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Second Language Action Words Learning in Chinese EFL Learners Through Fast-Mapping and Explicit Encoding

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Abstract

Research on fast-mapping (FM) and explicit encoding (EE) has focused exclusively on the learning of concrete nouns, and few studies have explored verb learning through FM and EE in speakers' mother language. The present study aims to investigate the role of fast-mapping and explicit encoding in Chinese EFL learners' second language action word learning. Forty participants were enrolled and randomly assigned to the FM and the EE group in the experiment, with a 2 (learning procedure) * 2 (test delay) two-way factorial design adopted. After the learning session, participants in both groups completed a series of tests in 10 minutes and again on the next day. The results demonstrate stronger declarative memory of the novel action words through explicit encoding, whereas fast mapping is conducive to learners' lexical and semantic integration.

Keywords: fast-mapping, explicit encoding, action words, second language

1. Introduction

The knowledge of vocabulary is fundamental to the process of language acquisition. Discrepancies in lexical usage, both in terms of production and interpretation, are less readily forgiven by native speakers, and particularly by learners of a second language (L2), than other types of linguistic errors (Nation, 2006). For L2 learners, the acquisition of vocabulary constitutes one of the most challenging aspects due to the vastness of the target language's lexicon. This challenge is exacerbated by the fact that L2 vocabulary is often imparted in a formal educational setting through the direct presentation of novel lexical items and the expectation of conscious effort on the part of the learner, such as the memorization of words in lists and the association of these words with visual imagery. These methods are collectively referred to as explicit encoding (EE). EE, also known as rote learning or deliberate learning, involves a deliberate focus on vocabulary acquisition but often lacks the contextual richness necessary for deeper understanding and practical application of the newly acquired terms (Hong et al., 2018). Ultimately, this detachment of learners 'rigid and narrow understanding of the learned vocabulary from the words' nuanced meanings and authentic usage patterns may impede the advancement of

L2 proficiency and could potentially lead to a disinclination towards vocabulary acquisition. As English emerges as the preeminent global L2, there is an urgent need for a more efficacious approach to vocabulary instruction.

In contrast to the acquisition of vocabulary in a second language (L2), the development of vocabulary in one's native tongue during early childhood typically occurs involuntarily and with remarkable efficiency within the natural course of daily life. This process is not facilitated by deliberate instruction but rather through the incidental exposure to words in their authentic contexts, where their meanings are deduced amidst a multitude of other potential referents. This form of vocabulary acquisition in infancy relies minimally on direct teaching or memorization techniques.

A substantial body of research (Carey & Bartlett, 1978; Uematsu et al., 2012) has characterized this phenomenon as "fast mapping" (FM), a concept that encapsulates the rapid and incidental learning of new words with minimal exposure. This learning is achieved through the inferential process of identifying referents by excluding known objects within the context (Hong et al., 2018). The pivotal function of fast mapping (FM) in the vocabulary acquisition of young children learning their first language (L1) has inspired a substantial amount of scholarly inquiry into its potential applicability to adult vocabulary learning. Empirical research has demonstrated that FM is instrumental not only in the lexical development of children (Heibeck & Markman, 1987; Gershkoff-Stowe & Hahn, 2007; Bion & Fernald, 2013; Pomper & Saffran, 2019), but also in the vocabulary acquisition of adults in their native language (L1) (Gupta, 2003; Coutanche & Thompson-Schill, 2014).

A separate strand of investigation has delved into the cognitive underpinnings of FM and contrasted its efficacy with explicit encoding (EE) in the context of L1 vocabulary acquisition (Sharon et al., 2011; Coutanche & Thompson-Schill, 2014; Merhav et al., 2015). Certain contemporary studies have suggested that FM may engage distinct neural pathways from EE and is capable of swiftly assimilating novel lexical items into the memory (Coutanche & Thompson-Schill, 2014; Merhav et al., 2015; Zaiser et al., 2021). However, there are studies that have not corroborated these findings (Warren & Duff, 2014; O'Connor & Riggs, 2019; Walker et al., 2019), casting doubt on the efficacy of FM (Cooper et al., 2019; O'Connor & Riggs, 2019). Furthermore, while FM was initially posited to elucidate the vocabulary acquisition of children learning L1, its pivotal role in this process offers a novel lens through which to view L2 vocabulary learning. Given that intentional learning might result in a disconnect between learners' constrained understanding of newly acquired words and the words' nuanced meanings and practical application, it is pertinent to investigate the potential significance of FM in L2 vocabulary acquisition.

