Author/s:
Wong, MHI;Zhao, H;MacWhinney, B

Title:
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Date:
2018-06-01

Citation:
Wong, M. H. I., Zhao, H. & MacWhinney, B. (2018). A Cognitive Linguistics Application for Second Language Pedagogy: The English Preposition Tutor. Language Learning, 68 (2), pp.438-468. https://doi.org/10.1111/lang.12278.

Persistent Link:
https://hdl.handle.net/11343/284969

<LRH>The English Preposition Tutor

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<ArtType>EMPIRICAL STUDY

<AT>A Cognitive Linguistics Application for Second Language Pedagogy: The English Preposition Tutor

<AU>Man Ho Ivy Wong,[a] Helen Zhao,[a] and Brian MacWhinney[b]

<AF>[a]The Chinese University of Hong Kong, [b]Carnegie Mellon University

<AN>We would like to thank Andrea Tyler, Randal Holme, Gerald Nelson, and John Kowalski for their invaluable support in various aspects of the project. We are also grateful for the helpful comments offered by the editors and anonymous reviewers. Any errors or omissions are ours alone. Previous versions of this study were presented at the International Cognitive Linguistics Conference in 2015 and the annual meeting of the American Association for Applied Linguistics in 2016. Support for this project was provided to Helen Zhao by the Direct Grant for Research (project 3132664).

Correspondence concerning this article should be addressed to Man Ho Ivy Wong, Department of English, The Chinese University of Hong Kong, Hong Kong. E-mail: iwong0515@gmail.com

<ABS>

This study investigated the effects of teaching English prepositions using schematic diagrams inspired by cognitive linguistics in a computer-based tutorial system called the English Preposition Tutor. Training was designed based on the theoretical framework of the Competition Model and a cognitive linguistic analysis of prepositions. Sixty-four Cantonese-speaking intermediate learners of English were trained using a sentence–picture matching task. They received one of the three types of feedback: schematic diagram feedback, metalinguistic rule feedback, or correctness feedback. Only the schematic diagram feedback group was exposed to chaining between spatial senses and nonspatial senses. Results showed that instruction was effective in all three feedback groups, as measured by a cloze test and a translation test. In the translation test, the group receiving schematic diagram feedback outperformed the correctness feedback group. The effects of the three feedback conditions were not significantly different in the cloze test.

<KWG>Keywords polysemy; schematic diagrams; Competition Model; computer-based feedback; grammar instruction

<A>Introduction

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In detailed descriptive grammars, such as Quirk, Greenbaum, Leech, and Svartvik (1985), the various meanings of English prepositions are often treated as highly idiosyncratic and arbitrary. The complexity of these patterns presents a descriptive problem for pedagogical grammars, such as that of Celce-Murcia and Larsen-Freeman (1999). Second language (L2) learners find prepositional meanings confusing, making English prepositions difficult to acquire (Tyler, 2012). Even highly proficient L2 learners experience difficulties in attaining nativelike use of spatial language (Lam, 2009). Fortunately, theoretical advances in cognitive linguistics and ongoing efforts of cognitive semanticists (Brugman, 1988; Dirven, 1993; Lakoff, 1987; Lindstromberg, 2010; Tyler & Evans, 2001, 2003) have introduced an alternative perspective that has begun to demystify this portion of spatial language usage by showing how seemingly arbitrary alternative interpretations are, in fact, highly systematic. If validated, these insights can be important for both theory and pedagogy.

Polysemy and image schema are two fundamental concepts in cognitive linguistics (Evans & Green, 2006). The combined application of these concepts has succeeded in generating a new perspective for analyzing the English prepositional system (Lakoff, 1987; Tyler & Evans, 2001, 2003). In particular, the principled polysemy approach of Tyler and Evans has been adopted to effectively guide vocabulary and grammar instruction in a series of empirical studies (see Tyler, 2012, for a comprehensive review). Typically, these studies were classroom-based studies comparing an experimental group exposed to materials based on concepts from cognitive linguistics with a comparison group taught by traditional methods relying on translation and rote memorization (Tyler, Muller, & Ho, 2011).

The current study is the first to apply cognitive linguistic concepts to a computer-based tutorial system for L2 instruction targeting English prepositions. We call this system the English Preposition Tutor. The tutor illustrates the online learning systems that we refer to as eCALL—experimentalized computer-assisted language learning (Presson, Davy, & MacWhinney, 2013). Such an approach to computer-based instruction collects controlled experimental data while engaging learners with computerized pedagogical tasks. Studies of eCALL applications have addressed L2 acquisition issues, such as L2 stages of development, the role of explicit instruction and/or feedback, practice effects, individualized student tracking, and modeling (Presson et al., 2013).

The eCALL tutor used in this study seeks to train learners in the use and understanding of cognitive semantic concepts related to spatial language use. It is, of course, a much bigger challenge to implement cognitive linguistic instruction on the computer than in a classroom. In a classroom, teachers can provide extended elaborations of cognitive linguistic concepts and instantaneous feedback to student responses. In contrast, it is difficult for a computerized tutor to make instantaneous judgments about a learner's understanding of an abstract concept. Therefore, it is essential to structure computerized training so that cognitive linguistic materials are easily comprehensible to learners. In this study, we therefore explored the instructional potential of computerized cognitive linguistic instruction.

<A>Background Literature

<B>Polysemy

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Polysemy, like homonymy, gives rise to lexical ambiguity, that is, two or more meanings associated with one word. For example, the word *ball* has one polyseme that refers to a round object used in a game, another to a round object found at the end of a pen, and yet another to a bony structure in the foot. These polysemes all share the related meaning of roundness, whereas the use of the word *ball* to refer to a dance event no longer encodes that same sense. In the case of the preposition *over*, we can see the polysemic forms involved in (a) *The painting is <u>over</u> the sofa* and (b) *The owner of the company has control <u>over</u> his staff*. The *over* in (a) carries a primary spatial sense of higher than; the meaning of *over* in (b) is a nonspatial sense of control.

Some linguists have viewed these alternatives as idiosyncratic options to be chosen on the basis of such considerations as context, pragmatic principles, speaker intention, or recognition of that intention by the hearer (Pustejovsky, 1995; Ruhl, 1989). Cognitive semantics, in contrast, has viewed polysemy as a fundamentally conceptual phenomenon. Lakoff (1987) posited that polysemy reflects conceptual organization and exists at the level of mental representation rather than being a purely surface or formal phenomenon. Tyler and Evans' (2003) account of polysemy also recognized the conceptual connectivity among the multiple meanings associated with a lexical item. When analyzing the English preposition system, Tyler and Evans contended that the multiple meanings associated with the preposition arise from a specific configuration of trajector and landmark, which they term a spatial scene, in conjunction with speakers' knowledge of force dynamics and experiential correlation, among other mechanisms. Trajector (the figure) relates to the focal entity in a spatial scene that is smaller and typically capable of motion. Landmark (the ground) relates to the background entity that serves as the frame of reference for the trajector.

For example, the primary sense of *over* involves a spatial configuration in which the trajector is located higher than the landmark. For Tyler and Evans (2003), this abstract mental representation of the primary sense is termed a protoscene. The control sense of *over* is derived from the protoscene in conjunction with embodied experience (humans' experience of being in a physically up position vis-à-vis others) and the experiential correlation between control and vertical elevation. For instance, if a person is physically higher, she tends to be able to see farther or better than if she were physically lower, and that is likely to give her more control over the situation. The word *over* forms its own semantic polysemy network, which is a conceptual category composed of a variety of distinct but related senses. Each sense is treated within the network as a node, linking to the protoscene in radial fashion. The semantic polysemy network is assumed to be psychologically real and is instantiated in long-term semantic memory (Tyler & Evans, 2001, 2003).

<B>Image Schema

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The term image schema was coined by Johnson (1987). The central principle of his theory is that image schemas are experiential gestalts that “emerge through our sensorimotor activity: as we orient ourselves spatially and temporally, direct our perceptual focus for various purposes” (Johnson, 1991, p. 8). In other words, image schemas are the mental representations of external physical experiences (Lakoff, 1987; Mandler, 1992).

Figure 1a provides an illustration of the SOURCE-PATH-GOAL schema that is used in *The soldier crawled over the wall*. Two spatial elements can be identified in this schema. The first element is the trajector, *the soldier*, which is spatially related to the landmark, *the wall*. The trajector in the schema follows a trajectory that consists of a starting point (SOURCE), a destination (GOAL), and a series of contiguous locations in between that relate the source and goal. The SOURCE-PATH-GOAL schema constitutes an experiential gestalt derived from humans’ sensory experience of moving from one location to another. Tyler and Evans (2003) added a more refined configuration to the SOURCE-PATH-GOAL schema by describing the ABOVE-ACROSS path of movement. The arc-shaped path diagram presented in Figure 1b represents a spatial configuration arising from humans’ basic knowledge of how to make forward progress by rising *above* an obstacle and then coming down *across* on the other side. Figures 1a and 1b are schematic drawings meant to reflect the structure of mental representations.

<COMP: Place Figure 1 near here>

<B>Cognitive Linguistic Frameworks for Analyzing English Prepositions

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On the basis of cognitive linguistic theoretical constructs (i.e., polysemy, image schema, etc.), cognitive linguists have proposed different frameworks for analyzing the semantic networks for English prepositions. The frameworks share the same basic premise that the central sense of the preposition is based on the physical spatial relationship between two (or more) objects (Tyler & Evans, 2001). Yet, there are large discrepancies on many issues among the frameworks, such as the number of senses for a preposition or the identification of the central sense for a preposition. These alternative theoretical formulations can provide very different guidelines for pedagogical implementations based on cognitive linguistics.

