning, knowledge, and use. In G. Hickok, & S. L. Small (Eds.). *Neurobiology of Language* (pp. 953-968). Academic Press.

- Vaquero, J. M., Jiménez, L., & Lupiáñez, J. (2006). The problem of reversals in assessing implicit sequence learning with serial reaction time tasks. *Experimental Brain Research*, 175, 97-109.
- VanPatten, B., & Williams, J. (2014). *Theories in Second Language Acquisition: An Introduction (2nd ed.)*. Routledge.
- VanPatten, B., & Smith, M. (2022). *Explicit and Implicit Learning in Second Language Acquisition*. Cambridge University Press.
- Vosniadou, S., & Ortony, A. (1983). The emergence of the literal-metaphorical-anomalous distinction in young children. *Child Development*, 54(1), 154-161.
- Wan, L., Dienes, Z., & Fu, X. (2008). Intentional control based on familiarity in artificial grammar learning. *Consciousness and Cognition*, 17(4), 1209-1218.
- Winner, E. (1979). New names for old things: The emergence of metaphoric language. *Journal of Child Language*, 6(2), 469-491.
- Williams, J. N. (2004). Implicit learning of form-meaning connections. In J. Williams, B. VanPatten, S. Rott, & M. Overstreet (Eds.). *Form Meaning Connections in Second Language Acquisition* (pp. 203-218). Lawrence Erlbaum Associates.
- Williams, J. N. (2005). Learning without awareness. *Studies in Second Language Acquisition*, 27, 269-304.
- Williams, J. N. (2009). Implicit learning in second language acquisition. In W. C. Ritchie, & T. K. Bhatia (Eds.). *The New Handbook of Second Language Acquisition* (pp. 319-353). Brill.
- Williams, J. & Rebuschat, P. (2011). Statistical learning and syntax: What can be learnt, and what difference does meaning make. In P. Rebuschat & J. Williams (Ed.), *Statistical Learning and Language Acquisition* (pp. 237-264). Berlin, Boston: De Gruyter Mouton.
- Williams, J., & Rebuschat, P. (2016). *Implicit Learning and Second Language Acquisition*. Routledge.
- Yu, C., & Smith, L. B. (2007). Rapid word learning under uncertainty via cross-situational

statistics. *Psychological Science*, 18(5), 414-420.

Yusuf, N. H. (2021). Implicit learning in second language acquisition: Insights from neuroscientific data. *Communication and Linguistics Studies*, 7(2), 21-30.

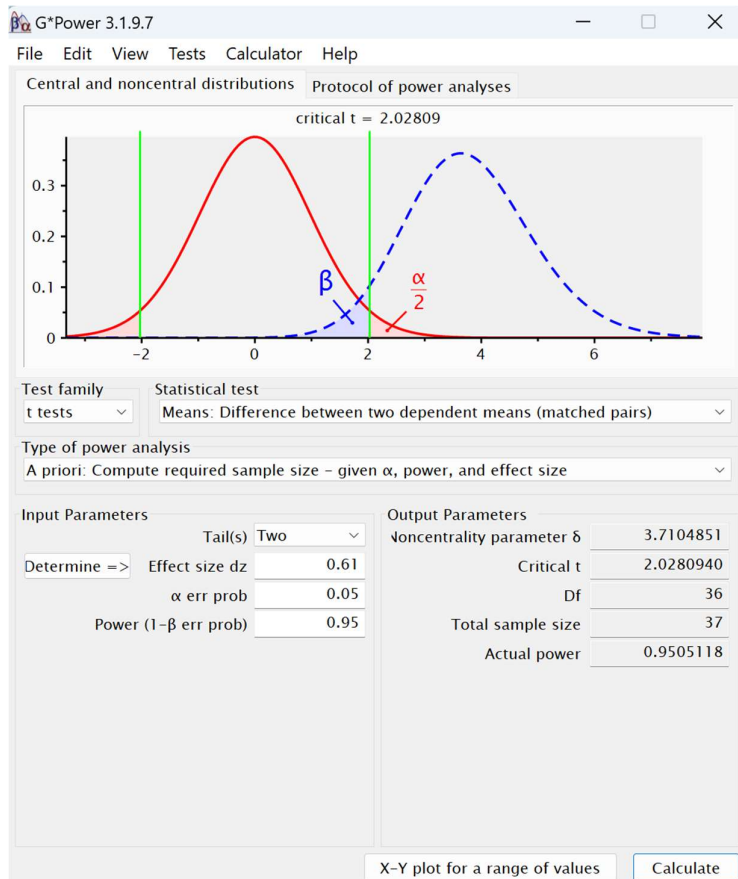
Ziori, E., & Dienes, Z. (2006). Subjective measures of unconscious knowledge of concepts. *Mind & Society*, 5, 105-122.