Recent scholarly work has directed attention toward the various factors that may modulate the efficacy of fast mapping (FM) in vocabulary acquisition. Research has indicated that in the case of pediatric language development, FM is subject to a variety of external influences such as word categorization, modes of input, and the provision of mnemonic support (Holland et al., 2015; Puccini & Liszkowski, 2012; Axelsson & Horst, 2014; Weatherhead et al., 2021). Additionally, individual differences such as constitutional temperament and linguistic history have been shown to play a role (Axelsson et al., 2022; Taylor & Kan, 2021; Kalashnikova et al., 2018). Furthermore, investigations have been conducted into the impact of these external and intrinsic factors on vocabulary learning in adults through FM (Coutanche & Koch, 2017; Li et al., 2020; Cooper et al., 2019; Zaiser et al., 2021). Given the complex cognitive processes that FM may entail, which are distinct from conventional learning paradigms, there is a pressing need for further research to elucidate the specific factors that may influence FM.

In general, verbs are perceived as more abstract and inherently complex compared to nouns, particularly in terms of their syntactic status and the grammatical intricacies associated with their argument structure (Druks, 2002; Johnson, 2010). A substantial body of research has established differences between English nouns and verbs. Early studies demonstrated that nouns and verbs differ at various levels of linguistic analysis (Patternson & Shewell, 1978; Levelt, 1989; Rapp & Caramazza, 1998). Further research indicated that these differences also exist at a conceptual level (Campbell & Manning, 1996; Druks & Shallice, 2000), with nouns typically denoting abstract or concrete entities and verbs denoting concrete or abstract actions (Ma et al., 2022). The semantic distinctions of their referents are what differentiate nouns and verbs at this level. Additionally, nouns and verbs differ at the lexical level, especially regarding imageability, the preservation of perceptual features, and associative features (Rapp & Caramazza, 1998; Berndt et al., 2002; Marshall et al., 1996a; Marshall et al., 1996b; Bird et al., 2000). However, some researchers propose that the differences between nouns and verbs might manifest at the output level, which is a perspective rooted in modality-specific theories (Miceli et al., 1984). Moreover, several studies suggest that the noun/verb distinction may be captured prior to lexical access, implying that such differences could be defined within the semantic system (Marshall et al., 1996b).

In everyday life, verbs are often considered as action labels and nouns as object labels, which leads to the intuitive expectation that there might be differences in the acquisition of object words and action words. There is a disconnect between the grammatical level of nouns and verbs and the conceptual level of objects and actions. Beyond linguistics, early research in neuropsychology explored the brain systems underlying the processing of words from these two categories diagnostically (McCarthy & Warrington, 1985; Caramazza & Hillis, 1991; Hillis & Caramazza, 1995). Subsequent studies on the neural basis of noun/verb processing confirmed that processing nouns and verbs can trigger distinct brain activation patterns, particularly the left superior temporal gyrus for nouns and the left inferior frontal regions for verbs (Tyler et al., 2001; Palti et al., 2007; Yang et al., 2017). Interestingly, there is an overlap between the brain networks activated during verb processing and those associated with fast mapping (FM) (Merhav et al., 2015). It has been hypothesized that action words could be acquired through the FM paradigm, and several studies have been conducted to test this hypothesis (Johnson & Villiers, 2009; Johnson, 2010; Southwood & White, 2021; Asadi & Zarifian, 2021). However, these studies focused on FM of verbs in children, and there was a lack of comparison of learning outcomes through different procedures. Therefore, considering the distinction between object words and action words in terms of linguistics and neuropsychology, further research is needed to determine whether L2 English action words could be acquired through FM.

2. Research Questions

In regard to what has been reviewed above, the present study aims to address the following questions:

1) Does learning procedure (EE vs. FM) have a significant effect on Mandarin-English speakers' declarative memory of L2 English action words?
2) Does learning procedure (EE vs. FM) have a significant effect on Mandarin-English speakers' lexical integration of L2 English action words?
3) Does learning procedure (EE vs. FM) have a significant effect on Mandarin-English speakers' semantic integration of L2 English action words?

3. Research Design

The current study employs a 2 (learning paradigm) × 2 (test time) factorial experimental design. The between-subjects independent variable is the learning procedure (EE vs. FM), and the within-subjects independent variable is the test time (immediate vs. delayed). The outcomes of participants' L2 action word learning is quantified as the dependent variables, including the declarative memory, lexical integration, semantic integration.