Lakoff (1987) and Brugman (1988) provided the earliest cognitive linguistic framework for analyzing English prepositions. They argued that the prototypical sense of *over* is a schema combination of both ABOVE and ACROSS. This central ABOVE-ACROSS schema can be developed into more detailed image schemas by the addition of varying properties of the landmark and the existence of any contact between the trajector and landmark. For example, the trajector can have contact with the landmark (e.g., *The soldier crawled <u>over</u> the wall*) or no contact with the landmark (e.g., *The bird flew <u>over</u> the wall*). These two frameworks are the variants of the central ABOVE-ACROSS schema. In addition, Lakoff (1987) argued for five other schemas (ABOVE, COVERING, REFLEXIVE, EXCESS, REPETITION), each of which represents a distinct sense of *over* that is extended from the central schema.

Subsequently, Lakoff's (1987) full specification approach was criticized for creating a potentially vast proliferation of senses for polysemous words (Evans, 2004; Tyler & Evans, 2001, 2003). Moreover, his approach offered no clear methodological principle for linguists to follow to differentiate one sense from the other senses. Often the linguistic context of a specific sentence had to be relied on to make a judgment. Such an approach was said to encourage vague and intuitive judgments "rather than actually representing the way a particular category is represented in the mind of the language user" (Evans & Green, 2006, p. 342).

Adopting a usage-based perspective to language, Tyler and Evans (2003) proposed the principled polysemy approach. This newer approach introduced criteria for differentiating senses, along with criteria for identifying prototypical senses. It provided a more objective means of making semantic judgments, and it merged some of the detailed sense distinctions of *over* postulated by Lakoff. For example, the two senses of *over* (one specifying trajector-landmark contact and one specifying lack of contact) were considered as one sense because the spatial relation between the trajector and landmark in the two senses is conceptually the same, regardless of the metric properties of the trajector and landmark. Tyler and Evans cited evidence from empirical experimental studies (e.g., Sandra & Rice, 1995), which showed that the actual polysemy networks of language users were not as fine grained as has been suggested by the full specification model. Another adjustment Tyler and Evans made in their approach was that senses were no longer restricted to image schema representations. As a result, their semantic category of *over* could include more extended senses, such as TEMPORAL (e.g., *There have been many changes over the years*) and FOCUS-OF-ATTENTION (e.g., *Let's not argue over the bill*) that could not be directly mapped onto image schemas. These senses are frequently used by native speakers but were not included in Lakoff's analysis. Tyler and Evans's approach presented a systematic, coherent, and comprehensive framework for analyzing the prototypical and extended senses of the majority of prepositions in the English language and therefore was adopted as the conceptual basis for the development of pedagogical materials in this study.

<B>L2 Instructional Studies Inspired by Cognitive Linguistics

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In a large body of literature, researchers have argued for the great potential of cognitive linguistic theories as guides to the development of L2 instructional materials (Boers & Lindstromberg, 2009; De Knop & De Rycker, 2008; Holme, 2009; Robinson & Ellis, 2008). Cognitive linguistics focuses on the relationship between form and meaning and the communicative functions of language, and thus it is compatible with a usage-based and communicative view of language teaching (Ellis & Cadierno, 2009). Pedagogy inspired by cognitive linguistics allows learners to draw on their intuitive background knowledge accumulated from everyday experiences with the world, such as figure-ground segregation and schemas (Tyler, 2008).

Despite this high level of interest, there is a dearth of empirical efforts investigating the instructional value of cognitive linguistic materials in supporting L2 preposition learning. The early cognitive linguistic studies were largely qualitative demonstrations rather than controlled empirical studies. For example, Lindstromberg (1996) developed a method for teaching the senses of *on* to L2 English students based on Lakoff's (1987) and Brugman's (1988) analysis of *over*. Tyler and Evans (2004) offered suggestions about how to teach the extended senses of *over* based on the principled polysemy approach (Tyler & Evans, 2003). To date, there have been only three empirical studies that have examined the benefits of cognitive linguistic instruction in the use of English prepositions.

The first such study investigated the acquisition of the figurative senses of *behind* and *beyond* by native French learners of English (Boers & Demecheleer, 1998). A reading comprehension task was adopted as the main method for training and testing. The participants were asked to translate and rephrase sentences in two texts that contained figurative uses of *behind* and *beyond*, respectively. Participants were provided with definitions of the spatial senses from which the figurative senses of the two prepositions were derived. The experimental group received cognitive semantic definitions of prepositions (e.g., *beyond* = located at the other side at some distance from). This group significantly outperformed the control group who received traditional definitions (e.g., *beyond* = located at the farther side of). Because training and testing were combined into one task, there was no pretest–posttest within-group evaluation.

The second study involved 12 intermediate L2 learners in an experiment in which half received cognitive linguistic preposition treatment and the other half received traditional rule-based treatment (Matula, 2007). Both treatments lasted for 1 hour. The cognitive linguistics group focused on the learning of the mappings between the spatial and temporal uses of the prepositions *on*, *in*, and *at* via polysemy and schemas. The traditional group learned only the rules for the temporal uses of the target prepositions. The learning was evaluated through a pretest and a posttest that included sentence completion and fill-in-blank tasks. The results demonstrated no differences either between the two groups or within each group. Due to the small sample size, no inferential statistics were used.

In the third study, Tyler et al. (2011) conducted a quasi-experiment that adopted the principled polysemy network (Tyler & Evans, 2003) to teach the semantics of *to*, *for*, and *at*. Fourteen advanced Italian-speaking translators of English participated in the study. There was no control group. Participants received two sessions of 50-minute teacher-fronted instruction followed by 30-minute pair work activities. PowerPoint slides, including cartoons and visual clips, were used to explain the cognitive linguistic interpretation of prepositions. Pair work involved interactive tasks, for example, filling in individual senses to label the semantic networks of prepositions. A cloze test was administered both before and after the training sessions. Significant accuracy gains were found at the posttest, especially for the prepositions *at* and *to*.

These studies indicated that cognitive linguistics concepts can be applied to teaching English prepositions with positive results. The authors also underscored the need to draw learners' attention to the relationship between spatial and nonspatial senses of a preposition, allowing them to understand the mechanism of meaning extension. Nevertheless, there were some limitations in these studies. One problem is that these studies are difficult to replicate. Boers and Demecheleer (1998) did not clearly illustrate how the target conceptual metaphors were framed into teaching materials, nor did they show the cognitive linguistic definitions of prepositions presented to learners. Furthermore, it is not clear what instructional paradigms were adopted in these studies. The studies used teacher-fronted instruction and tasks. It was not clear whether they adopted the task-based language teaching paradigm (Ellis, 2003) or a mixture of the presentation-practice-production model (Willis, 1996) with task-structured activities. Limitations of this type indicated that computerized control could provide a more defined framework for investigating the instructional benefits of cognitive linguistic pedagogy.

<B>The Competition Model

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This study adopted the Competition Model (MacWhinney, 1987, 2012) as the methodological framework for designing computerized preposition instruction. The model takes a usage-based functionalist approach to language processing and views language as a dynamic process, mediated by competition among lexical items (MacWhinney, 1987, 2012). The model holds that processing relies on form–function mappings. For instance, the prepositional form *at* is mapped onto its targeting function in the sentence *The boy threw a ball at his dog*. MacWhinney (1987) calls this type of *at–to target* form–function mapping a *polyseme*. In the current study, we define a polyseme as one of the members of a group of conceptually related form–function mappings linked to a particular lexical item.

MacWhinney (1987) has claimed that natural languages seldom rely on one-to-one mappings. For example, the prepositional form *at* can also be mapped to other functions (senses), such as *to position at a point along a route* (e.g., *The hikers paused at the pavilion before reaching the peak*). This *at–to position* polyseme coexists and competes with the above *at–to target* polyseme in English. At the same time, these interpretations compete with other polysemes of *at*, as well as the polysemes of other prepositions. The selection of any one of these competing polysemes is determined by cues (MacWhinney, 2012). For example, the cue that supports the position reading of *pavilion* (*The hikers paused at the pavilion before reaching the peak*) is the fact that the pavilion can be conceptualized as a stationary building with a front and a back whereas this does not work for *dog* (*The boy threw a ball at his dog*). It is important not to confuse cues with polysemes. Cues support the choice of one polyseme over the other, but they are not themselves polysemes.

The Competition Model views both first language (L1) and L2 acquisition as a process of learning the cues to choose between polysemes and setting their proper relative strengths (MacWhinney, 1987). The time frame of this learning extends over years, but the strengthening of the links between cues and polysemes occurs each time a sentence is processed. When the cues function to pick out the correct polyseme, each usage leads to a modest growth in strength, eventually producing proceduralization, fluency, and entrenchment (MacWhinney, 1987).

