Applied Psycholinguistics (2026), **47**, e55, 1–27
doi:10.1017/S0142716426101039

CAMBRIDGE UNIVERSITY PRESS

ORIGINAL ARTICLE

Representation characteristics of English psych verbs in Chinese-English bilinguals: The modulating role of language proficiency

Yun Wang[1] and Xinfang Liu[2]

[1]School of AI for the Humanities, Zhejiang International Studies University, Hangzhou, China and [2]School of Foreign Languages and Literature, Suzhou University of Science and Technology, China
Corresponding author: Xinfang Liu; Email: xfliu168@126.com

(Received 3 December 2025 UTC; revised 2 August 2026 UTC; accepted 31 August 2026 UTC)

Abstract

This study investigates the semantic representation of English psych verbs in Chinese-English bilinguals (CEBs) and how L2 proficiency modulates this process. A total of 180 CEBs, divided into low-, intermediate-, and high-proficiency groups, completed two masked priming experiments. Experiment 1 examined intralanguage semantic processing (synonym/antonym associations, word frequency effects) and found that high-proficiency learners showed a significant processing facilitation for high-frequency synonyms over antonyms, reflecting robust facilitation of high-frequency synonym priming. Experiment 2 explored interlanguage processing via Chinese-English (C-E)/English-Chinese (E-C) translation equivalents and word frequency, showing that low-proficiency participants exhibited the largest translation priming effects, particularly for high-frequency words in the C-E direction. Across all proficiency levels, intralanguage processing was generally faster than interlanguage processing, whereas interlanguage priming effects tended to be more pronounced overall. These findings reveal proficiency-dependent shifts in the interaction between semantic and frequency information, highlight translation equivalence as a core mechanism in bilingual semantic organization, and refine the distributed feature model and the shared asymmetric model by demonstrating their applicability to abstract verb categories beyond the concrete nouns on which they were originally developed.

Keywords: Chinese-English bilinguals; English psych verbs; language proficiency; masked priming; mental lexicon semantic representation

Introduction

Early theories of bilingual lexical representation centered on the independent representation theory, which proposed the complete segregation of a bilingual's two languages within the mental lexicon, each possessing unique concepts and semantic systems (Doctor et al., 1987; Klein & Doctor, 1992). However, advances in cognitive

© The Author(s), 2026. Published by Cambridge University Press. This is an Open Access article, distributed under the terms of the Creative Commons Attribution licence (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted re-use, distribution and reproduction, provided the original article is properly cited.

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

neuroscience challenged this view. The shared representation theory emerged, positing that both languages access a standard conceptual representation system (Fontes & Schwartz, 2010), a notion strongly supported by evidence on semantic memory and cross-linguistic semantic activation (Francis, 2018; Ip et al., 2017; Kubus et al., 2014). Acknowledging the complexity, the mixed representation theory suggests that bilingual lexicons operate on a continuum between independence and integration, influenced by factors such as proficiency, age of acquisition, and usage frequency (Miozzo et al., 2009). Yet, despite theoretical advancements, the specific mechanisms by which proficiency, word frequency, and semantic relationships shape the representation of abstract lexical categories, such as psych verbs, remain underexplored.

Language proficiency, a key indicator of linguistic command, critically shapes the structure and processing within the bilingual mental lexicon. Highly proficient bilinguals demonstrate efficient semantic access in both languages and more symmetrical interlanguage priming effects (Cumming, 1989). Luk and Bialystok (2013) found that proficiency significantly influences both intra- and interlanguage processing, with higher proficiency associated with enhanced intralanguage efficiency and greater flexibility in controlling interlanguage switching. As proficiency increases, lexical access, syntactic parsing, and semantic integration in the L2 improve, alongside better inhibition of irrelevant lexical competitors (Zeng et al., 2022). For instance, highly proficient bilinguals exhibit sustained automatic activation of L1 translations during L2 processing, whereas low-proficiency individuals show brief activations that require greater cognitive effort to suppress. Research using masked priming and translation tasks confirms variations in performance across proficiency levels in lexical access, semantic integration, and the suppression of cross-linguistic competition (Kahraman & Beyersmann, 2024). High-proficiency bilinguals access word meanings more quickly (Dijkstra et al., 2018) and integrate semantics more efficiently than their low-proficiency counterparts, who face greater L1 influence during rapid processing (Lachelin et al., 2024; Tabori & Pyers, 2025; Wolna et al., 2024). Proficiency impacts not only reaction times (RTs) but also response accuracy, reflecting deeper cognitive engagement (Fang & Zhang, 2021). Furthermore, higher proficiency correlates with more efficient resolution of language competition and reduced switch costs (Zhu et al., 2025), suggesting that proficiency dynamically modulates the semantic network. Consequently, bilingualism is increasingly viewed not as a categorical but as a continuum in which proficiency substantially influences processing outcomes (Hell, 2023; Wang et al., 2022, 2023), a perspective crucial for examining nuanced aspects of lexical representation, such as psych-verb processing.

Word frequency interacts with L2 proficiency to shape bilingual lexical processing. Although high-frequency words are processed faster and more accurately than low-frequency words in monolinguals (Maye et al., 2008), bilinguals possess a system that integrates information from both languages (Altarriba & Heredia, 2017). Frequency effects arise through two pathways; stronger neural representations resulting from repeated exposure facilitate easier activation, and frequency information acts as a statistical constraint that interacts with semantic, morphological, and phonological cues (Hamrick & Pandža, 2020). However, bilingual semantic overlap and cross-linguistic co-activation complicate this effect.

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

Representations involve higher-order semantic integration (Belinkov et al., 2020), and retrieving a word in one language often activates representations in the other, potentially weakening the high-frequency advantage (Marian et al., 2009). For example, cognate processing speed varies with usage frequency in each language context (Paradis, 2010), indicating that bilingual vocabulary access involves both simultaneous activation and suppression, which, in turn, influences frequency effects. Current models explain dual-language activation (Whitford & Joanisse, 2021) but do not adequately specify how interlanguage interactions cause different frequency words to exhibit varying processing advantages (Whitford & Titone, 2017). The combined effects of frequency and proficiency on abstract verb processing remain particularly poorly understood (Duñabeitia et al., 2015).

Beyond proficiency and frequency, the nature of semantic relationships itself critically shapes bilingual lexical representation. Research in this area examines intra- and interlinguistic dimensions. Intralinguistically, studies focus on semantic relationships (such as synonyms and antonyms) and the structure of semantic networks within a single language (Wolter, 2001). Synonyms and antonyms elicit distinct brain activation patterns and occupy specific positions in semantic space (Klepousniotou, 2002). Semantic priming paradigms demonstrate that lexically related words readily establish activation links, whereas unrelated words exhibit inhibition (Wolter & Gyllstad, 2011), underscoring the crucial role of intralanguage semantic microstructure. However, a systematic account of how activation patterns for synonyms and antonyms are modulated by proficiency and frequency is lacking (Plaut & Gonnerman, 2000). Interlinguistically, research explores semantic transfer and the processing of translation equivalents (TEs). Bilinguals often communicate via a shared semantic network during language switching, with neuroimaging studies showing overlapping brain regions involved in semantic processing across languages (Thierry & Rebuschat, 2020). Positive activation of TEs, even in nontarget-language tasks, supports a shared representation (Ye & Zhao, 2024). However, a bias toward the L1's conceptual system persists, potentially explaining variations in TE processing speed and priming effects (Goetry et al., 2009; Lachelin et al., 2024). Key questions remain unresolved: the consistency and asymmetry of rapid TE activation, and how these relate to bilingual experience, vocabulary frequency, and proficiency differences during language switching.

Psych verbs, which denote internal mental states and affective/emotional experiences, present unique challenges due to their abstract nature and syntactic and semantic peculiarities across languages (Rudolph & Försterling, 1997). Functional magnetic resonance imaging (fMRI) studies reveal distinct neural mechanisms, such as activation of the dorsomedial prefrontal cortex, for processing these verbs (Tomasino et al., 2018). Cross-linguistic comparisons show significant structural and functional differences (e.g., Latin/Italian fragility: Giusti & Iovino, 2019; Arabic diversity: Amzali et al., 2020). For L2 learners, proficiency has a critical influence on psych-verb processing; higher proficiency is associated with faster semantic integration and greater accuracy, whereas lower proficiency is associated with reliance on explicit markers and cross-linguistic transfer (Kim & Chung, 2024). Because psych verbs map onto abstract semantic features (e.g., cognitive vs. affective, stative vs. dynamic) whose degree of cross-linguistic overlap varies considerably, they

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

provide an ideal test case for examining how proficiency and frequency shape distributed semantic representations.

Despite the unique properties of psych verbs and their potential to inform bilingual lexical models, the combined influence of L2 proficiency, word frequency, and semantic relations (synonymy/antonymy) on their intra- and interlanguage representations remains unexplored. The present study addresses this gap by systematically manipulating these three factors within a single masked priming design. We draw on prior masked priming research demonstrating this paradigm's sensitivity to the architecture of the bilingual lexicon. Jiang and Forster (2001) demonstrated asymmetric interlanguage priming effects in lexical decision, with stronger priming from L1 to L2 than from L2 to L1, a pattern we examine across proficiency levels. Wolter and Gyllstad (2011) used masked priming to investigate collocational links in the L2 mental lexicon, showing that semantic relatedness (SR) (including synonyms) produces facilitation only under specific proficiency conditions. More recently, Kahraman and Beyersmann (2024) employed masked compound priming to compare L1 and L2 speakers, revealing proficiency-dependent effects on morphological decomposition. Together, these studies provide the methodological foundation for our use of masked priming with synonym/antonym and translation-equivalent manipulations.