3.1 Participants

Forty individuals (31 females and 9 males, with an age range from 21 to 25), possessing normal or corrected-to-normal vision and exhibiting no learning or dyslexia impairments, were recruited. All participants are Mandarin Chinese native speakers, majoring in English at a university in China, and share comparable experiences in learning English. All participants were randomly distributed into 2 groups, each consisting of 20 members, and each group was tasked with learning identical word-video associations under one of two distinct learning conditions: FM (Fast Mapping), EE (Explicit Encoding). Prior to the experiment, the proficiency in English among the three groups was measured using the Quick Placement Test, and statistical analysis revealed no significant disparities in English proficiency levels ($F = .13$ $p = .852$).

3.2 Materials

This study utilized three kinds of learning stimuli: (1) video clips depicting the actions, (2) linguistic stimuli in the form of sentences integrating novel action vocabulary, and (3) auditory stimuli consisting of audio recordings of the afore mentioned sentences during the learning phase.

Eight target action words (as shown in Table 1) were derived from existing English hermit action words. For instance, "*forpid*" was created from the hermit "forbid". Half of these hermit action words were associated with concrete actions, while the other half were linked to abstract actions. By "concrete action", we refer to actions that can be brought to life through a sequence of specific physical movements in a way that is universally understood (e.g., "kidnap"). On the other hand, "abstract action" implies actions that cannot be clearly manifested through a series of specific physical movements in a particular way, or actions that pertain to mental or cognitive activities that are exclusive to the human mind (e.g., "behave"). The newly minted action words were then randomly assigned to 8 videos depicting unfamiliar actions, thereby establishing 8 word-action associations for the pivotal trials in both the EE and FM processes.

Table 1. Hermit action words used to create novel words and the corresponding novel words

Hermit action words used to create novel words and the corresponding novel words			
Concrete words	**Novel words**	**Abstract words**	**Novel words**
Kidnap	Kidlap	Behave	Behive
Cajole	Cajoll	Forbid	Forpid
Impugn	Imbugn	Modify	Modipy
Bypass	Byposs	Betray	Bebray

The familiarity of the actions in the videos was rated by an independent group of evaluators with similar educational background to the participants. The learning session encompasses a total of 32 videos, each 8 seconds in duration, comprising 16 videos featuring unfamiliar actions (with 2 videos for each action) and 16 videos with familiar actions. The term "unfamiliar action" refers to actions that participants may have observed or performed in their daily lives but are not readily and accurately describable with a precise single English word. Each action was demonstrated by a male actor and a female actress in separate scenes. The rationale for employing two distinct actors is to ensure equivalence in variability between actions and objects, aligning with the use of two unique images for each object in the object word learning segment. Participants viewed each video in a sequence beginning with the actor or actress in a stationary position, followed by the action unfolding as the individual moves away from the initial posture, and concluding with the return to the original stance.

For the EE group, 16 videos depicting unfamiliar actions were deployed. For the FM group, the same set of 16 video pairs were presented, including 8 unfamiliar and 8 familiar actions. Eight target action words (as illustrated in Figure 2) were derived from existing English hermit action words, such as "*forpid*" from the hermit word "*forbid*". Half of these action words were defined as to tangible actions, while the other half pertain to intangible actions. By "concrete action," we denote an action that can be physically executed through a sequence of specific bodily movements in a manner that is commonly recognized (e.g., "*kidnap*"), whereas "abstract action" refers to an action that cannot be physically manifested through specific movements in a defined manner, or it refers to a mental or cognitive process that is internally emergent within the human mind (e.g., "*behave*"). These newly-constructed action words were randomly assigned to 8 videos of unfamiliar actions, establishing 8 word-action associations for the pivotal trials in both the EE and FM procedures.

3.3 Instruments

To distinguish the mechanisms of EE and FM, this study examined participants' L2 learning outcomes in terms of declarative memory, lexical integration and semantic integration followed the study of Coutanche and Thompson-Schill (2014).

3.4 Free Recall and the 3 AFC Tests

In the free recall test, Participants were allocated a 5-minute interval to record as many of the 8 recently acquired words as possible, with an emphasis on accuracy. In the subsequent three-alternative forced-choice test, they were concurrently presented with three video clips. Each trial contains three items: one that is the correct representation of a newly-learned term and two distractors. The task was to identify the correct match for the word displayed beneath the options by indicating the corresponding choice, labeled "A," "B," or "C," by pressing the keyboard.