A central account of the Competition Model is that polysemic competition takes place during language comprehension and production. Keen competition among the polysemes leads to the strengthening or weakening of connections between form and function. Compare the sentences *The boy threw a ball to his dog* and *The boy threw a ball at his dog.* The learner has to decide whether the indirect object, *his dog*, is receiving the object or being attacked by the object. If the dog is actively trying to catch the ball, then the preposition *to* receives support from the *receive* cue and wins over the preposition *at*. Within the group of polysemes for the preposition *to*, there is then a further competition between the receiver polyseme and the direction-toward polyseme. Here, again, the fact that the dog is trying to catch the ball supports the receiver polyseme of the preposition *to.* As the learner advances to a higher proficiency, the ability to make accurate distinctions between polysemes becomes crucial (McDonald, 1989; Sokolov, 1988, 1989). The learner must be able to differentiate the competing polysemes (*to–receive* and *at–target*) to flexibly and accurately use them in various speech contexts.

The Competition Model has been predominantly applied to the study of sentence processing (MacWhinney, 1997). However, in recent years, there have been extensions of the model to support studies of L2 instruction. Based on an analysis of polysemic competition, Zhao and MacWhinney (in press) presented contrasting polysemes of English articles to L2 learners. They claimed that such an instructional paradigm had several advantages. By presenting article usages in contrasting pairs, learners could formulate a more organized knowledge space of the complexities of the article system. This could reduce learners' memory load and storage cost and, consequently, increase their learning capacity. It was found that, for both intermediate and advanced L2 English learners, cue-based instruction significantly increased accuracy and reduced reaction time at the posttest after two 1-hour sessions of computer-based training.

Presson, MacWhinney, and Tokowicz (2014) applied the Competition Model to the computer-based teaching of French gender to novice learners. They designed instruction based on the concept of cue focusing through explicit cue statement and correctness feedback. During training and testing, participants were asked to categorize French nouns by gender. On each trial, they were shown a noun in French with its English translation. They needed to press M for masculine words and F for feminine words. During training, their response was followed by immediate feedback, which took the form of correctness feedback (informing them whether the response was correct or incorrect) and explicit cue focusing that directed learners' attention to the orthographic endings of the words that predicted grammatical gender (e.g., "–é → M," meaning that a final long –*é* in a word was a cue to signal masculine gender). In some cases, rule explanation presented competing cues such as "–é → M" versus "–té → F" to explain the idea that the more specific cue should dominate over the less specific cue. Such explicit instruction through cue presentation was predicted to produce better noticing and knowledge consolidation (MacWhinney, 1997). The results showed that 90 minutes of such training with cue focusing led to significant and high levels of generalization to untrained items and long-term retention. In sum, the studies reviewed in this section have extended the theoretical and pedagogical implications of the Competition Model to L2 learning. More empirical evidence from other domains of language is required to further substantiate this promising line of research.

<A>The Current Study

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This study aimed at exploring effective ways of teaching English prepositions to L2 learners. We adopted the Competition Model concept of cue support for polysemic competition (MacWhinney, 1987) as the theoretical framework of preposition instruction. We investigated whether pedagogical materials based on cognitive linguistic concepts (polysemy and image schemas) lead to better learning outcomes than materials used in traditional methods of teaching prepositions that heavily rely on rote memorization of dictionary definitions. We also examined whether cognitive linguistic instruction can improve the learning of both spatial and nonspatial polysemes of prepositions. The study was programmed into a computer-based tutorial system called the English Preposition Tutor. The training task focused on the presentation of cues for polysemic selection, along with examples and feedback. Effectiveness of instruction was evaluated in terms of improved accuracy in processing- and production-based measurements. Specifically, we addressed three research questions. The first question was motivated by the Competition Model, and the second and third questions were motivated by cognitive linguistic pedagogy.

1. Is instruction that focuses on contrasts between polysemic interpretations an effective way of teaching English prepositions?
2. Is schematic diagram feedback more effective than the traditional mode of computer-based explicit feedback (correctness feedback or metalinguistic rule and exemplar feedback)?
3. How do the participants learn spatial and nonspatial polysemes via the tutor?

<A>Method

<B>Setting and Participants

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This study was carried out in Hong Kong, a former British colony, where learners receive institutionalized English language education from as early as 3 years of age. Secondary schools in Hong Kong use either Chinese- or English-medium instruction. The Education Bureau categorizes secondary schools into three different bands. Band 1 schools enjoy high academic prestige in the community due to their outstanding overall academic performance.

Eighty-one Cantonese-speaking learners from a Band 1 English-medium instruction school were chosen to participate in this study. We chose to work in a Band 1 context to make sure that students could fully understand the nature of the task and instruction. The target participants were Secondary 4 students aged 15 to 16 years with at least 10 years of experience learning English. Their other L2 was Mandarin. All participants attained Level 4 or Level 5 in their school's standardized English test. According to the Hong Kong Examinations and Assessment Authority (2015), Level 4 and Level 5 are equivalent to Band 6 of the International

English Language Testing System (or equivalent to the score range of 60–78 on the Test of English as a Foreign Language Internet-Based Test), indicating that the participants were competent users with effective command of English despite some inaccuracies and misunderstandings in some situations. The English panel of the school selected two out of four Secondary 4 classes that were taught by the same English teacher with a Cantonese L1 background. The teacher had no prior knowledge of cognitive linguistics. She was informed that the study was to investigate the effectiveness of a computer-based tutor that tested a new method of teaching English prepositions, but she was not informed about the instructional design of the study. All students from her two classes were invited to participate in this study.

The training and testing sessions of the study were assigned to participants as homework. They were instructed to do each session only once and not to refer to external materials, such as dictionaries or Internet information during the training and assessment. They were informed by the teacher that their performances in all sessions would be tracked through computer logs. It turned out that some participants were highly motivated to learn from the tutor and did some sessions more than once. These participants' data were removed from the study. We also removed participants who spent significantly more time on each session than the group mean (i.e., >2.5 standard deviations of mean amount of time), potentially due to distraction. In the end, 18 participants were removed, and 63 participants remained in the final pool for data analysis. We only report on this final sample of participants.

<B>Design

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The participants were randomly assigned by the tutor to one of the four groups, including three treatment groups (*n* = 45) and a control group (*n* = 18). The three treatment groups received preposition training with the same sets of training and testing stimuli but in a random order. The control group did not receive training on prepositions; instead, this group received computer-based English article training (Zhao & MacWhinney, in press) but was tested on the same testing stimuli as the treatment groups.

The three treatment groups were trained on 12 prepositional polysemes in the form of a sentence–picture matching task (see the top half of Figure 2). We adopted the practice-based model of training (Anderson, 1995; DeKeyser, 1998). There was no prior presentation of grammar rules before practice. The key manipulation was polyseme contrast. On each training screen, participants were shown a picture stimulus and two contrasting sentences. The two sentences were identical except for the prepositions that were presented in bold typeface, one being the target preposition and the other being a distractor. The distractor was syntactically acceptable and semantically plausible but did not correspond to the picture stimulus. The target and distractor sentences were randomly placed at either the upper or the lower position of the training screen.

<COMP: Place Figure 2 near here>

Participants were asked to choose the sentence that best described the picture stimulus. This minimal pair presentation of training stimuli was intended to focus on form, that is, to draw learners' attention to the target item. They had to figure out the form–function mappings based on the linguistic context set by the picture. The picture provided crucial information about the supporting interpretations required to make accurate distinctions between the two competing polysemes. Participants were provided with immediate feedback after each choice. Feedback was shown on the same training page and was provided regardless of whether the choice was correct or wrong. Participants could control the amount of time that they spent in reading feedback. They clicked on the NEXT button whenever they were ready to move on to the next screen.

The three treatment groups, who differed in terms of the type of feedback they received, were the schematic diagram feedback group (n = 17), the rule and exemplar feedback group (n = 15), and the correctness feedback group (n = 13). The schematic diagram feedback group (see Figure 2) was regarded as the core treatment group because one of the main objectives of the study was to evaluate the effectiveness of a cognitive linguistic approach to preposition instruction. Schematic diagram feedback was composed of a schematic diagram or drawing meant to reflect the spatial configuration of the target polyseme accompanied by a short description explaining how the schematic diagram fit the prepositional usage of the target sentence. As can be seen in Figure 2, the description included two parts: (a) highlighting to indicate the landmark and the trajector in the target sentence and (b) an explanation in concrete terms of how the spatial or nonspatial relation between the landmark and the trajector fit the diagram for the preposition and how the distractor preposition failed to express that relation. To prepare students for the terms used in the schematic diagram feedback, the participants in this feedback group were shown one instructional page that provided a brief introduction to the cognitive linguistic terms of *schema*, *landmark*, and *trajector* before practice. The schematic diagram feedback group needed to relate these terms to the schematic diagram feedback provided for each training stimulus. The same schematic diagram feedback was provided for all the items of the same polyseme.

The correctness feedback and rule and exemplar feedback groups were the comparison groups that received traditional explicit instruction on prepositions. The rule and exemplar feedback group received metalinguistic rule explanation together with three example sentences that illustrated usage (see Figure 3). The spatial polyseme and the nonspatial polyseme were given their own definitional explanations. The same metalinguistic or exemplar feedback was provided for all the items of the same polyseme. The metalinguistic rule explanation was selected from the Oxford Advanced Learner's Dictionary of Current English (Hornby, Cowie, & Lewis, 1974) whereas the exemplar sentences were selected from the Corpus of Contemporary American English (Davies, 2008) and were modified to include lexical items that matched the learners' proficiency level. The metalinguistic and selected exemplar feedback used in the study is available in Appendix S1 in the Supporting Information online. The participants in the correctness feedback group received feedback as to whether their responses were correct or incorrect with no other information. The rule and exemplar feedback and correctness feedback groups did not see schematic diagrams at all.