Zobl, H. (1995). Converging evidence for the 'acquisition-learning' distinction. *Applied Linguistics*, 16(1), 35-56.

Appendix A Statistical Power Calculation with G*Power

A statistical power calculation was conducted using G*Power 3.1 to decide the sample size of this study. According to Cohen (1977), a threshold of power should be set to forestall rejecting the null hypothesis incorrectly (type I error, α), or falsely accepting the null hypothesis (type II error, β). The power analysis suggested that a minimum of 37 participants would be required to achieve 95% power at the $\alpha = .05$ level [$(1-\beta) = .95$] for the main effect. Forty participants were therefore invited to the main experiment.

Figure 6. Statistical Power Calculation with G*Power.



Appendix B Recruitment Message

Hi! I hope you are well. My name is xxx, a postgraduate student at the Department of Education at the University of Oxford. I am conducting a research project with Chinese native speakers and wanted to invite you to participate. The goal of the project is to examine implicit learning in the acquisition of morphosyntax in a second language. There were a series of computer-based tasks to be completed remotely, which might take about 30 mins. Please let me know if you have any questions or need any further information. Many thanks!

Appendix C Demographic Information of Participants

Table 2. Demographic Information of Participants (The First Pilot Study).

Participant ID	Age	Gender	Nationality	Education Level	Native Language	English Proficiency	Knowledge of Other Languages
1	30	Male	China	Undergraduate	Mandarin	C2	N/A
2	22	Female	China	Postgraduate	Mandarin	C2	N/A
3	24	Male	China	Undergraduate	Mandarin	C2	Hungarian, German, French
4	23	Female	China	Undergraduate	Mandarin	C2	Japanese, Spanish, French
5	24	Female	China	Postgraduate	Mandarin	C2	French, Cantonese, Thai
6	22	Female	China	Postgraduate	Mandarin	C2	N/A
7	23	Female	China	Postgraduate	Mandarin	C2	Cantonese
8	25	Male	China	Postgraduate	Mandarin	C1	Cantonese
9	22	Female	China	Postgraduate	Mandarin	C2	Japanese, American Sign Language
10	23	Female	China	Postgraduate	Mandarin	C2	French
11	23	Female	China	Postgraduate	Mandarin	C2	German, Spanish, French, Thai
12	20	Male	China	Postgraduate	Mandarin	C2	Cantonese
13	22	Female	China	Postgraduate	Mandarin	C2	Spanish
14	22	Female	China	Postgraduate	Mandarin	C2	French, Japanese, Korean
15	22	Female	China	Postgraduate	Mandarin	C2	German
16	23	Female	China	Postgraduate	Mandarin	C1	N/A
17	23	Male	China	Postgraduate	Mandarin	C1	N/A
18	23	Male	China	Postgraduate	Mandarin	C2	Hmong
19	22	Female	China	Postgraduate	Mandarin	C2	Spanish
20	22	Female	China	Postgraduate	Mandarin	C2	Sinhalese, Hindi, French, Korean

Table 3. Demographic Information of Participants (The Second Pilot Study).