3.5 Lexical Integration Test

According to Bowers et al. (2005), the lexical integration of the novel vocabulary by participants was inferred from the observed increase in response times when encountering the hermit words utilized in the construction of the novel words during the training session. To this end, an additional set of 8 hermit action words were incorporated into the lexical integration test. The lexical competition among participants was quantified by the disparity in their response times between the hermit words that were employed to coin the novel words and those that were not. It is hypothesized that if participants had successfully integrated the novel words into their mental lexicon, they would exhibit slower reactions to the "used" hermits compared to the "unused" ones. This observed difference in their response times was designated as the lexical integration effect in the present study. Participants were tasked with categorizing the object denoted by the word as either concrete or abstract by pressing the corresponding keys "F" or "J" on the keyboard.

3.6 Semantic Integration Test

In the semantic integration test, the present study incorporates a total of 32 action word pairs to measure participants' semantic priming. In each pair, the first word serves as the prime, and the second as the target. Among these, 8 critical pairs were designated for experimental scrutiny: 4 of these pairs consists of novel words that semantically prime related targets, while the other 4 novel words were coupled with semantically unrelated targets. The remaining 24 pairs are intended as filler material, comprising 8 real word pairs with 4 being semantically related and the other 4 being semantically unrelated. An additional 16 pairs were present a juxtaposition of real English prime words with fictional target words.

The integration of the novel second language (L2) words into the participants' semantic networks was inferred from the participants' response times. Specifically, if the novel words have been effectively integrated, it is anticipated that responses to targets preceded by semantically related novel words would be faster than those preceded by semantically unrelated novel words. The semantic priming effect was quantified by measuring the response times differential between targets introduced by semantically related versus unrelated novel words, and the measured difference were referred to as the semantic integration effect within the scope of this study.

3.7 Procedure

The experiment was divided into the learning session and the testing session. 40 participants were randomly assigned to two groups (1) FM of action words and (2) EE of action words. All participants' learning outcomes were tested in 10 minutes immediately after training, and again in approximately 24 hours on the next day. The experiment was carried out using Psychopy 2021.2.3.

3.8 Learning Session

The action word learning phase is comprised of 16 trials for both the EE and FM groups, with each video of a novel action being showcased twice across two rounds. In the EE procedure, for each trial, a video clip featuring an unfamiliar action was centered on the screen, followed by the sequential presentation of three sentences underneath the video (with each sentence displayed for 2,000ms). The sentence included an explicit instructional component (e.g., "The man/woman will forpid," "The man/woman is forpidding," and "The man/woman had forpidden"). These sentences illustrated the novel action word in the simple present, progressive, and past tenses, adhering to the regular inflectional morphology rules of English. Auditory playback of each sentence coincided with its on-screen appearance. Participants were instructed to commit the action words to memory with no key response required. Each trial initiates with a fixation cross displayed for 1,000ms, followed by the video and sentences, which are presented together for 8,000ms. The 8 word-action pairings were displayed in a random sequence, and once the 8 trials are completed, the subsequent round commences with a new random order.

For the FM procedure, each video of an unfamiliar action was juxtaposed with a video of a familiar action. Participants were posed with three perceptual questions per trial (e.g., "Where will the man/woman forpid?" "Where is the man/woman forpidding?" or "Where has the man/woman forpidden?"). Each question was presented individually for 2,000ms. The questions are designed to focus on discernible features that differentiate the two actions, such as the position or color of the individual's attire. The novel actions were equally likely to appear on either the left or right side of the screen, and the accuracy of true/false responses were evenly distributed. In each trial, the pair of videos and corresponding sentences were displayed for 8,000ms, preceded by a 1,000ms fixation cross. Participants are tasked with responding to the true/false queries by pressing the keys "F" (True) or "J" (False) within an 8-second window. Each novel action was presented twice over the two rounds (in random order), each time accompanied by a different foil action.

3.9 Testing Session

Participants' L2 action word learning was analyzed in terms of their declarative memory, lexical integration, and semantic integration. The test session was conducted in two identical sessions. The immediate post-test session is scheduled in 10 minutes after learning, with a vocabulary assessment to be undertaken by participants during this interval, thereby precluding the opportunity for rehearsal. Then, participants were asked to undertake a delayed post-test approximately 24 hours following the learning phase, typically on the subsequent day. The principal objective of the delayed post-test is to evaluate the retention and integration of the learned vocabulary after a short period that includes sleep, a factor known to enhance offline memory consolidation and facilitate the stabilization of newly acquired information within memory networks.