<COMP: Place Figure 3 near here>

<B>Materials

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The three target prepositions selected were *in*, *at*, and *over*. *Over* was chosen due to the extensive cognitive linguistic analyses available. *In* and *at* were selected due to their high frequency in natural language production (Sinha, Thorseng, Hayashi, & Plunkett, 1994). In addition, *in* and *at* demonstrate a semantic distinction between the notions of containment and pinpointing in English. This semantic contrast is not observed in some other languages, for example, in Chinese (Cantonese and Mandarin) and Japanese (Casad, 1996; Pederson et al., 1998; Taylor, 1988), and could therefore pose a challenge for learners from these L1s (Matula, 2007).

The tutor provided training for six pairs of prepositional polysemes (Table 1), including three pairs for *over*, two pairs for *at*, and one pair for *in*. Each pair contained one spatial polyseme and one nonspatial polyseme, both of which could be elucidated by the same schematic diagram. In other words, the image schema served to conceptually chain the two senses together. For example, the spatial polyseme and the nonspatial polyseme of *in* in Table 1 shared the CONTAINER schema (Tyler & Evans, 2003). Although this schema was grounded in the directly embodied experience of interacting with bounded landmarks, the conceptual structure could also give rise to the more abstract and nonspatial meaning as in the phrases of *in love* or *in trouble*. This meaning extension was licensed by the primary metaphor STATES ARE CONTAINERS (Grady, 1997; Kövecses, 2002; see Tyler & Evans, 2003, pp. 187–189). The schematic diagrams used for training in the current study were selected mainly from Tyler and Evans with modifications for computer visual enhancement. When no existing diagram was found for a particular polyseme, we created it based on verbal descriptions provided by Tyler and Evans. The diagrams were submitted for review and revision to a cognitive linguist with a L2 acquisition background.

<COMP: Place Table 1 near here>

Only the schematic diagram feedback group was guided to make the connection between the spatial and nonspatial polysemes in a pair. Participants in the schematic diagram feedback group were not explicitly told that there were six pairs of polysemes, each including a spatial and a nonspatial polyseme mapped to the same schematic diagram. However, the same schematic diagram was provided as feedback to the schematic diagram feedback group for training with items of the paired polysemes. Hence, there was a potential for members of the group to figure out the spatial–nonspatial connection. The rule and exemplar feedback and the correctness feedback groups followed the traditional approach of training and were not provided with any explicit exposure to the spatial–nonspatial connection.

There were seven training items for each polyseme, yielding a total of 84 training items (12 × 7). All training stimuli were selected and revised (a) from major grammar books (Celce-Murcia & Larsen-Freeman, 1999; Huddleston & Pullum, 2002; Quirk et al., 1985) that have been adopted to support L2 grammar learning and (b) from Lindstromberg (2010), whose work provided rich cognitive linguistic materials for teaching prepositions. The 84 computer-based training screens were randomly presented to participants once. Sample training items (with picture stimuli) are available in Appendix S2 in the Supporting Information online. The experiment was programmed in JavaScript.

<B>Procedure

<TXT>

The study was administered online in three sessions of data collection: a pretest, a training session, and a posttest. There was an interval of 2 days between the pretest and training as well as between training and the posttest. Completion of the three sessions counted as part of participants' homework grade. Before the first session, the instructor distributed a handout with the URLs required to access the tutor. The handout provided a brief introduction to the tutor and, most importantly, the specified dates for the participants to complete each session. The participants finished the initial login at home as instructed. They registered for a username and filled out an online background questionnaire before they took the pretest. The questionnaire collected information about the participants' L1 background, L2 learning experiences, and other demographic information. Participants were specifically instructed not to stop in the middle of a session and were asked to jot down their accuracy scores automatically generated by the tutor at the end of each session for their own reference. Data were automatically saved to our server in the form of computer logs.

<B>Measurements

<TXT>

Two tests were used to measure learner performance at the pretest and posttest: a sentence-level cloze test and a translation test. No feedback was given to participants during testing. The cloze test was composed of 68 sentences, four items for each polyseme (4 × 12) and 20 control items that measured prepositions other than *in*, *at*, and *over*, for example, "The fox jumped ___ the fallen log.” Participants used a drop-down menu bar and selected the most appropriate preposition among three provided—the target preposition, *over*, plus two distractor prepositions, *with* and *at*. No picture stimuli were provided for the cloze test items. The test items were validated by two native speakers of English. Any distractor prepositions reported by the raters as equally good or better than the target prepositions were replaced.

In the translation test, the participants were given 50 sentences, three items for each polyseme (3 × 12) and 14 control items that examined untrained prepositions. For example, in the case of *青蛙跳過了石頭* (hop) (“The frog hopped over the rock”), participants were asked to translate the Chinese sentence into English using the verb provided. The verb was supplied to create an obligatory context for the use of the target preposition. A native English speaker validated the English version of the test sentences. Two native Cantonese speakers were shown the Chinese sentences to ensure that they were authentic and colloquial for Cantonese readers. The same set of test items was used in the pretest and posttest. Test items did not overlap with training items. Also, there were no overlapping items between the cloze and translation tests. Only the target items were included in the data analysis. Participants’ performances in the translation test were only graded on the uses of target prepositions. Other errors were not included in analyses. Sample assessment items from the cloze and translation tests are available in Appendix S3 in the Supporting Information online.

<A>Results

<TXT>

The data were analyzed using SPSS. Percent accuracy was entered into the analyses for both the cloze test and the translation test. The specific inferential statistical tests are described in the following sections with respect to the three research questions. The alpha value was set at .05 for all tests. In reporting results, we included effect-size values associated with inferential comparisons (partial eta squared η_p^2). The reliability of the two tests was verified by means of the internal consistency of responses to the items that made up each test. The Cronbach alpha coefficients for the cloze test were .879 at the pretest and .804 at the posttest. The coefficients for the translation test were .877 at the pretest and .903 at the posttest. All exceeded .80, which is generally considered to demonstrate a satisfactory level of reliability in social science research (Ellis, 2005). Before we analyzed the results for the three research questions, we compared the time on task among the four conditions in the study (the schematic diagram feedback, rule and exemplar feedback, correctness feedback conditions, and the control condition) to ensure that any differences that we might observe in the learning outcomes were not due to different amounts of time accessing the tutor. Three one-way analyses of variance (ANOVAs) showed no significant difference among conditions on the basis of time on task at the pretest, $F(3, 71) = 0.567$, $p = .638$, $\eta_p^2 = .023$, during training, $F(3, 71) = 0.444$, $p = .722$, $\eta_p^2 = .018$, and at the posttest, $F(3, 71) = 0.115$, $p = .951$, $\eta_p^2 = .005$.

<B>Effects of Polyseme Contrast Instruction

<TXT>

With regard to the first research question motivated by the Competition Model, we found that polyseme contrast was an effective instructional method for teaching English prepositions. The descriptive statistics for mean accuracies of the three treatment groups combined and of the control group for both cloze and translation tests at each point of time (pretest and posttest) are presented in Table 2. To facilitate easy reading of the learning effect, Table 2 also presents the mean of gain accuracy scores from the pretest to the posttest. Gain accuracy scores were calculated by subtracting the mean accuracy on the pretest from the mean accuracy on the posttest for each participant.

<COMP: Place Table 2 near here>

A 2 × 2 mixed ANOVA with training (treatment, control) as a between-subjects factor and time (pretest, posttest) as a within-subjects factor was performed on each assessment. In the cloze test, we found a main effect for time, $F(1, 61) = 26.902$, $p < .0001$, $\eta_p^2 = .306$, and a significant interaction between time and training, $F(1, 61) = 18.171$, $p < .0001$, $\eta_p^2 = .230$. In the translation test, we also found a main effect for time, $F(1, 61) = 10.326$, $p = .002$, $\eta_p^2 = .145$, and a significant interaction between time and training, $F(1, 61) = 7.241$, $p = .009$, $\eta_p^2 = .106$. Separate one-way ANOVAs were then carried out to investigate the time and training interactions in the two tests.

First, the cloze test results showed that the pretest accuracy of the treatment groups was not significantly different from that of the control group, $F(1, 61) = 1.121$, $p = .294$, $\eta_p^2 = .018$. So, the groups were comparable before training. We observed a significant difference between the treatment groups and the control group at the cloze posttest, $F(1, 61) = 7.978$, $p = .006$, $\eta_p^2 = .116$. This indicated that the treatment groups improved in their performance on the trained prepositions via the tutor whereas the control group, who did not receive preposition instruction, did not show any improvement in the cloze test.

In the translation pretest, the mean accuracy of the treatment groups showed no significant difference compared to that of the control group, $F(1, 61) = 2.298$, $p = .135$, $\eta_p^2 = .036$. Although no significant difference was found at the translation posttest between the treatment groups and the control group, $F(1, 61) = 1.377$, $p = .245$, $\eta_p^2 = .022$, a paired-samples t test showed that the mean accuracy gained between the translation pretest and posttest of the treatment groups was significant, $t(44) = -5.293$, $p < .0001$, $d = 0.789$, but not for the control group, $t(17) = -0.352$, $p = .729$, $d = 0.080$. This means that there was significant learning by the treatment groups but not by the control group. The lack of a significant difference between groups at the posttest can be attributed to a relatively higher (albeit not significantly higher) starting point of the control group at the pretest. A summative response to our first research question is that effective learning occurred within a compressed amount of training time when L2 learners were exposed to many exemplars presented in contrasting pairs and when the comprehension of sentence stimuli was facilitated by pictorial illustrations.