Participant ID	Age	Gender	Nationality	Education Level	Native Language	English Proficiency	Knowledge of Other Languages
1	22	Female	China	Postgraduate	Mandarin	C1	N/A
2	27	Female	China	Postgraduate	Mandarin	C2	N/A
3	26	Female	China	PhD	Mandarin	C1	N/A
4	25	Female	China	PhD	Mandarin	C2	N/A
5	30	Female	China	Postgraduate	Mandarin	C2	N/A
6	24	Female	China	Postgraduate	Mandarin	C2	Cantonese

7	29	Female	China	Postgraduate	Mandarin	C2	N/A
8	23	Female	China	PhD	Mandarin	C2	N/A
9	25	Male	China	Postgraduate	Mandarin	C2	French, Japanese
10	26	Female	China	Postgraduate	Mandarin	C1	N/A
11	22	Female	China	Postgraduate	Mandarin	C2	Spanish
12	25	Female	China	Postgraduate	Mandarin	C2	French
13	25	Female	China	PhD	Mandarin	C1	N/A
14	30	Female	China	PhD	Mandarin	C1	Japanese
15	30	Female	China	PhD	Mandarin	C2	Japanese
16	25	Female	China	Postgraduate	Mandarin	C2	French, Spanish
17	22	Female	China	Postgraduate	Mandarin	C2	N/A
18	22	Female	China	Postgraduate	Mandarin	C1	German
19	28	Female	China	Postgraduate	Mandarin	C1	French
20	25	Female	China	Postgraduate	Mandarin	C1	Japanese

Table 4. Demographic Information of Participants (Main Experiment).

Participant ID	Age	Gender	Nationality	Education Level	Native Language	English Proficiency	Knowledge of Other Languages
1	22	Female	China	Postgraduate	Mandarin	C2	N/A
2	29	Female	China	Postgraduate	Mandarin	C2	German
3	19	Female	China	Undergraduate	Mandarin	C1	N/A
4	25	Female	China	Postgraduate	Mandarin	C1	N/A
5	22	Female	China	Postgraduate	Mandarin	C2	N/A
6	27	Female	China	PhD	Mandarin	C2	Zulu
7	27	Female	China	PhD	Mandarin	C1	Germany
8	23	Female	China	Postgraduate	Mandarin	C1	Malay
9	25	Male	China	Undergraduate	Mandarin	C2	Spanish, French, German
10	25	Female	China	PhD	Mandarin	C2	N/A
11	27	Female	China	Postgraduate	Mandarin	C2	German
12	30	Male	China	Postgraduate	Mandarin	C2	Japanese
13	30	Male	China	Postgraduate	Mandarin	C2	Japanese, French, Spanish
14	24	Female	China	Undergraduate	Mandarin	C2	N/A
15	25	Male	China	Undergraduate	Mandarin	C2	N/A
16	18	Female	China	Postgraduate	Mandarin	C2	Afrikaans
17	24	Female	China	Postgraduate	Mandarin	C1	N/A
18	22	Male	China	Undergraduate	Mandarin	C2	French, Korean
19	29	Female	China	PhD	Mandarin	C1	N/A
20	22	Female	China	Undergraduate	Mandarin	C2	Cantonese, Korean
21	23	Male	China	Postgraduate	Mandarin	C1	Japanese
22	24	Female	China	Postgraduate	Mandarin	C1	N/A
23	21	Male	China	Undergraduate	Mandarin	C1	German, Afrikaans
24	21	Male	China	Undergraduate	Mandarin	C1	N/A

25	21	Male	China	Undergraduate	Mandarin	C1	French, Arabic, Spanish
26	22	Female	China	Postgraduate	Mandarin	C2	N/A
27	30	Male	China	Postgraduate	Mandarin	C2	Hebrew
28	27	Female	China	Postgraduate	Mandarin	C2	N/A
29	26	Female	China	Undergraduate	Mandarin	C1	German
30	19	Female	China	Undergraduate	Mandarin	C2	N/A
31	30	Male	China	PhD	Mandarin	C1	N/A
32	25	Male	China	Postgraduate	Mandarin	C2	Japanese, Spanish, Russian, Korean, Arabic
33	23	Female	China	Undergraduate	Mandarin	C1	Malay, Cantonese
34	24	Male	China	Postgraduate	Mandarin	C1	N/A
35	19	Female	China	Undergraduate	Mandarin	C2	Spanish
36	19	Female	China	Undergraduate	Mandarin	C2	N/A
37	20	Male	China	Undergraduate	Mandarin	C1	N/A
38	23	Female	China	Undergraduate	Mandarin	C2	Spanish
39	25	Female	China	Undergraduate	Mandarin	C1	N/A
40	25	Male	China	PhD	Mandarin	C2	N/A