To evaluate participants' declarative memory of the novel L2 action words. As was mentioned in the instruments session, a combination of free recall and three-alternative forced choice (3AFC) testing was employed. During the free recall test, participants were given 5 minutes to write down as many of the novel words from the learning session as they can recall with accuracy on a blank sheet. The 3AFC test consisted of 13 trials, with 5 practice trials leading into the 8 formal trials. All trials were randomly ordered, with each beginning with a 1,000ms fixation cross, a subsequent 300ms blank screen, and conclusion upon participant response.

The lexical integration test follows, comprising 5 practice trials and 16 formal trials (8 "used" and 8 "unused"), and the presentation order of all trials words is randomized. Participants were instructed to indicate whether the word denotes a concrete or abstract action by pressing "F" (Concrete) or "J" (Abstract). Each trial initiated with a 1,000 ms fixation cross, a 300 ms blank screen, and then the presentation of the hermit word at the screen's center. The trial end once a response is provided.

The final assessment focuses on semantic integration, consisting of 37 trials per group, with 5 practice trials and 32 formal trials, all presented in random sequence. In this test, participants were asked to judge whether the target word is a real or artificially-coined English word by pressing "F" (Real) or "J" (False) as quickly as possible. The semantic integration test begins with a 1,000 ms fixation cross, followed by a 1,500 ms prime word. A 300 ms blank screen precedes the target word, which vanishes upon participant response. At the end on the post-tests on the second day, participants were asked to complete the Quick Placement Test and a questionnaire concerning their familiarity with the novel objects and actions before they join the experiment.

4. Data Collection and Analysis

The answer sheets from the free recall test were gathered and scored manually, with each correct recall of a novel word earning one point. The learning outcomes, including accuracy and response times for the 3AFC test, lexical integration test, and semantic integration test, were all electronically captured using Psychopy 2021.2.3.

To determine the lexical competition effects, individual participant response times for "unused" hermit words were subtracted from those for "used" hermit words. The semantic priming effects were quantified by taking the reaction times for unrelated targets and subtracting the response times for related targets.

Consequently, the data from the 20 participants in the EE, and the 20 in the FM group were collected for further statistical analysis using SPSS software.

5. Results

5.1 Results of the Free Recall and 3AFC Test

To assess the declarative memory retention of the newly acquired vocabulary, participants were given both a free recall test and a 3AFC test. The average scores for each of the three groups across the two testing days for both tests are summarized in Table 2.

Table 2. Descriptive statistics of the free recall test and the 3AFC test

	Learning condition	**Day 1**	**Day 2**
Free recall test	**EE**	**7.60 (2.33)**	**4.60 (2.20)**
	FM	**4.96 (1.46)**	**2.72 (.89**
3AFC test	**EE**	**14.60 (1.80)**	**12.40 (2.43)**
	FM	**9.52 (2.02)**	**9.00 (3.03)**

Note: Standard deviations are shown in parentheses.

The effects of learning procedure and testing time on the declarative memory of the newly learned words were analyzed through a two-way mixed analysis of variance (ANOVA), results are presented in Table 3.

The analysis revealed a significant main effect of learning procedure on performance in the free recall test (F = 16.22, p < .001) and in the 3AFC test (F = 44.13, p < .001). This indicates that the learning procedure had distinct effects on the retention of L2 novel action words in declarative memory.

Additionally, a significant main effect of testing time was observed (free recall: F = 107.24, p < .001; 3AFC test: F = 21.43, p < .001), suggesting that participants performed better on the initial testing day (Day 1) compared to the subsequent testing day (Day 2).

However, no significant interaction between learning procedure and testing time was detected in either the free recall test and the 3AFC test.

Table 3. Results of two-way ANOVA of the free recall test and the 3AFC test

	Source	Type III SS	*df*	Mean Square	*F*	Sig.	Partial Eta squared
Free recall test	Learning procedure	150.87	2	75.43	16.22	.000	.32
	Testing time	267.63	1	267.63	107.24	.000	.61
	Learning procedure × Testing time	4.47	2	2.23	.87	.410	.03
	Error	170.76	69	2.48			
3AFC test	Learning procedure	510.66	2	255.33	44.13	.000	.57
	Testing time	74.07	1	74.07	21.43	.000	.23
	Learning procedure × Testing time	18.05	2	9.02	2.32	.088	.07
	Error	247.78	69	3.60			

5.2 Results of the Lexical Integration Test

The mean response times and the lexical competition effect in the lexical integration test are shown in Table 4. The reaction time of the unused hermits in the EE group was similar to the reaction time of the unused hermits, while two reaction times in the FM group were rather different. EE group did not report lexical competition effects for the newly acquired vocabulary. Conversely, the response times for "used" hermits were notably longer compared to "unused" hermits within both the FM group, signifying significant lexical competition effect occurred in the FM group.