We adopt the distributed feature model of semantic representation (Plaut & Gonnerman, 2000; Van Hell & De Groot, 1998), which posits that word meanings are represented as distributed patterns of activation across shared semantic features rather than as discrete, localist entries. Within this framework, psych verbs are assumed to be represented as configurations of abstract semantic features (e.g., cognitive vs. affective, stative vs. dynamic) that may overlap to varying degrees across languages. The shared asymmetric model (Kroll & Stewart, 1994) further suggests that bilinguals have stronger lexical–semantic links from their L1 to their L2, especially at lower-proficiency levels, due to continued reliance on L1-mediated conceptual access during L2 processing. These two models jointly motivate the following research questions:

(1) How do synonym/antonym semantic relations and word frequency modulate intralanguage masked priming effects for English psych verbs in Chinese-English bilinguals (CEBs)?
(2) How do translation direction (Chinese-English vs. English-Chinese [C-E vs. E-C]) and word frequency modulate interlanguage masked priming effects for English psych verbs in CEBs?
(3) How does L2 proficiency modulate the relative magnitude of intra- versus interlanguage priming effects, and does this pattern differ for high- vs. low-frequency words?

Drawing on the distributed feature model and the shared asymmetric model, we propose the following hypotheses. First, for intralanguage processing (Experiment 1), high-proficiency learners should show faster RTs and larger priming effects for synonyms than for antonyms, reflecting increased featural overlap with proficiency; low-proficiency learners should not show this synonym advantage. Additionally, high-frequency words should produce larger priming effects than low-frequency

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

words across all groups, with this frequency effect being most pronounced in low-proficiency learners. Second, for interlanguage processing (Experiment 2), translation priming effects should be stronger in the C-E direction than in the E-C direction, consistent with the shared asymmetric model's claim of stronger L1-to-L2 connections. This asymmetry should be largest for low-proficiency learners. High-frequency words should yield larger translation priming effects than low-frequency words, and this advantage should diminish as L2 proficiency increases. Third, intralanguage processing should yield faster RTs, whereas interlanguage processing should produce significantly larger priming effects across all groups. The efficiency gap between the two should narrow as L2 proficiency increases, especially for low-frequency words. Together, these hypotheses test whether the distributed feature model and the shared asymmetric model—originally developed for concrete nouns—extend to abstract verbs under the modulating influence of L2 proficiency.

Method

Participants

The study recruited 180 CEBs divided into three proficiency groups based on educational attainment and standardized certification: 60 high school seniors (G1: low proficiency), 60 second-year English majors with Test for English Majors-4 (TEM-4) certification (G2: intermediate proficiency), and 60 English postgraduates with TEM-8 certification (G3: high proficiency). The TEM is a nationwide standardized English proficiency test widely used as a valid indicator of L2 proficiency in bilingualism research (Fang & Zhang, 2021; Zeng et al., 2022). TEM-4 and TEM-8 correspond to intermediate and advanced levels, respectively. The sample size determination using MorePower 6.0 (Campbell & Thompson, 2012) indicated a minimum requirement of 132 participants (effect size $\eta^2 = .25$, power $= .95$, $\alpha = .05$). One hundred eighty participants were enrolled to account for potential attrition. Proficiency differences were objectively validated using the Lexical Test for Advanced Learners of English (LexTALE) (Lemhöfer & Broersma, 2012), in which participants completed a 5-minute online lexical decision task (comprising 60 items: 40 pseudowords and 20 real words) with automated accuracy-based scoring. We performed an Analysis of Variance (ANOVA) to compare group differences. A one-way ANOVA confirmed significant between-group differences in LexTALE scores, $F(2, 177) = 451.06$, $p < .001$, with post hoc comparisons revealing the expected hierarchy: G1 (50.55 ± 6.30) < G2 (64.97 ± 3.08) < G3 (80.93 ± 6.56; all $ps < .001$), thereby establishing three discrete levels of L2 lexical proficiency. All participants signed an informed consent form in accordance with the Declaration of Helsinki (1991) and received 30 RMB for their participation. All experimental procedures were reviewed and approved by the local ethics committee.

Design

Experiment 1, which focused on intralanguage semantic priming, utilized a mixed two-factor design crossing priming type (SR, semantic unrelatedness [SUR], and a nonword filler [NF] condition) with L2 proficiency group (low, intermediate, and high). Similarly, Experiment 2, which investigated interlanguage semantic priming,

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

employed a mixed two-factor design crossing priming type (TEs, non-translation equivalents [NTEs], and NF) with L2 proficiency group (low, intermediate, and high). The dependent variables in both experiments were RTs and priming effects. The NF condition was included solely to ensure task engagement and maintain the lexical-decision nature of the task; it was not of theoretical interest and was excluded from all priming-effect calculations. All priming effects were computed as the difference between RTs in the unrelated condition and RTs in the related condition (i.e., unrelated RT–related RT). In Experiment 1, the critical comparison between SR and SUR isolates the facilitatory effect of semantic associations (synonyms/antonyms) on lexical access. Comparing these effects across proficiency groups allows us to infer how L2 proficiency modulates the organization of intralanguage semantic links. In Experiment 2, the critical comparison between TE and NTE reveals whether L1–L2 semantic links are automatically activated across languages, with the C-E versus E-C contrast testing the asymmetry hypothesis (stronger priming from L1 to L2). Comparing these effects across proficiency groups reveals how L2 proficiency shapes interlanguage semantic integration and the degree of reliance on TEs.

Materials

The experimental materials were based on a set of 30 psych verbs identified by Schwanenflugel et al. (1994) as the most prototypical for native English speakers. These verbs were adapted for CEBs through a rating task administered to 142 second-year English majors who did not participate in the formal experiment. They rated the verbs on a scale of 1–7 for typicality. Twenty verbs scoring above the mean value were selected as the core experimental materials (see Table 1). To explore the frequency effect, the study used the 2024 Contemporary American English Corpus (COCA), which contains approximately 600 million words. The 20 verbs were ranked by frequency and divided into high- and low-frequency groups using a median split. To validate the suitability of this categorization for CEBs, the same raters were asked to assess their familiarity with each psych verb using a 7-point scale. Paired sample *t*-tests confirmed higher familiarity ratings for high-frequency words (6.48 ± .31) than for low-frequency words (5.52 ± .30), $t = 26.70$, $df = 141$, Cohen's $d = 3.15$, $p < .001$, confirming the validity of the frequency classification.

Experiment 1 used 20 English psych verbs from Table 1 to create 120 prime–target pairs. These pairs were categorized into three conditions: (1) related priming, where primes were synonyms or antonyms of the target (half each); (2) unrelated priming, where targets were the same as those in Condition 1, but primes were semantically unrelated; and (3) NF condition, where primes were the same as those in Condition 1, but targets were nonwords. The materials were randomized using a Latin square to ensure that each prime–target pair was presented to each participant only once. An example is shown in Table 2.

The selection of synonyms and antonyms followed a two-step procedure. In the first step, candidate synonyms and antonyms for each target verb were drawn from the first sense item of the Random House Roget's Thesaurus (2012). Ten professors specializing in psycholinguistics then reviewed these candidates, providing up to five synonyms and five antonyms that best captured the affective and cognitive

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

Table 1. The typicality ratings of English psych verbs by CEBs ($N = 142$)

Psych verbs	*M* ± *SD*	Freq.	Freq. type	Psych verbs	*M* ± *SD*	Freq.	Freq. type
Know	4.04 ± 1.93	2,112,089	High	Choose	5.15 ± 1.27	78,991	
Think	6.36 ± 1.01	1,492,793	High	Decide	5.75 ± 1.29	62,075	
Question	4.24 ± 1.48	299,541	High	Notice	4.09 ± 1.49	60,252	
Understand	5.76 ± 1.20	260917	High	Figure out	5.58 ± 1.17	40,655	
Remember	4.48 ± 1.55	239,679	High	Explore	4.32 ± 1.49	27,968	
Reason	5.89 ± 1.19	213,833		Compare	5.02 ± 1.26	27,197	Low
Plan	5.25 ± 1.22	198,471		Estimate	5.28 ± 1.30	22,513	Low
Guess	5.77 ± 1.09	157,631		Observe	4.13 ± 1.63	15,825	Low
Learn	4.06 ± 1.68	143,010		Pay attention	4.76 ± 1.42	10,035	Low
Explain	4.26 ± 1.25	86,933		Memorize	4.87 ± 1.60	2,109	Low

Note: freq. = frequency.

Table 2. Material examples for Experiments 1 and 2

Priming conditions	Experiment 1	Priming conditions Experiment 2	Experiment 2
SR	Select-choose	TE	选择-choose
	Refuse-choose		Choose-选择
SUR	Invent-choose	NTE	发明-choose
	Describe-choose		Invent-选择
NF	Select-reduse	NF	选择-invant
	Refuse-depand		Choose-明发

Note: SR = semantically related; SUR = semantically unrelated; NF = nonword filler; TE = translation equivalent; NTE = nontranslation equivalent.

attributes of each target verb. The selection criteria adhered to the principles of exclusivity and mutual exclusion, ensuring no repetition of the original 20 psych verbs and no overlap between synonyms and antonyms. In the second step, based on the top three consistently identified candidate words, 30 second-year English majors who did not participate in the formal experiment rated the semantic appropriateness of each set of synonyms and antonyms on a scale of 0–10 (0 = completely inappropriate, 10 = completely appropriate). The words with the highest ratings were selected as the formal experimental materials.

Experiment 2 used an expanded set of materials comprising 20 English psych verbs (Table 1), yielding 120 prime–target pairs. These pairs were classified into three prime conditions: (1) translation priming, where English psych verbs and their Chinese equivalents were used interchangeably as primes and targets (half in the E-C direction and half in the C-E direction); (2) nontranslation priming, where the targets remained consistent with those in Condition 1, but the primes were

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

semantically unrelated; and (3) the NF condition, where the primes were the same as those in Condition 1 but the targets were nonwords. The experimental design was adapted from Li and Peng (1999) and modified for the present study, as shown in Table 2. Unlike Li and Peng's (1999) sentence-completion approach, this study employed a masked priming paradigm in conjunction with a lexical decision task, providing a more direct evaluation of lexical-level semantic activation.