Appendix D The Experimental Materials Used in the First Pilot Study

1. Pretraining Task

Four artificial articles: *gi*, *ro*, *ul*, and *ne*

2. Training Task

High (tall) and animate noun phrases: *gi* giraffe, *gi* elephant, *gi* tree, *gi* eagle, *gi* bear

High (tall) and inanimate noun phrases: *ro* sky, *ro* sun, *ro* ceiling, *ro* roof, *ro* skyscraper

Low (short) and animate noun phrases: *ul* mouse, *ul* ant, *ul* snail, *ul* turtle, *ul* goldfish

Low (short) and inanimate noun phrases: *ne* ground, *ne* puddle, *ne* cave, *ne* basement, *ne* garage

3. Testing Task

1) Literal Noun Phrases

High: ___ro___ cloud, ___ro___ mountain, ___ro___ bridge, ___ro___ flagpole, ___ro___ hilltop,
___gi___ dinosaur, ___ro___ peak, ___ro___ lighthouse, ___ro___ moon, ___ro___ satellite

Low: ___ne___ carpet, ___ne___ mine (n.), ___ne___ valley, ___ne___ seafloor, ___ne___ cave,
___ne___ grassland, ___ne___ farmland, ___ne___ well (n.), ___ne___ grass, ___ne___ floor

2) Metaphorical Noun Phrases

Powerful: ___gi___ principal, ___gi___ supervisor, ___gi___ authority, ___gi___ leader,
___gi___ professor, ___gi___ king, ___gi___ captain, ___gi___ official (n.), ___gi___ dean,
___gi___ boss

Powerless: ___ul___ orphan, ___ul___ slave, ___ul___ assistant, ___ul___ victim, ___ul___ minority,
___ul___ prisoner, ___ul___ refugee, ___ul___ interviewee, ___ul___ employee, ___ul___ maid

Appendix E Information Sheet and Consent Form for the Pilot Study

The Role of Implicit Learning in L2 Morphosyntax: An artificial-grammar Language Learning Experiment

Pilot Study

PARTICIPANT INFORMATION SHEET

Central University Research Ethics Committee Approval Reference: [C1B-24HT-Educ-010]

You are being invited to take part in a pilot study for a research project. It is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask us if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part.

What is the purpose of this pilot study?

Drawing on the experiment paradigm of William (2004, 2005), this study employed a mixed method to shed light on the involvement of implicit learning in the learning of L2 morphosyntax.

Why have I been invited to take part?

You have been invited to take part in this research because you meet the inclusion criteria of this research. The inclusion criteria for this research are Chinese native speakers, sequential bilinguals with English as their second language, with advanced English proficiency or at least C1 level according to the Common European Framework of Reference for Languages (CEFR), aged between 18 and 30 years old.

Do I have to take part?

No. It is up to you to decide if you want to take part in this research. You can withdraw yourself from the research at any time without giving a reason. If you withdraw from the study, any data collected up to that point will not be used in the following analysis.

What will happen to me if I take part in the research?

The researcher will reach out to you by email to go over the information sheet and explain what you will need to do. If you are eligible and agree to participate in this pilot study, you will be asked to sign an electronic consent form and complete a questionnaire online. You are free to ask to pause or stop the research activities at any time.

What are the possible disadvantages and risks of taking part?

There are no evident disadvantages or risks in taking part in this pilot study. You will not be identifiable from the data and the research outputs. All the collected data and research outputs will be entirely anonymous.

Are there any benefits in taking part?

While there are no immediate benefits for those participating in this pilot study, it is hoped that this research will contribute to a better understanding of the process of word learning among L2 learners.