Table 4. Mean response times (ms) and lexical competition effect in the lexical integration test

	Day 1			Day 2		
Learning procedure	Neighbor hermits	Non-neighbor hermits	Lexical competition effect	Neighbor hermits	Non-neighbor hermits	Lexical competition effect
EE	1489.78	1500.19	-10.40	1343.75	1290.89	52.86

	(372.58)	(121.00)	(344.80)	(260.59)	(276.64)	(85.42)
FM	1679.02 (192.08)	1498.68 (199.38)	180.34 (277.40)	1316.88 (388.87)	1220.28 (298.91)	96.60 (178.23)

Participants' reaction times of the used hermits and the unused hermits in the lexical integration test on both Day 1 and Day 2 were analyzed by a series of two-way repeated-measures ANOVAs to examine whether there was lexical integration of the newly-learned words in each of the four learning conditions (see Table 5). The results show significant main effect of hermit type (F= 9.81, p = .002) and a significant interaction between learning procedure and hermit type on Day 1 (F = 3.64, p = .039). On Day 2, a significant main effect of hermit type is found (F = 15.04, p < .001).

Table 5. Two-way ANOVA results of response times (ms) in the lexical integration test

	Source	Type III SS	*df*	Mean Square	*F*	Sig.	Partial Eta squared
Day 1	Learning procedure	252681.42	2	126340.71	1.57	.199	.05
	Hermit type	383613.83	1	383613.83	9.81	.002	.13
	Learning condition × Hermit type	250786.46	2	125393.23	3.64	.039	.09
	Error	2593618.43	69	37588.67			
Day 2	Learning procedure	90413.75	2	45206.88	.31	.714	.01
	Hermit type	196713.44	1	196713.44	15.04	.000	.18
	Learning procedure × Hermit type	11990.14	2	5995.07	.41	.685	.01
	Error	873667.70	69	12661.85			

5.3 Semantic Integration Test

The semantic integration of the novel L2 action words was assessed by analyzing whether these novel words facilitated the processing of semantically associated terms. The average response times, standard deviations, and the semantic priming (calculated as the response times for targets in semantically unrelated pairs minus those for targets in semantically related pairs) across the two participant groups on both testing days are presented in Table 6.

Table 6. Mean response times (ms) and semantic priming effect in the semantic integration Test

	Day 1			Day 2		
	Related	Unrelated	Semantic priming effect	Related	Unrelated	Semantic priming effect
EE	911.27 (229.65)	912.67 (186.94)	1.40 (99.01)	897.73 (205.50)	930.98 (187.27)	33.25 (91.16)
FM	750.44 (122.57)	861.55 (108.38)	111.11 (52.20)	757.44 (117.53)	821.38 (158.54)	63.93 (91.83)
FM + EE	827.09	912.94	85.85	826.53	880.39	53.86

(109.72)	(135.97)	(73.15)		(187.25)	(188.10)	(145.02)

A series of two-way repeated-measures ANOVAs were conducted to examine whether the reaction times of the target words in different pair types (semantically related and semantically unrelated) in different learning procedures were significantly different on Day 1 and Day 2 (Table 7).

Table 7. Two-way ANOVA of reaction times (ms) in the semantic integration test

	Source	Type III SS	*df*	Mean Square	*F*	Sig.	Partial Eta squared
Day 1	Learning procedure	284477.28	2	142238.64	3.11	.053	.08
	Pair type	156812.20	1	156812.20	50.99	.000	.43
	Learning procedure × Pair type	81912.71	2	40956.35	14.16	.000	.28
	Error	206509.16	69	2992.89			
Day 2	Learning procedure	390382.04	2	195191.02	3.44	.036	.09
	Pair type	90936.60	1	90936.60	14.08	.000	.18
	Learning procedure × Pair type	6095.47	2	3047.73	.51	.620	.01
	Error	421733.94	69	6112.09			

On Day 1, a marginally significant main effects of learning procedure was observed ($F = 3.11$, $p = .053$), as well as a significant main effect of pair type ($F_{(1, 69)} = 50.99$, $p < .001$) and interaction effect between learning procedure and pair type ($F = 14.16$, $p < .001$). On Day 2, there are significant main effects of learning procedure ($F = 3.44$, $p = .036$) and pair type ($F = 3.09$, $p = .052$), but the interaction between learning procedure and pair type was not significant.