The process for selecting Chinese translation words for English psych verbs followed a procedure similar to that in Experiment 1: expert-provided candidate translation words were evaluated for appropriateness by a student group to identify vocabulary that accurately conveys the original affective and semantic attributes while adhering to Chinese expression conventions.

Procedure

Experiment 1: Stimuli were presented using E-Prime 2.0 on a computer screen, with black text on a white background. The procedure included displaying instructions (infinite), a 500-ms fixation cross, a 500-ms prime, a 500-ms mask (######), and a target word shown for a maximum of 2,000 ms. Participants were instructed to judge the lexicality of the target word by pressing the "D" key with their left middle finger for real words and the "K" key with their right middle finger for nonwords. The key assignment was counterbalanced among participants. Before the formal experiment, participants completed 20 practice trials, achieving an accuracy rate of over 90%. Experimental materials were presented at random, and the entire experiment lasted approximately 10 minutes. Data were collected individually in a quiet laboratory setting. The 500-ms prime duration was chosen based on evidence that L2 intra-language semantic priming, particularly for abstract verbs, may require a longer prime exposure to yield reliable facilitation effects due to weaker L2 lexical representations (Elgort, 2011). A 500-ms pattern mask immediately followed the prime to minimize prime visibility, and post-experiment debriefing confirmed that no participant reported awareness of the primes. Thus, although the prime duration is longer than in canonical masked priming studies with L1 participants, the procedure qualifies as masked priming in the functional sense, i.e., primes were rendered invisible via pattern masking, and the paradigm served to probe automatic lexical activation rather than strategic or conscious processing.

Experiment 2: Based on pilot testing, the prime duration was set at 100 ms, as pilot data indicated that interlanguage translation priming between Chinese and English was robust at this shorter duration, consistent with standard masked priming parameters for TEs (Jiang & Forster, 2001). All other aspects of the procedure remained consistent with Experiment 1. The experiment lasted approximately 8 minutes, and the data collection method was identical to that used in Experiment 1.

All participants completed both experiments. To counteract order effects, participants were divided into two groups: one completed Experiment 1 first, followed by Experiment 2, and the other completed the experiments in the opposite order.

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

Table 3. Descriptive statistics for RTs and priming effects under different conditions in Experiment 1 (*M* ± *SD*)

Group	SR	SUR	NF	Priming effects
Group 1	614.46 ± 140.13	608.68 ± 139.45	803.05 ± 220.15	−5.78 ± 54.77
Group 2	649.57 ± 132.12	662.69 ± 140.40	849.05 ± 190.17	13.12 ± 51.07
Group 3	731.35 ± 110.87	731.15 ± 118.09	993.10 ± 182.25	−.20 ± 82.56

Note: Priming effects = SUR RTs—SR RTs.

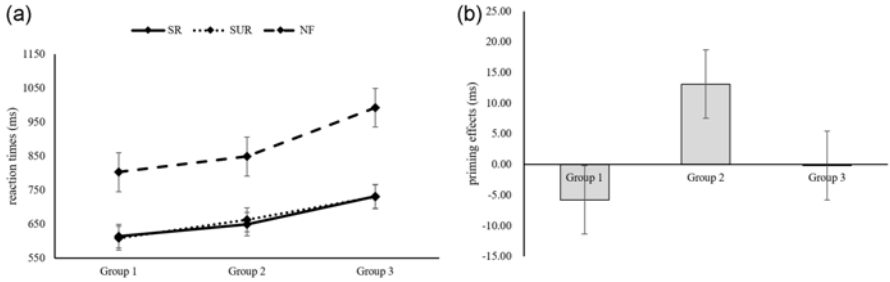


Figure 1. The average RTs (a) and priming effects (b) under different priming conditions in Experiment 1. Error bars indicate standard errors.

Data processing

Accuracy rates consistently exceeded 95% across all experimental conditions, indicating a ceiling effect due to the high familiarity of the selected psych verbs. Consequently, RTs were used as the primary dependent variable. For RT data, trials with incorrect responses and RTs deviating by ±2.5 standard deviations from each participant's mean were excluded. In total, 9.83% of the data in Experiment 1 and 8.16% in Experiment 2 were removed. Subsequently, *p*-values for all post hoc comparisons and correlation analyses involving RTs were adjusted using the Bonferroni method to control for multiple comparisons.

Results

Experiment 1: the intralanguage representation characteristics

Processing efficiency and priming effect

The descriptive statistics for RTs and priming effects under different conditions are presented in Table 3 for each group. The distributions of RTs and priming effects for each group are illustrated in Figure 1.

A two-way ANOVA on RTs with priming type (SR, SUR, NF) and proficiency group (low, intermediate, high) revealed significant main effects of priming type (F (2,354) = 406.24, $p < .001$, $\eta_p^2 = .70$) and proficiency group (F (2,177) = 11.24, $p < .001$, $\eta_p^2 = .11$). However, the interaction was not significant (F (4,354) = .36, $p = .835$, $\eta_p^2 = .01$). Post hoc comparisons showed that RTs in the NF condition were significantly longer than those in the SR and SUR conditions within each

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

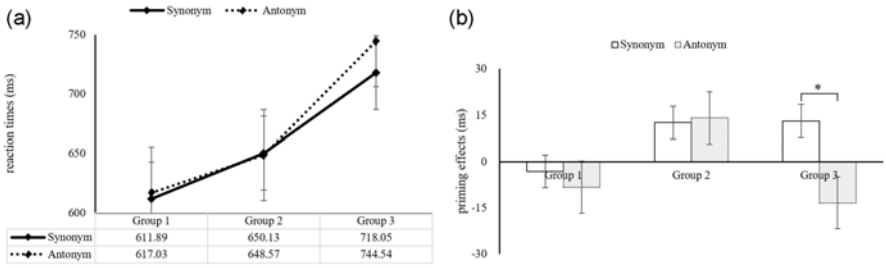


Figure 2. The average RTs (a) and priming effects (b) under different semantic relations in Experiment 1. ***<.001, **<.01, *<.05.

group (ps < .001), confirming that participants successfully discriminated words from nonwords.

Critically, the SR and SUR conditions did not differ significantly in any proficiency group (ps > .05), and the priming effect (SUR–SR) did not vary significantly across groups (F (2,177) = 1.37, p = .258). Thus, intralanguage SR did not produce reliable facilitation in overall RTs. However, a significant proficiency effect emerged within the SR condition: RTs for the low- and intermediate-proficiency groups were significantly shorter than those for the high-proficiency group (ps < .01), with no significant difference between the low- and intermediate-proficiency groups (p = .136).

As shown in Figure 1b, the priming effect exhibited an inverted V-shaped pattern across proficiency levels, increasing from low-to-intermediate proficiency and then decreasing at high proficiency. However, this variation did not reach statistical significance (p = .258).

The influence of lexical–semantic relations on intralanguage representation

Figure 2a illustrates participants' RTs to synonyms and antonyms in the context of intralanguage priming, along with the distribution of their corresponding priming effects shown in Figure 2b.

A two-way ANOVA on RTs with semantic relation (synonym, antonym) and proficiency group (low, intermediate, high) revealed a significant main effect of proficiency (F (2,177) = 13.11, p < .001, η_p^2 = .13). The main effect of semantic relation was not significant (F (1,177) = 1.96, p = .163, η_p^2 = .01), nor was the interaction (F (2,177) = 1.39, p = .251, η_p^2 = .02). Within the high-proficiency group, RTs for synonyms were significantly faster than for antonyms (p < .05). Conversely, no significant differences between synonyms and antonyms were found in the low- and intermediate-proficiency groups (ps > .05). Thus, a significant synonym advantage emerged only at high proficiency.

As shown in Figure 2b, the priming effects mirrored the RT pattern: the synonym advantage over antonyms reached significance only in the high-proficiency group (p < .05). All other pairwise comparisons, both within each proficiency group and between groups for each semantic relation, were not significant.

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

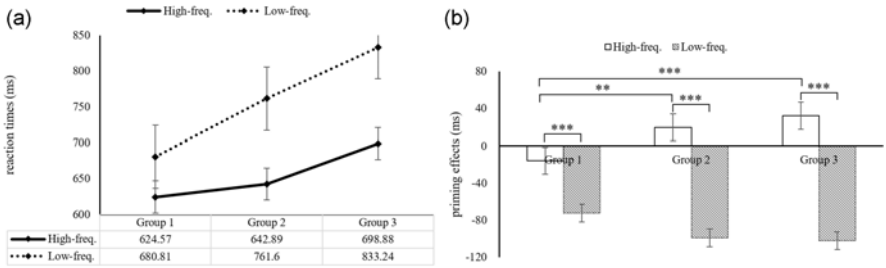


Figure 3. The average RTs (a) and priming effects (b) under different frequencies in Experiment 1.

The influence of word frequency on intralanguage representation

The RTs for high- and low-frequency words in each group are illustrated in Figure 3a, and the distributions of their respective priming effects are displayed in Figure 3b.

A two-way ANOVA on RTs with word frequency (high, low) and proficiency group (low, intermediate, high) revealed a significant main effect of frequency (F (1,177) = 155.60, $p < .001$, $\eta_p^2 = .47$), a significant main effect of proficiency (F (2,177) = 7.75, $p < .01$, $\eta_p^2 = .08$), and a significant interaction (F (2,177) = 8.34, $p < .001$, $\eta_p^2 = .09$). High-frequency words elicited significantly shorter RTs than low-frequency words within each group ($ps < .001$). The interaction reflected that, for high-frequency words, the low- and intermediate-proficiency groups responded significantly faster than the high-proficiency group ($ps < .05$); for low-frequency words, the low-proficiency group responded the fastest, and the high-proficiency group responded the slowest, with all pairwise differences being significant ($ps < .05$).