What information will be collected and why is the collection of this information relevant for achieving the research objectives?

We collect operational data (e.g., consent forms, contact information) and research data (e.g., questionnaire results). Participants will not be identifiable from the collected data and research outputs.

Electronic consent forms and contact details will be collected via email and will be stored on a password-protected local computer. Contact details will be destroyed at the end of your involvement in this research unless you give permission for us to retain your contact details to let you know about future studies. You can have your details removed from the database at any time by contacting the researchers.

Questionnaire results will be stored on a password-protected local computer. Personal data will be stored with a unique participant code rather than participants' real names. In general, copies stored on a password-protected local computer will be deleted once all participants have completed experimental sessions.

The researcher and supervisor will have access to the research data. Additionally, access will be granted to the Department of Education at the University of Oxford for the purposes of monitoring the current research. We may use the data from this research in future studies, but this data will not be shared with other researchers. This will only be in a form that does not identify you.

Will the research be published? Could I be identified from any publications or other research outputs?

The findings from the research may be written up in a master dissertation, and conference presentations or academic publications if possible. Participants will remain unidentifiable from the collected data or research outputs. You do have a choice regarding this matter. A copy of this dissertation might be deposited both in print and online in the [Oxford University Research Archive](#) where it will be publicly available to facilitate its use in future research

Data Protection

The University of Oxford is the data controller with respect to your personal data, and as such will determine how your personal data is used in the research. The University will process your personal data for the purpose of the research outlined above. Research is a task that is performed in the public interest.

Who has reviewed this research?

This research has received ethics approval from a subcommittee of the University of Oxford Central University Research Ethics Committee.

Consent to take part in ‘The Role of Implicit Learning in L2 Morphosyntax: An artificial-grammar Language Learning Experiment’

Pilot Study

Central University Research Ethics Committee (CUREC) approval reference: C1B-24HT-Educ-010

Purpose of Study: Drawing on the experiment paradigm of William (2004, 2005), this study employed a mixed method to shed light on the involvement of implicit learning in the learning of L2 morphosyntax.

**Please initial each
box if you agree
with the statement**

I confirm that I have read and understand the information sheet for the pilot study version 1.0, dated 06/02/2024 for the above research. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

I understand that my participation is voluntary and that I am free to withdraw at any point until the completion of testing without giving any reason.

I understand who will have access to personal data provided, how the data will be stored and what will happen to the data at the end of the project.

I understand that I will not be identifiable from any academic publications, dissertations or conference presentations.

I give permission for you to contact me again to clarify information.

I understand how to raise a concern or make a complaint.

I agree to take part in the above study.

Optional: I agree that my personal contact details can be retained in a secure database so that the researchers can contact me about future studies.

YES / NO

Name of participant dd / mm / yyyy _____
Date Signature

Name of person taking
consent dd / mm / yyyy _____
Date Signature

Appendix F Information Sheet and Consent Form for the Norming Study

The Role of Implicit Learning in L2 Morphosyntax: An artificial-grammar Language Learning Experiment

Norming Study

PARTICIPANT INFORMATION SHEET

Central University Research Ethics Committee Approval Reference: [C1B-24HT-Educ-010]

You are being invited to take part in a pilot study for a research project. It is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask us if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part.

What is the purpose of this pilot study?

This norming study is to collect data for testing the reliability and validity of experimental materials.

Why have I been invited to take part?

You have been invited to take part in this pilot study because you meet the inclusion criteria of this research. The inclusion criterion for this pilot study is English native speakers. We will recruit around ten participants for this pilot study.

Do I have to take part?

No. It is up to you to decide if you want to take part in this research. You can withdraw yourself from the research at any time without giving a reason. If you withdraw from the study, any data collected up to that point will not be used in the following analysis.

What will happen to me if I take part in the research?

The researcher will reach out to you by email to go over the information sheet and explain what you will need to do. If you are eligible and agree to participate in this pilot study, you will be asked to sign an electronic consent form and complete a questionnaire online. You are free to ask to pause or stop the research activities at any time.

What are the possible disadvantages and risks in taking part?