The results indicated that EE group did not show lexical competition effects for the newly acquired vocabulary. Conversely, the response times for "used" hermits were notably longer compared to "unused" hermits within both the FM group, signifying significant lexical competition effect occurred in the FM group.

6. Discussion

The present study explored the effects of explicit encoding and fast-mapping Mandarin-English speakers' L2 action word learning. Participants' learning outcomes was measured by their declarative memory, lexical integration, and semantic integration.

6.1 Influence of Learning Procedure on the Declarative Memory

The results showed that EE induced stronger declarative memory of the novel action words than the FM group, which may be attributed to the distinct neural substrates engaged by the two learning procedures. Empirical research (Merhav et al., 2015; Antony et al., 2017) has established that EE engages the CLS for vocabulary acquisition. The newly-acquired lexical items initially undergo consolidation within the hippocampus, which is instrumental in forming robust declarative memories, prior to their integration into the associative networks of the neocortex. In contrast, the FM process, by leveraging the information present in familiar stimuli from the same categorical domain as the novel word's referent, may elicit a circumvention of hippocampal consolidation. Consequently, under the FM condition, the declarative memory for the newly-learned words, which is purported to depend on the hippocampal consolidation, appears to be significantly less robust compared to the EE condition.

However, it is precisely by circumventing the hippocampal consolidation process, which is theorized to be slow and sleep-dependent (Davis & Gaskell, 2009; Tamminen & Gaskell, 2013), that FM facilitates swift lexical integration immediately following learning on Day 1 and again approximately 24 hours on Day 2. As anticipated, the performance of the EE group did not exhibit this effect on either Day 1 or Day 2. The findings on lexical integration of the newly-learned words by the EE and FM groups suggest that rapid lexical integration may come at the expense of accessibility to declarative memory. This can also be interpreted as evidence for the dissociation between declarative memory and lexical learning, as previously observed in amnesic patients with hippocampal damage (Bayley & Squire, 2002; Sharon et al., 2011). These results are in line with prior research demonstrating that FM can quickly integrate information into existing memory networks in healthy adults (Coutanche & Thompson-Schill, 2014). It is significant that the current study extends the understanding of FM's impact on healthy adults' second language (L2) vocabulary learning (Hong et al., 2018) by confirming that FM's rapid integration effect is also applicable to L2 vocabulary acquisition.

6.2 Influence of Learning Procedure on the Lexical Integration

Generally, lexical competition leads to inhibitory effects due to the interference from the simultaneous activation of lexically similar words during retrieval. As a result, the identification of a word is impeded by the presence of numerous lexical neighbors, (e.g., a delayed response to the word "house" due to its lexical neighbors such as "horse," "louse," etc.). In the context of this study, the significant disparity in response times for neighbor hermits versus non-neighbor hermits in the FM group indicated that FM facilitated lexical integration across both testing days. In contrast, no such lexical integration was observed in the EE group on either Day 1 or Day 2.

As previously elucidated, FM is thought to enable swift lexical integration on Day 1 by bypassing the hippocampal consolidation process, which is considered to be a slow mechanism that typically requires sleep (Davis & Gaskell, 2009; Tamminen & Gaskell, 2013). The findings from this study corroborate the notion that EE and FM engage distinct cognitive processing mechanisms (Sharon et al., 2011; Merhav et al., 2014, 2015; Himmer et al., 2017). Furthermore, they suggest that FM may facilitate a more immediate and direct cortical integration of lexical items in healthy adults, a process that is not limited to first language (L1) vocabulary but also extends to second language (L2) vocabulary acquisition.

According to the CLS systems model, lexical integration of word-picture associations in the EE condition should become evident approximately 24 hours post-learning. It is plausible that the consolidation process might be overshadowed by a decline in the salience of the novel words after an overnight period. Although word-picture associations might potentially integrate over a 24-hour period, the retrieval process could become excessively laborious after such an extended interval, potentially leading to the lack of observable integration effects in the EE condition on both testing days.