Figure 3b shows the corresponding priming effects. For each proficiency group, high-frequency words elicited significantly larger priming effects than low-frequency words ($ps < .001$). Between-group comparisons revealed significant differences only for high-frequency words: the low-proficiency group showed significantly smaller priming effects than both the intermediate- and high-proficiency groups ($ps < .01$), whereas no significant difference was found between the intermediate- and high-proficiency groups. For low-frequency words, no significant group differences were observed ($ps > .05$).

The joint influence of word frequency and semantic relation on intralanguage representation

Table 4 shows the results of the partial correlation analysis of synonyms and antonyms, adjusting for word frequency and controlling for semantic relationships, for high- and low-frequency terms and across various cohorts.

Table 4 shows significant correlations between synonyms and antonyms across all proficiency levels ($ps < .001$) without controlling for word frequency. However, for low-frequency words, significant correlations are observed only in the low- and intermediate-proficiency groups. Similarly, after accounting for high-frequency words, significant correlations are found solely in the intermediate-proficiency group. In contrast, significant correlations between high- and low-frequency words

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

Table 4. The results of the partial correlation analysis under different conditions in Experiment 1

		Synonyms and antonyms			High- and low-frequency words		
		Un-Ctrl	LFW Ctrl	HFW Ctrl	Un-Ctrl	Antonym Ctrl	Synonym Ctrl
Group 1	Correlation	.908***	.562**	.172	.827***	−.074	−.099
	Sig.(2-tailed)	.000	.000	.194	.000	.576	.454
Group 2	Correlation	.900***	.334*	.416**	.857***	−.057	.210
	Sig.(2-tailed)	.000	.010	.001	.000	.669	.110
Group 3	Correlation	.421***	.083	.185	.753***	.704***	−.144
	Sig.(2-tailed)	.001	.531	.162	.000	.000	.277

Note: (1) LFW = low-frequency words; HFW = high-frequency words; Antonym = antonyms; Synonym = synonyms; Ctrl = controlled; Un-Ctrl = uncontrolled. Combinations indicate the variable controlled for (e.g., LFW Ctrl = controlled for low-frequency words). (2) ***< .001, **< .01, *< .05.

Table 5. Descriptive statistics for RTs and priming effects under different conditions in Experiment 2 (*M* ± *SD*)

Group	TE	NTE	NF	Priming effects
Group 1	750.15 ± 117.35	942.97 ± 166.56	938.13 ± 169.87	192.82 ± 92.12
Group 2	756.92 ± 85.23	897.93 ± 127.87	882.18 ± 131.67	141.01 ± 86.41
Group 3	770.62 ± 76.25	884.25 ± 123.69	865.46 ± 117.34	113.63 ± 91.65

Note: Priming effects = NTE RTs—TE RTs.

are observed across all groups, even without controlling for semantic relations. Notably, when controlling for antonyms, a significant correlation between high- and low-frequency words is apparent exclusively within the high-proficiency group.

In summary, the partial correlation analyses showed that the relationship between synonyms and antonyms was modulated by word frequency. With increasing proficiency, semantic integration between synonyms and antonyms became less frequency-dependent. In contrast, the link between high- and low-frequency words became more dependent on semantic relation, particularly antonymy.

Experiment 2: the interlanguage representation characteristics

Processing efficiency and priming effect

Table 5 shows the statistical results for RTs and priming effects, while Figure 4 illustrates the distribution of RTs and priming effects within each group.

A two-way ANOVA on RTs with priming type (TE, NTE, NF) and proficiency group (low, intermediate, high) revealed a significant main effect of priming type (F (2,354) = 407.50, p < .001, η_p^2 = .70) and a significant interaction (F (4,354) = 13.04, p < .001, η_p^2 = .13). The main effect of proficiency was not

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

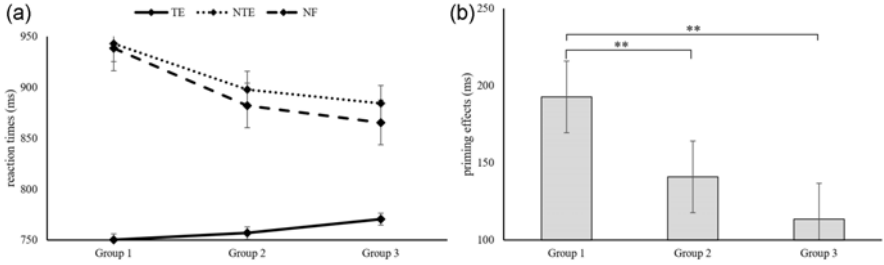


Figure 4. The average RTs (a) and priming effects (b) under different priming conditions in Experiment 2.

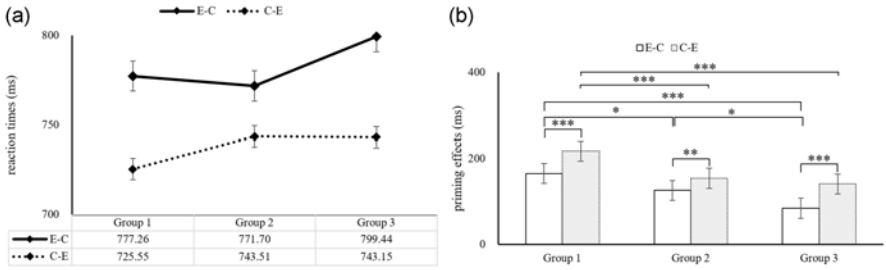


Figure 5. The average RTs (a) and priming effects (b) under different directions in Experiment 2.

significant (F (2,177) = 1.68, p = .190, η_p^2 = .02). Post hoc comparisons confirmed that RTs in the NF condition were significantly longer than those in the TE and NTE conditions within each group (ps < .001), validating task compliance. RTs in the TE condition were significantly shorter than those in the NTE condition (p < .001), indicating robust facilitation from TEs. No significant RT differences were observed among proficiency groups within the TE condition (ps > .05).

As shown in Figure 4b, the priming effect decreased consistently as L2 proficiency increased. A one-way ANOVA on the priming effect with proficiency as the independent variable yielded a significant main effect (F (2,177) = 11.96, p < .001). Post hoc comparisons confirmed that the priming effect was significantly larger for the low-proficiency group than for the intermediate- and high-proficiency groups (ps < .01); the intermediate- and high-proficiency groups did not differ significantly (p = .089). The translation priming effect was strongest at the lowest proficiency level and weakened as proficiency increased.

The influence of language direction on interlanguage representation

Figure 5a depicts the TE RTs for three groups in both E-C and C-E directions, and Figure 5b shows the distribution of priming effects for each direction.

A two-way ANOVA on RTs with language direction (E-C, C-E) and proficiency group (low, intermediate, high) revealed a significant main effect of direction (F (1,177) = 58.31, p < .001, η_p^2 = .25). Neither the main effect of proficiency (F (2,177) = .69, p = .501, η_p^2 = .01), nor the interaction (F (2,177) = 2.14,

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

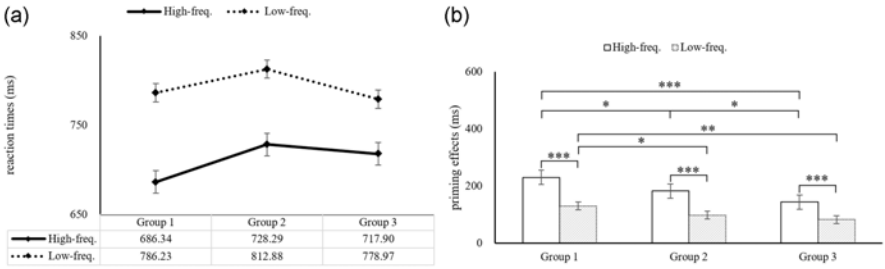


Figure 6. The average RTs (a) and priming effects (b) under different frequencies in Experiment 2.

$p = .120$, $\eta_p^2 = .02$) was significant. RTs were significantly shorter in the C-E direction than in the E-C direction within each proficiency group ($ps < .01$). This C-E advantage was consistent across proficiency levels.

As shown in Figure 5b, the priming effects decreased with increasing proficiency in both directions. Within each proficiency group, the C-E priming effect was significantly larger than the E-C priming effect ($ps < .01$). In the E-C direction, the priming effect of the low–proficiency group was significantly larger than those of the intermediate- and high–proficiency groups ($ps < .01$), and the intermediate group also showed a significantly larger effect than the high group ($p < .05$). In the C-E direction, the low-proficiency group had significantly larger priming effects than both the intermediate and high groups ($ps < .001$), but there was no significant difference between the intermediate and high groups ($p > .05$).

The influence of word frequency on interlanguage representation

Figure 6a depicts the RTs for high- and low-frequency words in three groups, and Figure 6b shows the distribution of their respective priming effects.

A two-way ANOVA on RTs with word frequency (high, low) and proficiency group (low, intermediate, high) showed a significant main effect of word frequency (F (1,177) = 174.25, $p < .001$, $\eta_p^2 = .50$). The main effect of proficiency was not significant (F (2,177) = .26, $p = .770$, $\eta_p^2 = .003$), but the interaction was significant (F (2,177) = 3.12, $p = .047$, $\eta_p^2 = .03$). Simple effect analyses revealed that RTs for high-frequency words were significantly shorter than those for low-frequency words in each proficiency group ($ps < .001$). No significant differences in RTs among proficiency groups were observed for either high- or low-frequency words ($ps > .05$).