There are no evident disadvantages or risks in taking part in this pilot study. You will not be identifiable from the data and the research outputs. All the collected data and research outputs will be entirely anonymous.

Are there any benefits in taking part?

While there are no immediate benefits for those participating in this pilot study, it is hoped that this research will contribute to a better understanding of the process of word learning among L2 learners.

What information will be collected and why is the collection of this information relevant for achieving the research objectives?

We collect operational data (e.g., consent forms, contact information) and research data (e.g., questionnaire results). Participants will not be identifiable from the collected data and research outputs.

Electronic consent forms and contact details will be collected via email and will be stored on a password-protected local computer. Contact details will be destroyed at the end of your involvement in this research unless you give permission for us to retain your contact details to let you know about future studies. You can have your details removed from the database at any time by contacting the researchers.

Questionnaire results will be stored on a password-protected local computer. Personal data will be stored with a unique participant code rather than participants' real names. In general, copies stored on a password-protected local computer will be deleted once all participants have completed experimental sessions.

The researcher and supervisor will have access to the research data. Additionally, access will be granted to the Department of Education at the University of Oxford for the purposes of monitoring the current research. We may use the data from this research in future studies, but this data will not be shared with other researchers. This will only be in a form that does not identify you.

Will the research be published? Could I be identified from any publications or other research outputs?

The findings from the research may be written up in a master dissertation, and conference presentations or academic publications if possible. Participants will remain unidentifiable from the collected data or research outputs. You do have a choice regarding this matter. A copy of this dissertation might be deposited both in print and online in the [Oxford University Research Archive](#) where it will be publicly available to facilitate its use in future research.

Data Protection

The University of Oxford is the data controller with respect to your personal data, and as such will determine how your personal data is used in the research. The University will process your personal data for the purpose of the research outlined above. Research is a task that is performed in the public interest. Further information about your rights with respect to your personal data is available from the University's Information Compliance website at <https://compliance.admin.ox.ac.uk/individual-rights>.

Consent to take part in ‘The Role of Implicit Learning in L2 Morphosyntax: An artificial-grammar Language Learning Experiment’

Norming Study

Central University Research Ethics Committee (CUREC) approval reference: C1B-24HT-Educ-010

Purpose of Study: This norming study is to collect data for testing the reliability and validity of experimental materials.

**Please initial
each box if you
agree with the
statement**

I confirm that I have read and understand the information sheet for the pilot study version 1.0, dated 06/02/2024 for the above research. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

I understand that my participation is voluntary and that I am free to withdraw at any point until the completion of testing without giving any reason.

I understand who will have access to personal data provided, how the data will be stored and what will happen to the data at the end of the project.

I understand that I will not be identifiable from any academic publications, dissertations or conference presentations.

I give permission for you to contact me again to clarify information.

I understand how to raise a concern or make a complaint.

I agree to take part in the above study.

Optional: I agree that my personal contact details can be retained in a secure database so that the researchers can contact me about future studies.

YES /
NO

_____ dd / mm / vvvv _____
Name of participant Date Signature

_____ dd / mm / vvvv _____
Name of person taking Date Signature
consent

Appendix G Information Sheet and Consent Form for the Main Experiment

The Role of Implicit Learning in L2 Morphosyntax: An artificial-grammar Language Learning Experiment

CUREC Approval Reference: C1B-24HT-Educ-010

General Information

Drawing on the experiment paradigm of William (2004, 2005), this study employed a mixed method to shed light on the involvement of implicit learning in the learning of L2 morphosyntax. We appreciate your interest in participating in this online task. You have been invited to take part in this research because you meet the inclusion criteria of this research. The inclusion criteria for this research are Chinese native speakers, sequential bilinguals with English as their second language, with advanced English proficiency or at least C1 level according to the Common European Framework of Reference for Languages (CEFR), aged between 18 and 30 years old.

In the experiment, you will be asked to complete a series of computer-based tasks. The experiment consists of three phases: pretraining, training, and testing. This should take about 30 minutes. No background knowledge is required. We will collect operational data (e.g., consent forms and contact information) and research data (e.g., task results). Participants will not be identifiable from the collected data and research outputs.