6.3 Influence of Learning Procedure on the Semantic Integration

The semantic information can be accessed directly according to the Revised Hierarchical Model (RHM), whereas the comprehension of L2 vocabulary is typically mediated by the equivalent L1 terms. Within the research conducted by Hong et al. (2018) on the acquisition of Chinese vocabulary by non-native speakers, the study's participants—adult learners enrolled in Chinese educational institutions—were already acquainted with the genuine words and their corresponding native language concepts (such as recognizing the term "松鼠" in Chinese as "squirrel" in English). Thus, the Fast Mapping (FM) task, which included familiar images as reference points, might have been bolstered by the participants' established L1-based conceptual framework, effectively forging connections between the newly introduced words and their visual representations. It is highly probable that the concepts of familiar items were accessed via L1, resulting in the ignition of pre-existing concepts that were semantically intertwined, the association between squirrel and cat. Nevertheless, the vocabulary items in this study were pseudowords, with most of their references being unfamiliar even in the participants' mother tongue (as inquired through a questionnaire administered at the end of the experiment, which sought to determine the participants' prior knowledge of the actual names for the novel items).

As suggested by McClelland (2013), learning at the neocortical level is contingent upon pre-existing knowledge rather than being a slow process. Building on this, Coutanche and Thompson-Schill (2014) proposed that novel vocabulary can be learned even with significant hippocampal damage if it is linked to existing knowledge. In the context of Fast Mapping (FM), the presentation of a familiar object likely triggers a relevant cognitive schema, facilitating the semantic integration of new words into the memory network. These theoretical insights, along with the results of previous neurophysiological research (Sharon et al., 2011; Greve et al., 2014; Atir-Sharon et al., 2015; Merhav et al., 2015), provide a framework for understanding the outcomes of semantic integration testing. A substantial body of literature (Sharon et al., 2011; Greve et al., 2014; Atir-Sharon et al., 2015; Merhav et al., 2015) has highlighted the anterior temporal lobe (ATL) as a critical region for FM. The ATL functions as an amodal semantic hub, integrating semantic information from various sensory-specific cortices (Lambon Ralph et al., 2017). In light of the aforementioned neurobiological theories, it is reasonable to suggest that the anterior temporal structures, which are crucial for FM, may rapidly incorporate new words into the semantic network. In contrast, the hippocampal-neocortical consolidation processes, which are integral to Explicit Encoding (EE), require more time to achieve such semantic integration.

7. Conclusion

The present study found that Mandarin-English speakers can acquire L2 English novel action words through EE and FM, which extend the word types in previous research on L2 vocabulary learning through FM. Specifically, stronger declarative memory was induced in the EE condition, while learning through FM produced rapid integration of novel action words. The findings of the present study show the capability of FM incorporate novel action words rapidly into cortical memory networks, suggesting a divergence in the neural underpinnings relied upon by Explicit Encoding (EE) and FM. Specifically, it is posited that EE depends on the Computational, Lexical, and Semantic (CLS) system, whereas FM leverages a hippocampally-independent mechanism. By extension, this study demonstrates that findings from L1 word learning studies, which have utilized both EE and FM methodologies, are applicable to the realm of L2 vocabulary acquisition. From an educational standpoint, the research suggests that FM techniques can be effectively incorporated into L2 instructional settings. This approach has the potential to mitigate the negative impacts often associated with the monotonous EE word learning process and to foster expedited integration of newly acquired vocabulary. In addition, video clips can be employed in L2 action word teaching and learning, which serve as lively multimodal learning materials for language learner.

As posited by McClelland (2013), neocortical learning is contingent upon pre-existing knowledge and is not inherently slow. Coutanche and Thompson-Schill (2014) expanded on this by suggesting that novel vocabulary can be integrated into memory even with significant hippocampal impairment, provided it is anchored to prior knowledge. In the context of the Fast Mapping (FM) condition, the presentation of a familiar object likely triggers a relevant schema, thereby facilitating the semantic assimilation of the novel term into the memory network. These hypotheses, along with findings from neurophysiological studies (Sharon et al., 2011; Greve et al., 2014; Atir-Sharon et al., 2015; Merhav et al., 2015), explain the outcomes observed in semantic integration testing. Previous research (Sharon et al., 2011; Greve et al., 2014; Atir-Sharon et al., 2015; Merhav et al., 2015) has indicated that the anterior temporal lobe (ATL) plays a pivotal role in FM, serving as an amodal semantic hub that integrates semantic information from modality-specific cortices (Lambon Ralph et al., 2017). These neurobiological theories suggest that the rapid integration of novel words into the semantic network, which is facilitated by ATL structures central to FM, may outpace the time-consuming hippocampal-neocortical consolidation processes that EE relies upon to achieve similar integration.

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