<B>Effects of Different Types of Feedback

<TXT>

We had hypothesized that the group exposed to the schematic diagram feedback would outperform the groups exposed to traditional modes of computer-based explicit feedback (correctness feedback or rule and exemplar feedback conditions). Descriptive statistics (Table 2) confirmed this trend of prediction. A 3 × 2 × 2 mixed ANOVA with feedback (schema, rule and exemplar, correctness) as a between-subjects factor and time (pretest, posttest) and idiomaticity (spatial, nonspatial) as within-subjects factors was performed on each assessment. With respect to the effects of feedback type, first of all, the pretest accuracy of the three feedback groups was not significantly different from each other on the cloze test, $F(2, 42) = 0.141$, $p = .868$, $\eta_p^2 = .007$, and also on the translation test, $F(2, 42) = 0.436$, $p = .650$, $\eta_p^2 = .020$. The three feedback groups were comparable before training. For the cloze test, the 3 × 2 × 2 mixed ANOVA showed a significant main effect for time, $F(1, 42) = 93.066$, $p < .0001$, $\eta_p^2 = .689$, but no interaction between time and feedback, $F(2, 42) = 0.415$, $p = .663$, $\eta_p^2 = .019$. There was no main effect for feedback, $F(2, 42) = 0.499$, $p = .611$, $\eta_p^2 = .023$. These results revealed no differences among the treatment groups in terms of gained accuracy from the pretest to the posttest for the cloze assessment. All groups showed a significant amount of improvement over time.

The 3 × 2 × 2 mixed ANOVA for the translation test revealed different results. We found a main effect for time, $F(1, 42) = 31.710$, $p < .0001$, $\eta_p^2 = .430$, a nonsignificant effect for feedback, $F(2, 42) = 2.601$, $p = .086$, $\eta_p^2 = .110$, and a significant interaction between time and feedback, $F(2, 42) = 4.635$, $p = .015$, $\eta_p^2 = .181$. A one-way ANOVA for the translation posttest showed a significant difference among the three groups, $F(2, 42) = 4.164$, $p = .022$, $\eta_p^2 = .165$. Tukey post hoc analysis indicated that the main source of variation came from a significant difference between the schematic diagram feedback group and the correctness feedback group ($p = .017$, $d = 1.00$). The schematic diagram feedback group did not outperform the rule and exemplar feedback group ($p = .260$, $d = 0.25$), and the rule and exemplar feedback group was not significantly different from the correctness feedback group ($p = .305$, $d = -0.65$).

Schematic diagram feedback showed its advantage over correctness feedback but not over rule and exemplar feedback, and this superiority effect was only found in the translation test but not the cloze test. In other words, when L2 learners performed a cloze task, simple yes-or-no feedback was good enough to promote a comparable amount of learning to feedback containing much richer contents. But when learners were given a cognitively more demanding task, they demonstrated a higher need for information from schematic diagram feedback to help them regulate more complex thinking.

<B>Learning of Spatial and Nonspatial Polysemes

<TXT>

Overall, the improvement on spatial polysemes was more than that of nonspatial polysemes, especially on the cloze test. The descriptive statistics of the three feedback groups' accuracy of performance for the spatial and nonspatial polysemes in both assessments are presented in Table 3. For the cloze test, the 3 × 2 × 2 mixed ANOVA revealed a main effect for idiomaticity, $F(1, 43) = 6.170$, $p = .017$, $\eta_p^2 = .125$, and significant interaction between time and idiomaticity, $F(1, 43) = 11.729$, $p = .001$, $\eta_p^2 = .214$, suggesting that the accuracy increase of spatial polysemes was significantly larger than that of nonspatial polysemes. But there was no significant interaction between idiomaticity and feedback, $F(2, 43) = 0.069$, $p = .934$, $\eta_p^2 = .003$, and no interaction between time, idiomaticity, and feedback, $F(2, 43) = 0.126$, $p = .882$, $\eta_p^2 = .006$. This means that type of feedback did not make a difference to the instructional effect on spatial versus nonspatial polysemes in the cloze assessment.

<COMP: Place Table 3 near here>

For the translation test, the 3 × 2 × 2 mixed ANOVA revealed a main effect for idiomaticity, $F(1, 42) = 98.647$, $p < .0001$, $\eta_p^2 = .701$, but no interaction between time and idiomaticity, $F(1, 42) = 0.430$, $p = .515$, $\eta_p^2 = .010$, suggesting that comparable amounts of accuracy increase were found on the spatial and nonspatial polysemes in the translation assessment. Furthermore, there was no interaction between idiomaticity and feedback, $F(2, 42)$

= 0.486, p = .618, η_p^2 = .023, and no interaction between time, idiomaticity, and feedback, F(2, 42) = 1.249, p = .297, η_p^2 =.056. The main effect of feedback was marginally significant, F(1, 42) = 2.601, p = .08, η_p^2 = .110. The absence of an interaction could be due to the fact that the overall accuracy gains on the translation test were relatively smaller. Variations among feedback groups might not be large enough to reach statistical significance in a model that takes all of the data into account. But we observed a clear trend in the accuracy gains on nonspatial polysemes. Although the rule and exemplar feedback and correctness feedback groups had minimal gains for nonspatial polysemes, scoring 3% and 6%, respectively, the schematic diagram feedback group showed a much greater improvement, gaining 19.6%. On the other hand, our data also indicated that traditional modes of feedback (correctness or rule feedback) produced an equally strong effect on the learning of spatial polysemes.

<A>Discussion

<TXT>

Our findings showed that polysemic contrast is an effective instructional method for acquiring English prepositions, requiring learners to spend no more than 1 hour learning 12 prepositional polysemes. The treatment groups improved from a baseline accuracy of 54.4% to a posttest accuracy of 70.2% for the cloze test and 43.7% to 54.1% for the translation test. The control group, who did not receive preposition instruction guided by the Competition Model, did not show improvement over time. Our findings are consistent with previous studies that adopted the Competition Model (MacWhinney, 1997) as the framework that guided L2 instructional design (Presson et al., 2014; Zhang, 2009; Zhao & MacWhinney, in press). An important common feature shared by these studies, including this one, is that they all have targeted basic syntactic, morphological, or phonological features whose L2 learning involves mastering complex systems of form–function mappings. For example, in this study, the preposition *over* can be mapped to 16 functions according to Tyler and Evans's (2003) principled polysemy analysis, leading to 16 polysemes for learners to acquire. Some of these polysemes compete with polysemes of other prepositions, such as *across* or *above*. Such a complex system of form–function mappings requires some type of regulation to facilitate learning.

MacWhinney (1997) argues that explicit rule instruction including a relevant and substantial set of examples that makes form–function mappings maximally reliable, transparent, and simple should improve learning. This analysis predicts that, if low salience or lack of consistency in grammar leads to more difficult learning, then explaining those patterns simply and clearly without forcing learners to consider complex interlocking patterns of polysemy should reduce that difficulty. In this study, learners were repeatedly exposed to polysemic contrasts in which the choice of a given form–function mapping was presented in simple learning units. Such an approach enabled improved focusing and representation of polysemic relations (Merriman, 1999). In the long run, the memory consolidation generated by repeated exposure to reliable polysemes might eventually give way to implicit control through proceduralization.

One of the most significant findings of the study is that the schematic diagram feedback group performed at least as well as the traditional modes of computer-based feedback, except for the translation test, where they outperformed the correctness feedback group. We interpret this result by recognizing the instructional value of traditional types of computer-based feedback. In the cloze test, even basic correctness feedback can provide sufficient information. There are several reasons for this. First, the cloze test was a relatively easier test, compared to the translation test. Also, the cloze test was administered without time pressure, and its format was similar to the format used during training. This allowed learners to easily transfer what they had learned during training to test performance. Also, the picture stimuli included in training pages might have augmented the instructional effects of correctness feedback. According to Paivio's Dual Coding Theory (1971, 1986), participants have better recall for the meanings of words that are presented with paired visual imagery. The picture stimuli in our study could have provided a semantic context to aid participants' comprehension of feedback. Also, some picture stimuli might have provided an implicit hint about the type of relationship between the trajector and the landmark that was explicitly described in the cognitive linguistics condition. For example, the arrow in the picture stimulus of Figure 3 (the rule and exemplar feedback condition) could hint at the path that the trajector goes through in relation to the landmark, indicating the primary metaphor underlying the cognitive linguistics understanding of this sense.

The effectiveness of correctness feedback was limited to the cloze test. When participants were given a more challenging translation test, schematic diagram feedback demonstrated its advantage. It is possible that the advantage of schematic diagram feedback over traditional types of explicit feedback could be shown when learners are asked to do more demanding tasks, such as output production or online processing tests under time pressure (R. Ellis, 2005). This interpretation is in line with a large body of literature on knowledge transfer in learning sciences (see Kimball & Holyoak, 2000), arguing that conceptual knowledge is more likely to transfer to novel items and novel tasks if it is mentally organized around schemas, models, or general principles.