The priming effects depicted in Figure 6b show a gradual decline for high- and low-frequency words as L2 proficiency increases. High-frequency words produced significantly larger priming effects than low-frequency words within each proficiency group ($ps < .001$). For high-frequency words, the priming effect was largest in the low-proficiency group and smallest in the high-proficiency group, with all pairwise differences being significant ($ps < .05$). For low-frequency words, the priming effect was significantly larger in the low-proficiency group than in the intermediate- or high-proficiency group ($ps < .05$).

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

Table 6. The results of the partial correlation analysis under different conditions in Experiment 2

		E-C and C-E directions			High- and low-frequency words		
		Un-Ctrl	LFW Ctrl	HFW Ctrl	Un-Ctrl	C-E Ctrl	E-C Ctrl
Group 1	Correlation	.728***	.152	.113	.833***	.483***	.454**
	Sig.(2-tailed)	.000	.251	.395	.000	.000	.000
Group 2	Correlation	.679***	.259*	.201	.574***	−.157	.069
	Sig.(2-tailed)	.000	.048	.127	.000	.234	.604
Group 3	Correlation	.685***	.289*	.331*	.589***	−.288*	.246
	Sig.(2-tailed)	.000	.027	.010	.000	.027	.061

Note: (1) Abbreviations for Ctrl, Un-Ctrl, LFW, and HFW are as defined in Table 4. Additional abbreviations: C-E = Chinese to English; E-C = English to Chinese. Combinations indicate the direction controlled for (e.g., C-E Ctrl = controlled for the C-E direction). (2) Significance levels are the same as in Table 4.

The joint influence of word frequency and language direction on interlanguage representation

Table 6 shows the partial correlation results for the E-C and C-E directions. It considers word frequency as a controlled variable for both high- and low-frequency words and incorporates language direction as a covariate across three groups.

Table 6 shows a significant correlation in TE representation between the E-C and C-E directions across all groups, with no control for word frequency. However, the correlation patterns change when low- and high-frequency words are controlled separately. Specifically, after controlling for low-frequency words, a significant correlation is observed only within the intermediate- and high-proficiency groups. In contrast, controlling for high-frequency words reveals a significant correlation only within the high-proficiency group. Moreover, irrespective of language direction, high- and low-frequency TEs exhibit significant correlations within each group. However, when controlling for the C-E direction, a positive correlation is present in the low-proficiency group, whereas a negative correlation emerges in the high-proficiency group. Conversely, a significant correlation is evident only within the low-proficiency group, even after controlling for the E-C direction.

The key findings were twofold. First, word frequency significantly modulates the TE correlation between the E-C and C-E directions, especially for advanced-proficiency learners. Second, the association between high- and low-frequency words varied by language direction. In the E-C direction, low-proficiency learners showed a significant positive correlation between high- and low-frequency TEs, whereas high-proficiency learners showed a negative correlation. In the C-E direction, a significant positive correlation emerged only in the low-proficiency group.

The comparison between the intra- and interlanguage representations of English psych verbs

At varying proficiency levels (low: 614.46 ± 140.13 vs. 750.15 ± 117.35; intermediate: 649.57 ± 132.12 vs. 756.92 ± 85.23; high: 731.35 ± 110.87 vs. 770.62 ± 76.25),

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

learners demonstrated significantly shorter RTs for intralanguage processing compared with interlanguage processing ($ps < .001$), indicating superior efficiency in intralanguage processing. High-frequency words consistently showed significantly shorter RTs in intralanguage processing than in interlanguage processing across all proficiency levels (low: 624.57 ± 148.59 vs. 706.23 ± 123.05; intermediate: 642.89 ± 145.79 vs. 707.37 ± 88.78; high: 698.88 ± 128.33 vs. 735.56 ± 79.75; $ps < .05$). However, for low-frequency words, significant differences between intra- and interlanguage processing were only evident in the low (680.81 ± 196.06 vs. 803.71 ± 146.02) and intermediate (761.60 ± 194.86 vs. 803.68 ± 110.64) proficiency groups ($ps < .05$), with no significant distinction in the high-proficiency group (833.24 ± 179.43 vs. 798.18 ± 102.62; $p = .092$). This suggests that the advantage of intralanguage processing for low-frequency words diminishes with increasing L2 proficiency. Notably, as L2 proficiency advances, the efficiency gap between intra- and interlanguage processing gradually narrows.

Across different proficiency levels (low, intermediate, high), interlanguage priming effects significantly exceeded intralanguage priming effects (priming effects: −6.19 ± 55.14 *vs.* 195.83 ± 89.90; 13.12 ± 51.07 vs. 141.01 ± 86.41; −.20 ± 82.56 vs. 113.63 ± 91.65), all with *p*-values less than .001. High-frequency words consistently showed higher interlanguage priming compared with intralanguage priming across all proficiency levels (priming effects: -15.89 ± 58.83 vs. 236.74 ± 115.52; 19.80 ± 79.18 vs. 190.56 ± 104.69; 32.27 ± 77.08 vs. 148.69 ± 108.03), all with *p*-values less than .001. Similarly, low-frequency words also exhibited significantly stronger interlanguage priming than intralanguage priming across all proficiency levels (priming effects: −72.13 ± 124.17 vs. 139.25 ± 116.39; −98.91 ± 89.97 vs. 94.25 ± 101.99; −102.08 ± 99.24 vs. 86.06 ± 107.09), all with *p*-values less than .001. These results indicate a consistent prevalence of interlanguage priming over intralanguage priming in CEBs, as shown in Figure 7, suggesting shared distributed lexical representations between English and Chinese. This challenges the traditional notion of distinct or highly segregated intra- and interlanguage representations.

Discussion

Intralanguage representation characteristics of English psych verbs

The finding that intralanguage semantic relatedness (SR vs. SUR) did not produce significant facilitation in overall RTs appears to reflect that lexical–semantic associations alone do not automatically drive psych-verb processing for CEBs; instead, processing appears to be modulated jointly by semantic relation, proficiency, and word frequency. The emergence of a significant synonym advantage—but only among high-proficiency learners—indicates that the integration of synonyms into a coherent semantic network is a proficiency-dependent achievement. This pattern is consistent with the distributed feature model (Plaut & Gonnerman, 2000), which predicts that increased proficiency leads to more differentiated and finely calibrated featural representations. The synonym advantage at high proficiency suggests that synonymous psych verbs achieve sufficient featural overlap to generate robust priming. In contrast, antonyms, which share fewer semantic features, remain less integrated even at advanced proficiency levels.

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

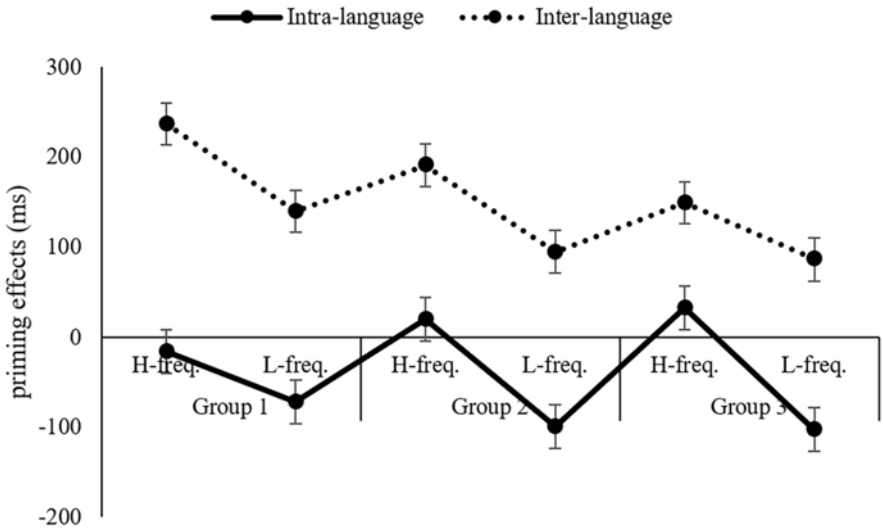


Figure 7. The priming effects between intra- and interlanguage under various frequencies for different groups.

Consistent with prior research, high-frequency words produced significantly larger intralanguage priming effects than low-frequency words across all groups (Monaco et al., 2007). Notably, this frequency advantage was smallest for low-proficiency learners, who showed significantly weaker high-frequency priming than the intermediate- and high-proficiency groups. Contrary to the hypothesis that frequency effects would be most pronounced in low-proficiency learners, the high-frequency advantage was smallest in this group. This unexpected pattern may reflect the fact that low-proficiency learners, whose lexical representations are less entrenched, benefit less from the cumulative exposure that drives high-frequency facilitation (Elgort, 2011; Kim, 2008).

The partial correlation analyses further revealed that proficiency moderates the interplay between semantic relations and word frequency. For low- and intermediate-proficiency learners, semantic associations—particularly antonymy—remained tied to word frequency; for high-proficiency learners, synonym integration became independent of frequency, whereas antonym processing remained frequency-sensitive. This asymmetry between the organization of synonyms and antonyms is consistent with the view that psych verbs carry inherent affective complexity, making antonymic contrasts harder to integrate, even at high proficiency (Ferré et al., 2015).

Interlanguage representation characteristics of English psych verbs

The robust translation priming effect (TE < NTE) across all proficiency levels confirms that TEs are automatically activated during bilingual psych-verb processing, consistent with the shared asymmetric model's claim that L1 and L2 lexical representations are interconnected via shared conceptual features (Kim & Chung,

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

2024; Kroll & Stewart, 1994). The magnitude of this priming effect decreased as proficiency increased, with low-proficiency CEBs showing significantly larger facilitation than intermediate- and high-proficiency CEBs. This pattern suggests a developmental shift; at lower proficiency, L2 processing relies heavily on L1-mediated access, whereas at higher proficiency, it enables more direct L2-to-concept mapping, reducing the relative contribution of translation-mediated activation (Kroll & Stewart, 1994).