Electronic consent forms will be collected from participants and stored in the experimenter's password-protected local computer and OneDrive for Business. Consent forms will be retained for three years after publication or public release of the work of the research.

Contact details will be collected using electronic methods (social media, email, etc.) and will be stored on a password-protected local computer and OneDrive for Business. Amazon Vouchers will be sent to you via email. Contact details will be destroyed at the end of your involvement in this research unless you give permission for us to retain your contact details to let you know about future studies. You can have your details removed from the database at any time by contacting the researchers.

Experiment results will be stored on a password-protected local computer and OneDrive for Business. Personal data will be stored with a unique participant ID rather than participants' real name. In general, all data and personal information stored will be deleted once all participants have completed experimental sessions.

Do I have to take part?

No. Please note that participation is voluntary. If you do decide to take part, you may withdraw at any point for any reason before submitting your answers by closing the browser. However, we are only able to reimburse participants who complete all research activities. All questions are optional.

How will my data be used?

The responses you provide will be stored in a password-protected electronic file on University of Oxford secure servers and may be used in a master dissertation, and conference presentations or academic publications if possible. Participants will remain unidentifiable from the collected data or research outputs. You do have a choice regarding this matter. A copy of this dissertation might be deposited both in print and online in the [Oxford University Research Archive](#) where it will be publicly available to facilitate future research. We will not collect any data that could directly identify you. We will take all reasonable measures to ensure that data remains confidential.

Who will have access to my data?

The University of Oxford is the data controller with respect to your personal data and, as such, will determine how your personal data is used in the research. The University will process your personal data for the purpose of the research outlined above. Research is a task that we perform in the public interest. Further information about your rights with respect to your personal data is available from <https://compliance.admin.ox.ac.uk/individual-rights>. The researcher and supervisor will have access to the research data. Additionally, access will be granted to the Department of Education at the University of Oxford for the purposes of monitoring the current research.

Who has reviewed this research?

The application was reviewed and approved by my supervisor on behalf of the Department of Education's Research Ethics Committee [C1B-24HT-Educ-010].

Please note that you may only participate in this survey if you are 18 years of age or over.

I certify that I am 18 years of age or over

If you have read the information above and agree to participate with the understanding that the data (including any personal data) you submit will be processed accordingly, please tick the box below to start.

Yes, I agree to take part

Appendix H Example of the Experiment

Figure 7. Example of Pretest.

The figure originally presented here cannot be made freely available via ORA because of copyright.

The figure was sourced at Gorilla Experiment Builder. (n.d.). Gorilla.sc [Online experimental platform]. Cauldron Science Ltd. Retrieved from <https://gorilla.sc>

Figure 8. Example of Pretraining Task.

The figure originally presented here cannot be made freely available via ORA because of copyright.

The figure was sourced at Gorilla Experiment Builder. (n.d.). Gorilla.sc [Online experimental platform]. Cauldron Science Ltd. Retrieved from <https://gorilla.sc>

The figure originally presented here cannot be made freely available via ORA because of copyright.

The figure was sourced at Gorilla Experiment Builder. (n.d.). Gorilla.sc [Online experimental platform]. Cauldron Science Ltd. Retrieved from <https://gorilla.sc>

The figure originally presented here cannot be made freely available via ORA because of copyright.

The figure was sourced at Gorilla Experiment Builder. (n.d.). Gorilla.sc [Online experimental platform]. Cauldron Science Ltd. Retrieved from <https://gorilla.sc>

Figure 9. Example of Training Task.

The figure originally presented here cannot be made freely available via ORA because of copyright.
The figure was sourced at Gorilla Experiment Builder. (n.d.). Gorilla.sc [Online experimental platform]. Cauldron Science Ltd.
Retrieved from <https://gorilla.sc>

Figure 10. Example of Test Task.