Though we did not have evidence for an interaction between feedback and idiomaticity on the translation test, there was a clear trend in the descriptive data indicating that schematic diagram feedback led to an effect for nonspatial polysemes. The nonspatial polysemes showed minimal gains on the translation test when learners were provided with metalinguistic and exemplar feedback (6%) or correctness feedback (3%). But when schematic diagram feedback was provided, a much larger accuracy gain for the nonspatial polysemes (20%) was observed on the translation posttest. Hence, we explored the gain accuracy on nonspatial polysemes in the translation test further, using a one-way ANOVA, which showed a significant difference among conditions, $F(2, 42) = 6.378$, $p = .004$, $\eta_p^2 = .233$. Tukey post hoc analysis indicated significant differences between the schematic diagram feedback and the correctness feedback groups ($p = .006$, $d = 0.89$) and between the rule and exemplar feedback and the correctness feedback groups ($p = .016$, $d = 1.98$) but no significant difference between the schematic diagram feedback and the rule and exemplar feedback groups ($p = .803$, $d = -0.64$). This was a particularly encouraging finding, suggesting that there can be effective ways of teaching nonspatial usages of prepositions that are abstract and much harder to visualize. Schematic diagram feedback allowed learners to recognize the mapping between the spatial polyseme and the nonspatial polyseme in a pair. The memory for the mapping was rehearsed and consolidated through the shared visual schema. As a result, learners could develop a deeper understanding of the nonspatial polysemes supported by enhanced knowledge of spatial polysemes.

<A>Limitations and Future Research

<TXT>

Although the findings generated by this study are promising, there are some areas that can be further improved and other research questions that can be explored in future studies. First, there was only one training session in the current study. The duration of training (1 hour) was relatively short. More training sessions can be included to enhance the power of instruction in future studies. Second, because we could not obtain approval from the school, we could not administer a delayed posttest to measure long-term retention of learning. Future studies should try to overcome such logistic hurdles and implement a delayed test. If conditions allow, longitudinal studies will be ideal to measure the long-term effects of our proposed instructional paradigm. Furthermore, the control group in the current study did not receive any instruction on prepositions. In future, it could be interesting to add another control group who would be taught prepositions but without the polysemic contrast. This would allow us to gather information about whether instruction guided by the Competition Model is more effective than other types of instruction.

Meanwhile, we only targeted learners from one L1 background (Cantonese) in this study. The materials developed for the current study are relevant to learners with various L1s. Future studies can include learners with other L1s, such as Mandarin and Japanese, who also have problems in learning English prepositions. Moreover, more scaffolding could be provided to participants with less advanced English proficiency. Our participants were familiar with English as the medium of instruction. Future studies that target learners who are not used to English as the medium of instruction should consider providing prior explanations of the cognitive linguistics concepts and terminologies that appear in schematic diagram feedback in learners' L1. Lastly, the online tutor was only used outside class time. Future studies could explore the possibility of incorporating the tutor into classroom-based communicative activities so as to encourage more learner interaction centered on sense distinctions and interconnectivity based on what they have already learned from the tutor. Classroom activities can be designed in line with focus on form as a principle in task-based language teaching, with the tutor as a resource for supporting learner negotiations.

<A>Conclusion

<TXT>

To conclude, this article reports on an innovative study in which the Competition Model and computer-delivered instruction were combined with a cognitive linguistics analysis of the semantics of English prepositions. The instructional system successfully trained L2 learners to perform accurate form–function mappings regarding selected spatial and nonspatial senses of three prepositions, *in*, *at*, and *over.* This finding supports the idea that drawing learners' attention to clearly described grammatical functions is beneficial for L2 development. Furthermore, different types of explicit feedback promoted different learning outcomes. Our findings suggest that schematic diagram feedback was beneficial for tackling nonspatial prepositional senses in a translation test. For the cloze test, traditional feedback produced learning comparable to what was achieved through cognitive linguistic training. We therefore conclude that rich feedback based on assumptions from cognitive linguistics powerfully demonstrated its advantage for promoting deeper understanding of the mental representations of prepositional senses and their interconnectivity. Polysemic contrasts and cognitive linguistic materials jointly provided a powerful mediational tool that encouraged a more systematic and strategic use of metalinguistic knowledge, thus cultivating learners' cognitive control over high-level mental operations (Roehr, 2008).

To our knowledge, this study is the first to use cognitive linguistic pedagogy in a computer-based language tutor. A demo version of the tutor is openly accessible for further study from http://sla.talkbank.org. Our findings have enriched the existing literature on applying cognitive linguistic methods to the learning of English prepositions in four important ways. First, the study provided much-needed empirical evidence for the effectiveness of using a cognitive linguistic analysis for teaching the multiple meanings associated with prepositions as well as much-needed consideration of how to interconnect a model of language learning and processing with a cognitive linguistic semantic model of a complex area of meaning. Second, we showed that concepts and assumptions from cognitive linguistics (e.g., image schemas, landmarks, trajectors), many of which are abstract and difficult to understand for L2 learners, could be implemented into effective computer-based learning materials. This encouraging finding provides new research potential for designing more language tutors with existing cognitive linguistic instructional materials for other grammatical structures, such as English phrasal verbs (Mahpeykar & Tyler, 2015), modal verbs (Tyler, 2008), conditionals (Jacobsen, 2016), and tense-aspect constructions (Kermer, 2016). Computer-based tutors are a promising method of promoting language teaching inspired by cognitive linguistics without increasing the burden on teacher training. Meanwhile, the availability of the tutor makes possible replications using other groups.

Third, we observed a task effect concerning the effects of cognitive linguistic instruction. Triangulation of measurements that includes both processing and production tests is necessary for future studies. Finally, the computer-based implementation of the experiment allowed us to achieve fine-grained control of the variations between the cognitive linguistic instructional condition and the traditional instructional conditions, eliminating possible intervening variables that may exist in studies implemented in authentic classroom settings. Such variables include different amounts of time on task or levels of teacher enthusiasm or attitudes toward certain instructional approaches that may function as a qualitative factor potentially influencing learner motivations and attitudes.

Final revised version accepted 20 September 2017

<A>References

<REF>Anderson, J. R. (1995). Developing expertise. In J. R. Anderson (Ed.), *Cognitive psychology and its implications* (4th ed., pp. 272–304). New York: W. H. Freeman.

<REF>Boers, F., & Demecheleer, M. (1998). A cognitive semantic approach to teaching prepositions. *English Language Teaching Journal*, *53*, 197–204. https://doi.org/10.1093/elt/52.3.197

<REF>Boers, F., & Lindstromberg, S. (2009). *Optimizing a lexical approach to instructed second language acquisition.* Basingstoke, UK: Palgrave Macmillan. https://doi.org/10.1057/9780230245006

<REF>Brugman, C. (1988). *The story of "over": Polysemy, semantics and the structure of the lexicon.* New York: Garland.

<REF>Casad, E. (1996). What good are locationals, anyways? In M. Pütz & R. Dirven (Eds.), *The construal of space in language and thought* (pp. 239–267). Berlin, Germany: Mouton de Gruyter. https://doi.org/10.1515/9783110821611.239

<REF>Celce-Murcia, M., & Larsen-Freeman, D. (1999). *The grammar book: An ESL/EFL teacher's course* (2nd ed.). Boston: Heinle & Heinle.

<REF>Davies, M. (2008) *The corpus of contemporary American English (COCA): 520 million words, 1990-present*. Retrieved ???? ??, ????, from http://corpus.byu.edu/coca[AU: Please provide retrieval date.]

<REF>De Knop, S., & De Rycker, T. (Eds.). (2008). *Cognitive approaches to pedagogical grammar*. New York: Mouton de Gruyter.

<REF>DeKeyser, R. M. (1998). Beyond focus on form: Cognitive perspectives on learning and practicing second language grammar. In C. Doughty & J. Williams (Eds.), *Focus on form in classroom second language acquisition* (pp. 42–63). New York: Cambridge University Press.

<REF>Dirven, R. (1993). Metonymy and metaphor: Different mental strategies of conceptualization. *Leuvense Bijdragen*, *82*, 1–25. https://doi.org/10.1515/9783110219197.75

<REF>Ellis, R. (2003). *Task-based language learning and teaching*. Oxford, UK: Oxford University Press.

<REF>Ellis, R. (2005). Measuring implicit and explicit knowledge of a second language: A psychometric study. *Studies in Second Language Acquisition*, *27*, 141–172. https://doi.org/10.1017/S0272263105050096

<REF>Ellis, N., & Cadierno, T. (2009). Constructing a second language: Introduction to the special issue. *Annual Review of Cognitive Linguistics*, *7*, 111–139. https://doi.org/10.1075/arcl.7.05ell

<REF>Evans, V. (2004). *The structure of time: Language, meaning and temporal cognition*. Amsterdam: John Benjamins. https://doi.org/10.1075/hcp.12

<REF>Evans, V., & Green, M. (2006). *Cognitive linguistics: An introduction*. Edinburgh, UK: Edinburgh University Press.

<REF>Grady, J. (1997). *Foundations of meaning: Primary metaphors and primary scenes*. Unpublished doctoral dissertation, University of California at Berkeley, Berkeley, CA.

<REF>Holme, R. (2009). *Cognitive linguistics and language teaching.* Basingstoke, UK: Palgrave Macmillan. https://doi.org/10.1057/9780230233676

<REF>Hong Kong Examinations and Assessment Authority (2015, April 17). Retrieved ???? ??, ????, from http://www.hkeaa.edu.hk/en/recognition/benchmarking/hkdse/ielts[AU: Please provide retrieval date.]