Consistent with the hypothesis, the C-E advantage was largest for low-proficiency learners, confirming that the translation priming asymmetry—with significantly stronger priming in the C-E than in the E-C direction—directly supports the shared asymmetric model's core prediction that lexical–semantic links are stronger from L1 to L2 than vice versa (Kroll & Stewart, 1994; Yang et al., 2023). This asymmetry was largest among low-proficiency learners and diminished with increasing proficiency, suggesting that the C-E advantage reflects L1-mediated access that weakens as direct L2 representations strengthen.

Word frequency further modulated cross-linguistic priming. High-frequency TEs produced larger priming effects than low-frequency ones across all proficiency levels, consistent with the idea that stronger L2 representations—built through repeated exposure—activate their L1 counterparts more efficiently (Marian et al., 2009). The frequency effect on translation priming was largest for low-proficiency learners. It weakened as proficiency increased, suggesting that frequency-driven facilitation is most critical when direct L2 representations are still developing.

The partial correlation analyses confirmed that language direction and word frequency jointly shape interlanguage representation. In the E-C direction, intermediate learners showed a positive correlation between high- and low-frequency TEs, suggesting that high-frequency words facilitate access to low-frequency counterparts when processing from L1 to L2. High-proficiency learners, by contrast, exhibited a negative correlation in the same direction, indicating that they process high- and low-frequency words via more differentiated pathways. In the C-E direction, only low-proficiency learners showed a significant positive correlation between high- and low-frequency words, reinforcing the view that frequency-driven co-activation is most pronounced when L2 proficiency is low (Marian et al., 2009).

Relationship between intra- and interlanguage representations and proficiency modulation

Across all proficiency levels, intralanguage RTs were significantly shorter than interlanguage RTs, consistent with prior evidence that intralanguage lexical processing imposes lower cognitive demands than interlanguage processing (Sabourin & Stowe, 2008). This intralanguage efficiency advantage likely reflects the fact that staying within a single language avoids the cost of cross-linguistic switching and integration (Frumuselu, 2018).

The intralanguage RT advantage was robust for high-frequency words across all proficiency levels. For low-frequency words, however, this advantage was significant only for low- and intermediate-proficiency groups and disappeared at high proficiency. This convergence suggests that as L2 proficiency increases, low-frequency words are more efficiently integrated into the interlanguage network, reducing the

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

gap between intra- and interlanguage access. Despite faster intralanguage RTs, interlanguage priming effects were consistently larger across all conditions. This dissociation—faster processing within a language but stronger interlanguage facilitation—is a signature of the shared asymmetric model, in which shared conceptual representations enable robust interlanguage activation even when language-specific lexical access remains more efficient (Jiang & Forster, 2001).

These results extend the shared asymmetric model (Kroll & Stewart, 1994) in two important ways. First, they demonstrate that the developmental shift from L1-mediated to direct L2 conceptual access applies to abstract psych verbs, not only to the concrete nouns on which the model was originally tested. Second, they show that this shift is modulated by word frequency; low-frequency words continue to rely on L1-mediated access even at intermediate proficiency, whereas high-frequency words develop direct L2-to-concept links earlier.

A central finding of this study is that interlanguage priming tended to exceed intralanguage priming across all proficiency levels, despite faster intralanguage RTs. This pattern supports the view that the bilingual lexicon is a fundamentally integrated system in which interlanguage connections remain active regardless of proficiency (Li et al., 2023; Siyambalapitiya et al., 2013). The persistent interlanguage facilitation observed here suggests that shared distributed representations between L1 and L2 are automatically co-activated during lexical processing, even when intralanguage access is more efficient.

Taken together, the results largely support the three core hypotheses, while also revealing an unexpected pattern. The synonym advantage emerged only at high proficiency (supporting the first prediction of Hypothesis 1). However, contrary to the second prediction of Hypothesis 1, the frequency effect was smallest, not largest, in low-proficiency learners, suggesting that cumulative exposure benefits are constrained when lexical representations are not yet entrenched. The C-E asymmetry was largest for low-proficiency learners (supporting Hypothesis 2), and the intra–inter gap narrowed with increasing proficiency, particularly for low-frequency words (supporting Hypothesis 3). Despite this partial deviation, the convergent findings robustly demonstrate that the distributed feature model and the shared asymmetric model—originally developed for concrete nouns—extend to abstract psych verbs under the modulating influence of L2 proficiency.

Limitations and future directions

Several limitations warrant consideration. First, the sample predominantly consisted of students within a narrow age range, which may have limited the generalizability of the findings to older bilinguals or to those with nonacademic language acquisition backgrounds. Second, methodologically, while the masked priming paradigm effectively probed implicit semantic processing, its focus on lexical decision-making tasks may not fully capture explicit memory retrieval or syntactic/discourse-level processing. The cross-sectional design also precludes the examination of longitudinal changes in semantic networks, and relying solely on RTs as the behavioral measure overlooks complementary neurocognitive data from techniques such as fMRI or electroencephalogram (EEG). Third, the study examined a specific set of English psych verbs within a single language pair (C-E); future

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

research should test whether the observed patterns generalize to other word classes and language combinations. Fourth, we employed aggregated ANOVA analyses to examine the effects of proficiency, priming type, and word frequency on RTs. Although this approach is well established in psycholinguistic research and remains appropriate for detecting population-level effects, it does not simultaneously model random variability associated with both participants and items. Recent studies have suggested that item-level variability may influence the magnitude of semantic priming effects and that mixed-effects models offer advantages in handling crossed random factors and estimating random slopes (Barr et al., 2013; Heyman et al., 2018). Future research with a sufficiently large stimulus set could employ linear mixed-effects models to complement the present findings and further examine item-level contributions to the observed priming patterns. Finally, the two experiments employed different prime durations (500 ms in Experiment 1 vs. 100 ms in Experiment 2). Although this choice was motivated by the distinct processing demands of intralanguage L2 priming and interlanguage translation priming, and post-experiment debriefing confirmed no conscious awareness of the prime in either experiment, the duration asymmetry should be taken into account when interpreting interexperiment comparisons. Future studies could adopt a unified parametric design to systematically examine how prime duration modulates both intra- and interlanguage priming effects in L2 abstract verb processing.

To address these gaps, future research could diversify participant demographics to include a broader range of ages and educational backgrounds. Integrating multimodal approaches, such as combining implicit and explicit tasks with neuroimaging, would deepen our understanding of the neural mechanisms underlying bilingual processing. Longitudinal designs tracking proficiency development over time, alongside comparative studies across multiple language pairs and word classes, would further refine theoretical models. Moreover, examining the relationships among proficiency, age of acquisition, and language use patterns may reveal additional dimensions of bilingual semantic representation, with practical implications for L2 pedagogy.

Conclusion

This study demonstrates that L2 proficiency significantly modulates the organization of English psych verbs in the mental lexicons of CEBs. Regarding intralanguage representation, the emergence of a synonym advantage only at high proficiency is consistent with the distributed feature model's prediction that featural representations become more differentiated with increasing L2 proficiency (Plaut & Gonnerman, 2000). In terms of interlanguage processing, the robust C-E translation priming asymmetry—largest for low-proficiency learners—provides direct support for the shared asymmetric model's core claim of stronger L1-to-L2 connections (Kroll & Stewart, 1994) and advances recent work on proficiency-dependent asymmetries in translation priming (Yang et al., 2023). Importantly, interlanguage priming tended to exceed intralanguage priming across all proficiency levels, suggesting that the integrated nature of the bilingual lexicon may extend to abstract verb categories. The central theoretical contribution lies in demonstrating that the

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

distributed feature model and the shared asymmetric model—originally developed for concrete nouns—generalize to abstract psych verbs, and that this generalization is modulated by L2 proficiency and word frequency. Advanced learners transcend frequency constraints for synonymy but not for antonymy, underscoring the unique featural complexity of psych verbs. These findings suggest that future models of the bilingual lexicon should incorporate both L2 proficiency and word frequency as interacting parameters that jointly govern the rate at which distributed L2 representations become autonomous from their L1 counterparts.

Replication package. All analysis, data, and code are available at: https://osf.io/kuc6w/.

Author contributions. Concept and design, data collection, and analysis: Yun Wang; drafting of the article and critical revision of the article for important intellectual content: Xinfang Liu. Both authors approved the final article.

Financial support. This work was supported by the National Social Science Foundation (21BYY100) from China.

Competing interests. The authors report there are no competing interests to declare.

References

Altarriba, J., & Heredia, R. R. (2017). *An introduction to bilingualism: Principles and processes* (2nd ed.). Routledge.

Amzali, A., Kourtin, A., Mourchid, M., Mouloudi, A., & Mbarki, S. (2020). Lexicon-grammar tables development for Arabic psychological verbs. *Communications in Computer and Information Science*, **1153**, 15–26. https://doi.org/10.1007/978-3-030-38833-1_2.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, **68**(3), 255–278. https://doi.org/10.1016/j.jml.2012.11.001

Belinkov, Y., Durrani, N., Dalvi, F., Sajjad, H., & Glass, J. (2020). On the linguistic representational power of neural machine translation models. *Computational Linguistics*, **46**(1), 1–52. https://doi.org/10.1162/coli_a_00367.

Campbell, J. I. D., & Thompson, V. A. (2012). MorePower 6.0 for ANOVA with relational confidence intervals and Bayesian analysis. *Behavior Research Methods*, **44**, 1255–1265. https://doi.org/10.3758/s13428-012-0186-0.

Crossley, S. A., Subtirelu, N., & Salsbury, T. (2013). Frequency effects or context effects in second language word learning. *Studies in Second Language Acquisition*, **35**(4), 727–755. https://doi.org/10.1017/S0272263113000375.