The figure originally presented here cannot be made freely available via ORA because of copyright.
The figure was sourced at Gorilla Experiment Builder. (n.d.). Gorilla.sc [Online experimental platform]. Cauldron Science Ltd.
Retrieved from <https://gorilla.sc>

The figure originally presented here cannot be made freely available via ORA because of copyright.
The figure was sourced at Gorilla Experiment Builder. (n.d.). Gorilla.sc [Online experimental platform]. Cauldron Science Ltd.
Retrieved from <https://gorilla.sc>

Figure 11. Example of Debriefing Report.

The figure originally presented here cannot be made freely available via ORA because of copyright.
The figure was sourced at
Gorilla Experiment Builder. (n.d.). Gorilla.sc [Online experimental platform]. Cauldron Science Ltd. Retrieved from <https://gorilla.sc>

Appendix I Ethical Approval

Dear Yuqing,

I am writing to acknowledge receipt of your CUREC 1B application entitled '*The Role of Implicit Learning in L2 Morphosyntax: An artificial-grammar language learning experiment*'. The application was reviewed and approved. No further approval from the Education DREC is required for applications reviewed under the CUREC 1B process. As such, the project will not receive a formal letter of ethical approval from the SSH IDREC.

The ethics reference for your application is C1B-24HT-Educ-010. Please add this reference to your CUREC 1B form and include it on documents for the research participants such as the participant information sheet.

Please note that this is contingent on the research project adhering to the criteria set out in the [CUREC 1B guidance](#). Please ensure, therefore, that you comply with the conditions of this process and, should anything change in the course of the project, you should discuss this with your supervisor to determine whether this requires further review and approval by the Education DREC.

All the best for your research.

Irina

Appendix J Results of the Norming Study

Table 27. Norming Study Results of Animal Word Items.

Word Items	Animal Rating	Prey Rating	Predator Rating
dinosaur	4.6	2.8	3.9
tiger	5	1.4	4.6
bear	5	1.3	4.9
gorilla	5	1.9	3.7
crocodile	4.7	1.1	5
snail	4.6	4	1.7
deer	5	4.1	2
rabbit	5	4.5	1.8
dragonfly	4.7	3.4	2.9
sheep	5	4.2	1.1
hawk	5	1.7	4.9
lion	5	1.8	5
eagle	5	1.6	4.9
wolf	5	1.4	4.9
leopard	5	1.5	5
shark	5	1.6	5
buffalo	5	3.5	2.2
chimpanzee	5	2.4	3.9
elephant	5	2	1.9
ox	4.9	3.1	2.1
mouse	4.9	4.7	1.6
ant	4.6	3.9	2.5
goat	5	4.4	1.8
squirrel	5	3.6	1.4
butterfly	4.6	3.5	1.5
worm	4.5	4.7	1.7
shrimp	4.6	4.6	1.8
cricket	4.6	3.8	2.5
sparrow	5	3.9	2.8
goldfish	5	4.2	1.5

Table 28. Norming Study Results of Human Word Items.

Word Items	Human Rating	Powerless Rating	Powerful Rating
chancellor	4.7	1.4	4.7
mayor	4.8	1.5	4.2
president	4.9	1.2	4.9
director	4.7	1.9	4.6
chief (n.)	4.8	1.7	4.4
beggar	4.8	4.8	1
slave	4.8	4.9	1
refugee	4.8	4.2	1.5
infant	4.7	3.7	2.2
employee	4.7	2.8	2.7
principal	4.6	1.4	4.4
supervisor	4.5	1.8	4
authority	3.8	1.6	4.5
leader	4.4	1.6	4.5
professor	4.8	2.3	3.9
king	4.7	1.3	4.9
captain	4.8	1.7	4.3
official (n.)	4.5	2.3	3.7
dean	4.7	1.9	4
boss	4.7	1.6	3.8
orphan	4.7	4.5	1.3
assistant	4.5	3.4	2.3
victim	4.7	3.8	2
minority	4.4	3.5	2
prisoner	4.8	4.8	1.3
interviewee	4.9	3.1	2.3
patient	4.8	3.5	2.1
immigrant	4.8	3.1	2.1
dependant	4.7	3.4	2
criminal	4.8	3.1	2.6