<REF>Hornby, A. S., Cowie, A. P., & Lewis, J. W. (1974). *Oxford advanced learner's dictionary of current English*. London: Oxford University Press.

<REF>Huddleston, R., & Pullum, G. (2002). *The Cambridge grammar of the English language*. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781316423530

<REF>Jacobsen, N. D. (2016). The best of both worlds: Combining cognitive linguistics and pedagogical tasks to teach English conditionals. *Applied Linguistics*. Published online 28 September 2016. https://doi.org/10.1093/applin/amw030

<REF>Johnson, M. (1987). *The body in the mind: The bodily basis of meaning, imagination and reason*. Chicago: University of Chicago Press.

<REF>Johnson, M. (1991). Knowing through the body. *Philosophical Psychology*, *4*, 2–18. https://doi.org/10.1080/09515089108573009

<REF>Kermer, F. (2016). *A cognitive grammar approach to teaching tense and aspect in the L2 context*. Newcastle, UK: Cambridge Scholars.

<REF>Kimball, D. R., & Holyoak, K. J. (2000). Transfer and expertise. In E. Tulving & F. I. M. Craik (Eds.), *The Oxford handbook of memory* (pp. 109–122). New York: Oxford University Press.

<REF>Kövecses, Z. (2002). *Metaphor: A practical introduction*. New York: Oxford University Press.

<REF>Lakoff, G. (1987). *Women, fire and dangerous things: What categories reveal about the mind*. Chicago: University of Chicago Press. https://doi.org/10.7208/chicago/9780226471013.001.0001

<REF>Lam, Y. (2009). Applying cognitive linguistics to teaching the Spanish prepositions *por* and *para*. *Language Awareness*, *18*, 2–18. https://doi.org/10.1080/09658410802147345

<REF>Lindstromberg, S. (1996). Prepositions: Meaning and method. *ELT Journal*, *50*, 225–236. https://doi.org/10.1093/elt/50.3.225

<REF>Lindstromberg, S. (2010). *English prepositions explained*. Amsterdam: John Benjamins. https://doi.org/10.1075/z.157

<REF>MacWhinney, B. (1987). The competition model. In B. MacWhinney (Ed.), *Mechanisms of language acquisition* (pp. 249–308). Hillsdale, NJ: Erlbaum.

<REF>MacWhinney, B. (1997). Second language acquisition and the competition model. In J. Kroll & A. De Groot (Eds.), *Tutorials in bilingualism* (pp. 49–67). Hillsdale, NJ: Erlbaum.

<REF>MacWhinney, B. (2012). The logic of the unified model. In S. Gass & A. Mackey (Eds.), *The Routledge handbook of second language acquisition* (pp. 211–227). New York: Routledge.

<REF>Mahpeykar, N., & Tyler, A. (2015). A principled cognitive linguistics account of English phrasal verbs with *up* and *out*. *Language and Cognition*, *7*, 1–35. https://doi.org/10.1017/langcog.2014.15

<REF>Mandler, J. M. (1992). How to build a baby II: Conceptual primitives. *Psychological Review*, *99*, 587–604. https://doi.org/10.1037//0033-295x.99.4.587

<REF>Matula, S. (2007). *Incorporating a cognitive linguistics presentation of the prepositions on, in, and at in ESL instruction: A quasi-experimental study*. Unpublished doctoral dissertation, Georgetown University, Washington, DC.

<REF>McDonald, J. L. (1989). The acquisition of cue-category mappings. In B. MacWhinney & E. Bates (Eds.), *The crosslinguistic study of language processing* (pp. 375–396). New York: Cambridge University Press.

<REF>Merriman, W. (1999). Competition, attention, and young children’s lexical processing. In B. MacWhinney (Ed.), *The emergence of language* (pp. 331–358). Mahwah, NJ: Erlbaum.

<REF>Paivio, A. (1971). *Imagery and verbal processes*. New York: Holt, Rinehart, & Winston. https://doi.org/10.1126/science.176.4035.628-b

<REF>Paivio, A. (1986). *Mental representations: A dual coding approach*. Oxford, UK: Oxford University Press.

<REF>Pederson, E., Danzinger, E., Wilkins, D., Levinson, S., Kita, S., & Senft, G. (1998). Semantic typology and spatial conceptualization. *Language*, *74*, 557–589. https://doi.org/10.2307/417793

<REF>Presson, N., Davy, C., & MacWhinney, B. (2013). Experimentalized CALL for adult second language learners. In J. Schwieter (Ed.), *Innovative research and practices in second language acquisition and bilingualism* (pp. 139–164). New York: John Benjamins. https://doi.org/10.1075/lllt.38.10pre

<REF>Presson, N., MacWhinney, B., & Tokowicz, N. (2014). Learning grammatical gender: The use of rules by novice learners. *Applied Psycholinguistics*, *35*, 709–737. https://doi.org/10.1017/s0142716412000550

<REF>Pustejovsky, J. (1995). *The generative lexicon*. Cambridge, MA: MIT Press. https://doi.org/10.1017/s1351324997241689

<REF>Quirk, R., Greenbaum, S., Leech, G., & Svartvik, J. (1985). *A comprehensive grammar of the English language*. London: Longman.

<REF>Robinson, P., & Ellis, N. (2008). Cognitive linguistics, second language acquisition and L2 instruction—issues for research. In P. Robinson & N. Ellis (Eds.), *Handbook of cognitive linguistics and second language acquisition* (pp. 480–545). London: Routledge.

<REF>Roehr, K. (2008). Linguistic and metalinguistic categories in second language learning. *Cognitive Linguistics*, *19*, 67–106. https://doi.org/10.1515/cog.2008.005

<REF>Ruhl, C. (1989). *On monosemy: A study in linguistics semantics*. New York: SUNY Press. https://doi.org/10.2307/414769

<REF>Sandra, D., & Rice, S. (1995). Network analyses of prepositional meaning: Mirroring whose—the linguist's or the language user's? *Cognitive Linguistics*, *6*, 89–130. https://doi.org/10.1515/cogl.1995.6.1.89

<REF>Sinha, C., Thorseng, L. A., Hayashi, M., & Plunkett, K. (1994). Comparative spatial semantics and language acquisition: Evidence from Danish, English, and Japanese. *Journal of Semantics*, *11*, 253–287. https://doi.org/10.1093/jos/11.4.253

<REF>Sokolov, J. L. (1988). Cue validity in Hebrew sentence comprehension. *Journal of Child Language*, *15*, 129–156. https://doi.org/10.1017/s0305000900012095

<REF>Sokolov, J. L. (1989). The development of role assignment in Hebrew. In B. MacWhinney & E. Bates (Eds.), *The crosslinguistic study of sentence processing* (pp. 158–184). New York: Cambridge University Press.

<REF>Taylor, J. R. (1988). Contrasting prepositional categories: English and Italian. In B. Rudzka-Ostyn (Ed.), *Topics in cognitive linguistics* (pp. 299–336). Amsterdam: John Benjamins.

<REF>Tyler, A. (2008). Applying cognitive linguistics to second language teaching: The English modals. In N. Ellis & P. Robinson (Eds.), *The handbook of cognitive linguistics and second language acquisition* (pp. 456–488). Mahwah, NJ: Erlbaum.

<REF>Tyler, A. (2012). *Cognitive linguistics and second language learning: Theoretical basics and experimental evidence.* New York: Routledge. https://doi.org/10.4324/9780203876039

<REF>Tyler, A., & Evans, V. (2001). Reconsidering prepositional polysemy networks: The case of over. *Language*, *77*, 724–765. https://doi.org/10.1515/9783110895698.95

<REF>Tyler, A., & Evans, V. (2003). *The semantics of English prepositions: Spatial scenes, embodied meanings and cognition.* Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/cbo9780511486517

<REF>Tyler, A., & Evans, V. (2004). Applying cognitive linguistics to pedagogical grammar. In M. Achard & S. Niemeier (Eds.), *Cognitive linguistics, second language acquisition, and foreign language teaching* (pp. 257–281). Berlin, Germany: Mouton de Gruyter.

<REF>Tyler, A., Mueller, C., & Ho, V. (2011). Applying cognitive linguistics to learning the semantics of English prepositions *to*, *for*, and *at*: An experimental investigation. *Vigo International Journal of Applied Linguistics*, *8*, 180–205.

<REF>Willis, J. (1996). *A framework for task-based learning*. Harlow, UK: Longman.

<REF>Zhang, Y. H. (2009). *Cue focusing for robust phonological perception in Chinese*. Unpublished doctoral dissertation, Carnegie Mellon University, Pittsburgh, PA.

<REF>Zhao, H., & MacWhinney, B. (in press). The instructed learning of form-function mappings in the English article system. *The Modern Language Journal*.

<A>Supporting Information

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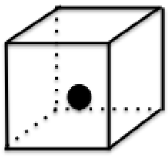
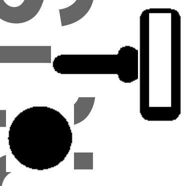
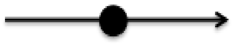
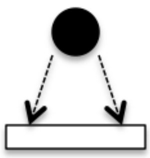
Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1. Metalinguistic and Exemplar Feedback.

Appendix S2. Sample Training Items.

Appendix S3. Sample Assessment Items.