Crossley, S., Salsbury, T., Titak, A., & McNamara, D. (2014). Frequency effects and second language lexical acquisition. *International Journal of Corpus Linguistics,* **19**(3), 301–332. https://doi.org/10.1075/ijcl.19.3.01cro

Cumming, A. (1989). Writing expertise and second language proficiency. *Language Learning*, **39**(1), 81–135. https://doi.org/10.1111/j.1467-1770.1989.tb00592.x.

Dijkstra, T., Wahl, A., Buytenhuijs, F., Halem, N., AL-Jibouri, Z., Korte, M., & Rekké, S. (2018). Multilink: A computational model for bilingual word recognition and word translation. *Bilingualism Language and Cognition*, **22**(4), 657–679. https://doi.org/10.1017/s1366728918000287.

Doctor, E. A., Ahmed, R., Ainslee, V., Cronje, T., Klein, D., & Knight, S. (1987). Cognitive aspects of bilingualism: Internal representation. *South African Journal of Psychology*, **17**(2), 63–71. https://doi.org/10.1177/008124638701700205.

Duñabeitia, J., Ivaz, L., & Casaponsa, A. (2015). Developmental changes associated with cross-language similarity in bilingual children. *Journal of Cognitive Psychology*, **28**(1), 16–31. https://doi.org/10.1080/20445911.2015.1086773.

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

Elgort, I. (2011). Deliberate learning and vocabulary acquisition in a second language. *Language Learning*, **61**(2), 367–413. https://doi.org/10.1111/j.1467-9922.2010.00613.x.

Fang, N., & Zhang, P. (2021). L1 congruency, word frequency, collocational frequency, L2 proficiency, and their combined effects on Chinese–English bilinguals' L2 collocational processing. *International Journal of Bilingualism*, **25**(5), 1429–1445. https://doi.org/10.1177/13670069211024747.

Ferré, P., Guasch, M., García-Chico, T., & Sánchez-Casas, R. (2015). Are there qualitative differences in the representation of abstract and concrete words? *Quarterly Journal of Experimental Psychology*, **68**(12), 2402–2418. https://doi.org/10.1080/17470218.2015.1016980.

Fontes, A., & Schwartz, A. (2010). On a different plane: Cross-language effects on the conceptual representations of within-language homonyms. *Language and Cognitive Processes*, **25**(4), 508–532. https://doi.org/10.1080/01690960903285797.

Francis, W. (2018). Shared core meanings and shared associations in bilingual semantic memory: Evidence from research on implicit memory. *International Journal of Bilingualism*, **24**(3), 464–477. https://doi.org/10.1177/1367006918814375.

Frumuselu, A. (2018). The implications of cognitive load theory and exposure to subtitles in English foreign language (EFL). *Translation and Translanguaging in Multilingual Contexts*, **4**(1), 55–76. https://doi.org/10.1075/ttmc.00004.fru.

Giusti, G., & Iovino, R. (2019). Psychological verbs as a vulnerable syntactic domain: A comparative study of Latin and Italian. *Lingua*, **223**, 29–45. https://doi.org/10.1016/j.lingua.2019.03.001.

Goetry, V., Kolinsky, R., & Mousty, P. (2009). Do Bilingual Beginning Readers Activate the Grapheme-Phoneme Correspondences of Their Two Languages When Reading in One Language? In **V. Goetry, R. Kolinsky & P. Mousty** (Eds.), *Contemporary perspectives on reading and spelling* (pp. 180–197). Routledge. https://doi.org/10.4324/9780203877838-18.

Hamrick, P., & Pandža, N. B. (2020). Contributions of semantic and contextual diversity to the word frequency effect in L2 lexical access. *Canadian Journal of Experimental Psychology*, **74**(1), 25–34. https://doi.org/10.1037/cep0000189.

Hell, J. (2023). The neurocognitive underpinnings of second language processing: Knowledge gains from the past and future outlook. *Language Learning*, **73**(S2), 172–181. https://doi.org/10.1111/lang.12618.

Heyman, T., Bruninx, A., Hutchison, K. A., & Storms, G. (2018). The (un)reliability of item-level semantic priming effects. *Behavior Research Methods*, **50**(6), 2173–2183. https://doi.org/10.3758/s13428-018-1040-9

Ip, K. I., Hsu, L. S., Arredondo, M. M, Tardif, T., & Kovelman, I. (2017). Brain bases of morphological processing in Chinese-English bilingual children. *Developmental Science*, **20**, e12449. https://doi.org/10.1111/desc.12449.

Jiang, N., & Forster, K. (2001). Cross-language priming asymmetries in lexical decision and episodic recognition. *Journal of Memory and Language*, **44**(1), 32–51. https://doi.org/10.1006/jmla.2000.2737.

Kahraman, H., & Beyersmann, E. (2024). Sand, sandpaper, and sandwiches: Evidence from a masked compound priming task in L1 and L2 speakers of English. *Journal of Cognition*, **7**(1), 30. https://doi.org/10.5334/joc.350.

Kim, J., & Chung, T. (2024). The role of cause in the L2 acquisition of English psychological verbs. *Korean Journal of English Language and Linguistics*, **24**, 15–34. https://doi.org/10.15738/kjell.24.202401.15.

Kim, Y. (2008). The role of task-induced involvement and learner proficiency in L2 vocabulary acquisition. *Language Learning*, **58**(2), 285–325. https://doi.org/10.1111/j.1467-9922.2008.00442.x.

Klein, D., & Doctor, E. (1992). Homography and polysemy as factors in bilingual word recognition. *South African Journal of Psychology*, **22**(1), 10–16. https://doi.org/10.1177/008124639202200102.

Klepousniotou, E. (2002). The processing of lexical ambiguity: Homonymy and polysemy in the mental lexicon. *Brain and Language*, **81**(1–3), 205–223. https://doi.org/10.1006/brln.2001.2518.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, **33**(2), 149–174. https://doi.org/10.1006/jmla.1994.1008

Kubus, O., Villwock, A., Morford, J., & Rathmann, C. (2014). Word recognition in deaf readers: Cross-language activation of German Sign Language and German. *Applied Psycholinguistics*, **36**(4), 831–854. https://doi.org/10.1017/s0142716413000520.

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

Lachelin, R., Marinova, M., Reynvoet, B., & Schiltz, C. (2024). Weaker semantic priming effects with number words in the second language of math learning. *Journal of Experimental Psychology*, **153**(3), 706–719. https://doi.org/10.1037/xge0001526.

Lemhöfer, K., & Broersma, M. (2012). Introducing LexTALE: A quick and valid lexical test for advanced learners of English. *Behavior Research Methods*, **44**, 325–343. https://doi.org/10.3758/s13428-011-0146-0.

Li, H., Cao, Y., Chen, C., Liu, X., Zhang, S., & Mei, L. (2023). The depth of semantic processing modulates cross-language pattern similarity in Chinese-English bilinguals. *Human Brain Mapping*, **44**(5), 2085–2098. https://doi.org/10.1002/hbm.26195.

Li, R., & Peng, D. (1999). Semantic representations in bilinguals. *Modern Foreign Languages*, **85**(3), 255–272. https://doi.org/CNKI:SUN:XDWY.0.1999-03-003.

Luk, G., & Bialystok, E. (2013). Bilingualism is not a categorical variable: Interaction between language proficiency and usage. *Journal of Cognitive Psychology*, **25**(5), 605–621. https://doi.org/10.1080/20445911.2013.795574.

Marian, V., Faroqi-Shah, Y., Kaushanskaya, M., Blumenfeld, H., & Sheng, L. (2009). Bilingualism: Consequences for language, cognition, development, and the brain. *ASHA Leader*, **14**(13), 10–13. https://doi.org/10.1044/leader.ftr2.14132009.10.

Maye, J., Weiss, D. J., & Aslin, R. N. (2008). Statistical phonetic learning in infants: Facilitation and feature generalization. *Developmental Science*, **11**(1), 122–134. https://doi.org/10.1111/j.1467-7687.2007.00653.x.

Miozzo, M., Costa, A., Hernández, M., & Rapp, B. (2009). Lexical processing in the bilingual brain: Evidence from grammatical/morphological deficits. *Aphasiology*, **24**(2), 262–287. https://doi.org/10.1080/02687030902958381.

Monaco, J. D., Abbott, L. F., & Kahana, M. J. (2007). Lexico-semantic structure and the word-frequency effect in recognition memory. *Learning Memory*, **14**(3), 204–213. https://doi.org/10.1101/lm.363207.

Paradis, J. (2010). The interface between bilingual development and specific language impairment. *Applied Psycholinguistics*, **31**(2), 227–252. https://doi.org/10.1017/s0142716409990373.

Plaut, D., & Gonnerman, L. (2000). Are non-semantic morphological effects incompatible with a distributed connectionist approach to lexical processing? *Language and Cognitive Processes*, **15**(4-5), 445–485. https://doi.org/10.1080/01690960050119661.

Random House. (2012). *Random House Roget's Thesaurus*. The Ballantine Publishing Group.

Rudolph, U., & Försterling, F. (1997). The psychological causality implicit in verbs: A review. *Psychological Bulletin*, **121**(2), 192–218. https://doi.org/10.1037/0033-2909.121.2.192.

Sabourin, L., & Stowe, L. A. (2008). Second language processing: when are first and second languages processed similarly? *Second Language Research*, **24**(3), 397–430. https://doi.org/10.1177/0267658308090186.

Schwanenflugel, P. J., Fabricius, W. V., Noyes, C. R., Bigler, K. D., & Alexander, J. M. (1994). The organization of mental verbs and folk theories of knowing. *Journal of Memory and Language*, **33**(3), 376–395. https://doi.org/10.1006/jmla.1994.1018.

Siyambalapitiya, S., Chenery, H., & Copland, D. (2013). Lexical-semantic representation in bilingual aphasia: Findings from semantic priming and cognate repetition priming. *Aphasiology*, **27**(11), 1302–1321. https://doi.org/10.1080/02687038.2013.817521.

Tabori, T., & Pyers, J. (2025). Individual differences in L2 proficiency moderate the effect of L1 translation knowledge on L2 lexical retrieval. *Bilingualism: Language and Cognition*, **28**(2), 300–311. https://doi.org/10.1017/s1366728924000385.

Thierry, G., & Rebuschat, P. (2020). An introduction to the cognitive neuroscience of second and artificial language learning. *Language Learning*, **70**(S2), 5–19. https://doi.org/10.1111/lang.12408.

Tomasino, B., Nobile, M., Re, M., Bellina, M., Garzitto, M., Arrigoni, F., Molteni, M., Fabbro, F., & Brambilla, P. (2018). The mental simulation of state/psychological verbs in the adolescent brain: An fMRI study. *Brain and Cognition*, **123**, 34–46. https://doi.org/10.1016/j.bandc.2018.02.010.

Van Hell, J. G., & De Groot, A. M. B. (1998). Conceptual representation in bilingual memory: Effects of concreteness and cognate status in word association. *Bilingualism: Language and Cognition*, **1**(3), 193–211. https://doi.org/10.1017/s1366728998000352

Wang, P., Huang, X., & Chang, X. (2023). The effect of inhibitory control and language proficiency on intra-sentential switching costs in reading comprehension. *Acta Psychologica*, **241**, 104063. https://doi.org/10.1016/j.actpsy.2023.104063.

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

Wang, Q., Wu, X., Ji, Y., Yan, G., & Wu, J. (2022). Second language proficiency modulates the dependency of bilingual language control on domain-general cognitive control. *Frontiers in Psychology*, **13**, 810573. https://doi.org/10.3389/fpsyg.2022.810573.

Whitford, V., & Joanisse, M. F. (2021). Eye movement measures of within-language and cross-language activation during reading in monolingual and bilingual children and adults: A focus on neighborhood density effects. *Frontiers in Psychology*, **12**, 674007. https://doi.org/10.3389/fpsyg.2021.674007.

Whitford, V., & Titone, D. (2017). Lexical entrenchment and cross-language activation: Two sides of the same coin for bilingual reading across the adult lifespan. *Bilingualism: Language and Cognition*, **22**(1), 58–77. https://doi.org/10.1017/s1366728917000554.

Wolna, A., Szewczyk, J., Diaz, M., Domagalik, A., Szwed, M., & Wodniecka, Z. (2024). Tracking components of bilingual language control in speech production: An fMRI study using functional localizers. *Neurobiology of Language*, **5**(2), 315–340. https://doi.org/10.1162/nol_a_00128.

Wolter, B. (2001). Comparing the L1 and L2 mental lexicon. *Studies in Second Language Acquisition*, **23**(1), 41–69. https://doi.org/10.1017/s0272263101001024.

Wolter, B., & Gyllstad, H. (2011). Collocational links in the L2 mental lexicon and the influence of L1 intralexical knowledge. *Applied Linguistics*, **32**(4), 430–449. https://doi.org/10.1093/applin/amr011.

Yang, F., Gao, F., & Zhang, K. (2023). Impacts of directionality on disfluency of English-Chinese two-way sight translation. *International Journal of Translation, Interpretation, and Applied Linguistics*, **5**(1), 1–15. https://doi.org/10.4018/IJTIAL.323448.

Ye, X., & Zhao, C. (2024). Cross-language semantic-affective interaction–with evidence from Chinese EFL learners. *Bilingualism: Language and Cognition*, **27**(5), 810–820. https://doi.org/10.1017/S1366728923000895.

Zeng, T., Chen, C., & Guo, J. (2022). First language translation involvement in second language word processing. *Frontiers in Psychology*, **13**, 986450. https://doi.org/10.3389/fpsyg.2022.986450.

Zhu, M., Sturt, P., & Damian, M. (2025). Language switch costs in sentence comprehension between Chinese and English: Evidence from self-paced reading. *Bilingualism: Language and Cognition*, **28**(5), 1363–1377. https://doi.org/10.1017/S1366728925000100.

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

Appendix 1

Table A1. Materials in Experiment 1

SR		SUR		NF	
Select	Choose	Invent	Choose	Select	Reduse
Refuse	Choose	Describe	Choose	Refuse	Depand
Contrast	Compare	Receive	Compare	Contrast	Resalve
Ignore	Compare	Descend	Compare	Ignore	Desgust
Determine	Decide	Create	Decide	Determine	Transleit
Hesitate	Decide	Travel	Decide	Hesitate	Firghten
Assess	Estimate	Dissolve	Estimate	Assess	Drenk
Measure	Estimate	Generate	Estimate	Measure	Decreese
Clarify	Explain	Command	Explain	Clarify	Comunicate
Confuse	Explain	Deceive	Explain	Confuse	Suggast
Investigate	Explore	Support	Explore	Investigate	Wellcome
Abandon	Explore	Protest	Explore	Abandon	Degenorate
Work out	Figure out	Care for	Figure out	Work out	Meka out
Give up	Figure out	Make up	Figure out	Give up	Mook up
Assume	Guess	Smoke	Guess	Assume	Beheva
Confirm	Guess	Drink	Guess	Confirm	Swrae
Grasp	Know	Knock	Know	Grasp	Throu
Wonder	Know	Beat	Know	Wonder	Bete
Study	Learn	Shake	Learn	Study	Oppoze
Overlook	Learn	Break	Learn	Overlook	Conplete
Retain	Memorize	Complain	Memorize	Retain	Seeze
Forget	Memorize	Threaten	Memorize	Forget	Admair
Detect	Notice	Defeat	Notice	Detect	Biuld
Neglect	Notice	Object	Notice	Neglect	Pretect
Watch	Observe	Promise	Observe	Watch	Preize
Disregard	Observe	Breathe	Observe	Disregard	Contineu
Focus on	Pay attention	Break down	Pay attention	Focus on	Fail out
Look away	Pay attention	Take back	Pay attention	Look away	Feed by
Devise	Plan	Burn	Plan	Devise	Beheva
Cancel	Plan	Rise	Plan	Cancel	Shivor
Challenge	Question	Practice	Question	Challenge	Prefor

(*Continued*)

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

Table A1. (*Continued*)

SR		SUR		NF	
Accept	Question	Regulate	Question	Accept	Pozzess
Infer	Reason	Punish	Reason	Infer	Comsume
Speculate	Reason	Exceed	Reason	Speculate	Chaet
Recall	Remember	Reinforce	Remember	Recall	Daigest
Omit	Remember	Convince	Remember	Omit	Repeir
Consider	Think	Cheat	Think	Consider	Postpoon
Suppress	Think	Climb	Think	Suppress	Raspect
Comprehend	Understand	Disappoint	Understand	Comprehend	Specialize
Puzzle	Understand	Compensate	Understand	Puzzle	Controul

Appendix 2

Table B1. Materials in Experiment 2

TE		NTE		NF	
Choose	选择	Invent	选择	选择	Invant
选择	Choose	发明	Choose	Choose	明发
Compare	比较	Descend	比较	比较	Descind
比较	Compare	下降	Compare	Compare	霞匠
Decide	决定	Create	决定	决定	Creete
决定	Decide	创造	Decide	Decide	疮噪
Estimate	估计	Dissolve	估计	估计	Dissalve
估计	Estimate	消除	Estimate	Estimate	萧刍
Explain	解释	Command	解释	解释	Commund
解释	Explain	命令	Explain	Explain	名呤
Explore	探索	Support	探索	探索	Suppirt
探索	Explore	支持	Explore	Explore	汁持
Figure out	想出	Care for	想出	想出	Cera for
想出	Figure out	关心	Figure out	Figure out	官锌
Guess	猜测	Smoke	猜测	猜测	Smeke
猜测	Guess	吸烟	Guess	Guess	希炎
Know	知道	Beat	知道	知道	Beuit
知道	Know	拍打	Know	Know	哌沓

(*Continued*)

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press

Table B1. (*Continued*)

TE		NTE		NF	
Learn	学习	Shake	学习	学习	Shiike
学习	Learn	动摇	Learn	Learn	动谣
Memorize	记忆	Complain	记忆	记忆	Camplain
记忆	Memorize	抱怨	Memorize	Memorize	孢院
Notice	留意	Defeat	留意	留意	Defeot
留意	Notice	击败	Notice	Notice	击拜
Observe	观察	Breathe	观察	观察	Braathe
观察	Observe	呼吸	Observe	Observe	呼系
Pay attention	注意	Break down	注意	注意	Braek down
注意	Pay attention	分解	Pay attention	Pay attention	奋皆
Plan	计划	Burn	计划	计划	Buon
计划	Plan	燃烧	Plan	Plan	然捎
Question	质疑	Practice	质疑	质疑	Prectece
质疑	Question	练习	Question	Question	链夕
Reason	推理	Punish	推理	推理	Penosh
推理	Reason	惩罚	Reason	Reason	琤罚
Remember	记得	Reinforce	记得	记得	Raenfurce
记得	Remember	加强	Remember	Remember	钾强
Think	思考	Cheat	思考	思考	Chuit
思考	Think	欺骗	Think	Think	栖骗
Understand	理解	Disappoint	理解	理解	Diseppuint
理解	Understand	失望	Understand	Understand	什望

Cite this article: Wang, Y. & Liu, X. (2026). Representation characteristics of English psych verbs in Chinese-English bilinguals: The modulating role of language proficiency. *Applied Psycholinguistics*. https://doi.org/10.1017/S0142716426101039

https://doi.org/10.1017/S0142716426101039 Published online by Cambridge University Press