Table 1 Six pairs of *in*, *at*, and *over* polysemes

Form	Schematic diagram	Function	Spatial polyseme	Nonspatial polyseme
IN		To enclose something within a container	There were five policemen *in* the station.	The couple was madly *in* love.
AT		To aim at a target	The council member threw an egg *at* the chairman.	Professor Chan is mad *at* a student.
		To locate a point along the route	Blair set out for Beijing, but stopped *at* Shanghai airport.	Johnson set out *at* a small company and then became the boss.
OVER		To approach downward, exerting influence	The mother leaned *over* the cradle of her baby.	The leader has power *over* his followers.

	To cross from one side to another	The horse jumped *over* the fence.	James got *over* his divorce.
	Higher than	The tree has grown *over* the rooftop of my house.	The shopaholic has spent *over* her credit limit.

Table 2 Effects of polyseme contrast instruction as a function of feedback type

	Cloze test				Translation test			
	Pretest		Posttest		Pretest		Posttest	
Accuracy (proportion)	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Feedback groups	.544	.018	.702	.020	.437	.016	.541	.023
SF group	.546	.030	.742	.036	.440	.025	.621	.040
RF group	.551	.028	.697	.032	.448	.025	.542	.035
CF group	.530	.033	.665	.038	.417	.029	.445	.042
Control group	.579	.028	.594	.032	.481	.025	.491	.035

Pretest-posttest gain	Cloze test		Translation test	
	M	*SE*	*M*	*SE*
SF group	.196	.033	.181	.033
RF group	.146	.028	.094	.030
CF group	.135	.033	.038	.035
Control group	.015	.028	.009	.030

Note. SF = schematic diagram feedback; RF = metalinguistic rule and exemplar feedback; CF = correctness feedback.

Table 3 Effects of feedback on the learning of spatial and nonspatial polysemes

	Pretest				Posttest			
	Spatial		Nonspatial		Spatial		Nonspatial	
Group	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Cloze test accuracy (proportion)								
SF group	.479	.031	.552	.035	.733	.042	.747	.037
RF group	.481	.027	.559	.030	.706	.037	.715	.032

CF group	.458	.032	.542	.036	.679	.043	.679	.038
Translation test accuracy (proportion)								
SF group	.520	.028	.361	.036	.685	.041	.558	.046
RF group	.522	.025	.375	.032	.648	.037	.435	.042
CF group	.500	.029	.333	.037	.547	.043	.363	.049
Pretest-posttest gain								
SF group	.254	.040	.195	.042	.165	.045	.196	.035
RF group	.225	.035	.157	.037	.126	.038	.060	.031
CF group	.221	.041	.138	.043	.047	.046	.030	.036

Note. SF = schematic diagram feedback; RF = metalinguistic rule and exemplar feedback; CF = correctness feedback.

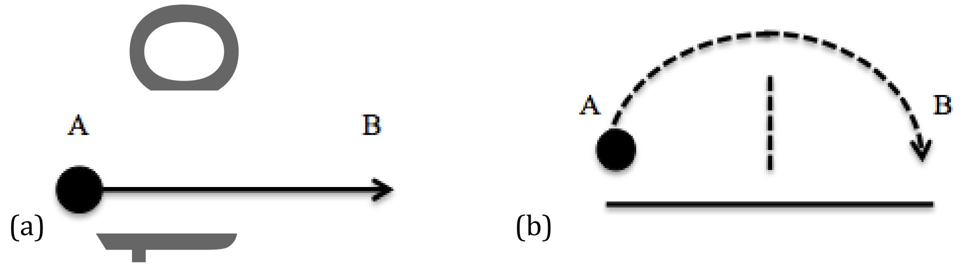


Figure 1 Schematic diagrams of mental representations of preposition *over* for the sentence *The soldier crawled over the wall*. Panel a depicts the basic SOURCE-PATH-GOAL schema; Panel b is a

refinement of the schema (Tyler & Evans, 2003) illustrating rising *above* and then coming down *across* on the other side.

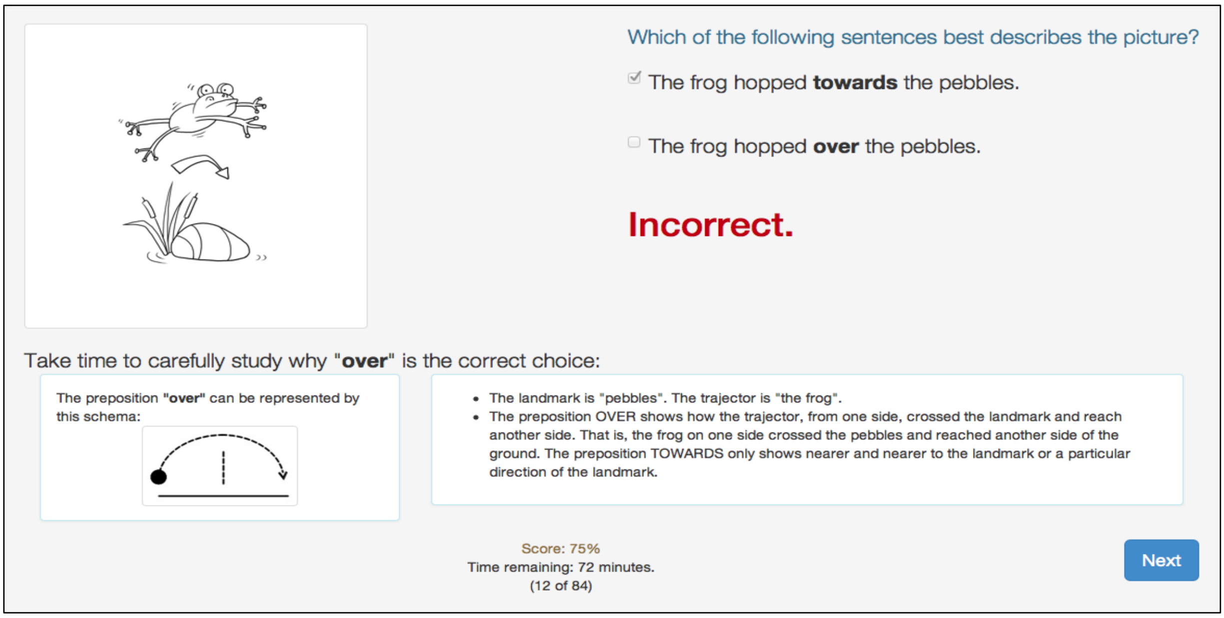


Figure 2 Training interface used with the schematic diagram feedback group.

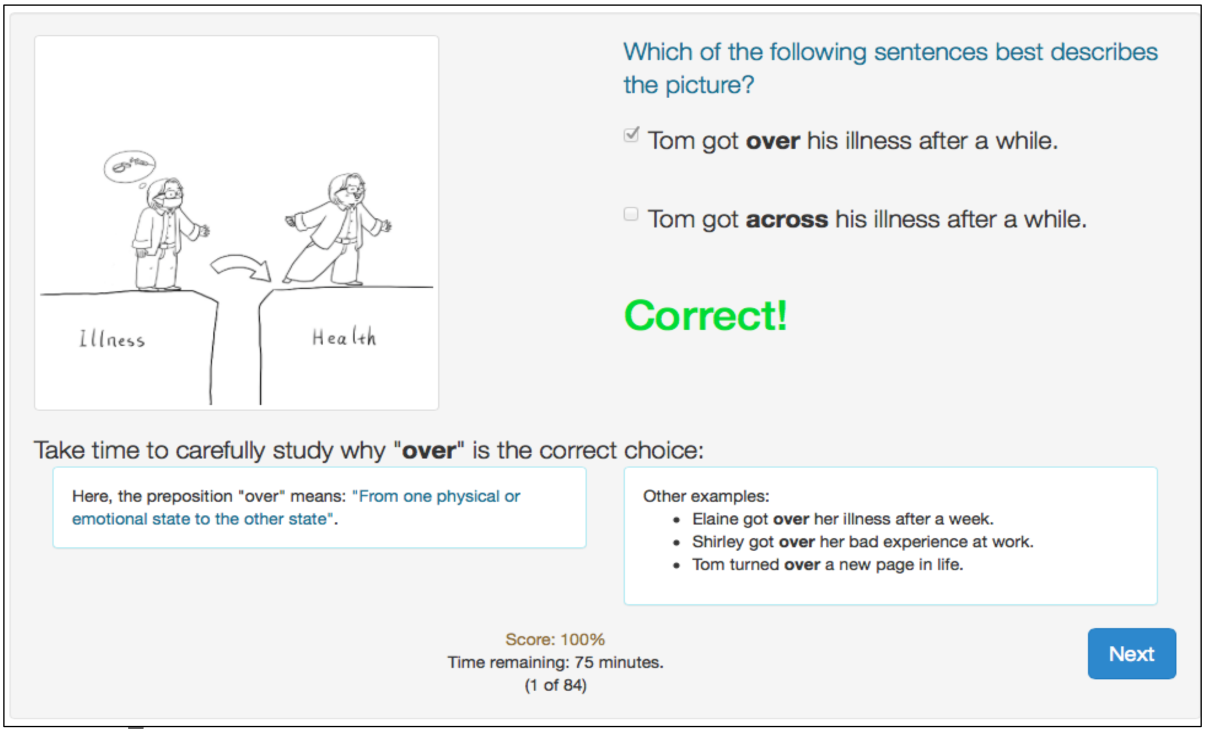


Figure 3 Training interface used with the metalinguistic rule and exemplar feedback group.