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SHORT REPORT / COMMUNICATION BRÈVES

Recognition Memory for Novel Syntactic Structures

Phillip Hamrick
Kent State University

It is commonly held that recognition memory for the surface syntax of language is not robust, especially when compared with memory for gist (e.g., Potter & Lombardi, 1998; Sachs, 1967). Nevertheless, it has been reported that memory for surface syntax occurs and can be surprisingly robust (e.g., Gurevich, Johnson, & Goldberg, 2011). However, most studies have focused on recognition memory for syntactic structures present in participants' native languages, but little is known about memory for novel (e.g., nonnative) syntactic structures. Adults were exposed under incidental learning conditions to a semiartificial language consisting of English words placed into non-English syntactic structures derived from Persian. They were then given an unexpected recognition memory test. Participants demonstrated clear recognition memory for novel syntactic structures. Overall, the results suggest that memory for surface syntax can be acquired under incidental learning conditions, consistent with previous findings in the implicit learning literature using nonlinguistic stimuli. The results also suggest that basic memory processes like those investigated in the recognition memory literature may be involved in the incidental learning of novel syntactic structures, consistent with some current neurocognitive approaches to language (e.g., Ullman, 2004).

Keywords: recognition memory, syntax, incidental learning, implicit learning

Early work on memory for language is remembered for revealing that verbatim memory for surface syntax (i.e., word order) is not particularly robust, especially when compared with memory for gist. For example, Sachs (1967) presented participants with sentences like "He sent a letter about it to Galileo, the great Italian scientist" embedded in a story. Participants' memory for verbatim recognition was tested after zero to 160 intervening syllables. Sachs reported that memory for exact syntax deteriorated rapidly, with participants often erroneously accepting sentences such as "He sent Galileo, the great Italian scientist, a letter about it." However, participants were able to reject sentences whose meaning had changed, for example, "Galileo, the great Italian scientist, sent him a letter about it." In short, memory for the gist meaning of the original sentence was more pronounced than memory for specific syntactic form. This basic finding has been more or less corroborated in numerous other studies (e.g., Bransford & Franks, 1971; Jarvella, 1973) and has been interpreted strongly as evidence that "there is no explicit memory for the surface syntactic structure of a perceived sentence" (Potter & Lombardi, 1998, p. 267).

Although memory for syntax is not as robust as gist memory, it is not absent altogether. For example, when people are forewarned of an impending memory test, they are much better at recalling surface syntax (Johnson-Laird & Stevenson, 1974). Similarly, if sentence stimuli are marked (e.g., because they are funny), then people are generally better at recognising exact surface syntax (e.g., Kintsch & Bates, 1977). Memory for syntax in nonmarked contexts has been demonstrated, too, at both short intervals (Anderson, 1974) and longer intervals (Gurevich et al., 2011). Indeed, Gurevich et al. (2011) reported a series of experiments demonstrating that participants could recall and recognise sentences from 300-word texts after a single exposure, without being warned of a test phase, for up to a 6-day delay.

However, little is known about memory for novel (e.g., nonnative) syntactic structures, because memory for syntax is typically assessed when the target syntactic structures are already known from the native language. To address this gap, the present study investigated whether adult learners exposed to novel syntax under incidental learning conditions were able to acquire recognition memory for surface syntax. The experimental paradigm was derived from implicit learning research using artificial grammars and serial reaction time (RT) tasks, in which it is well-established that adults can induce structural information from passive exposure to stimuli without deliberate attempts to learn or memorise (for overviews, see Perruchet, 2008, and Shanks, 2005). Participants were exposed to a semiartificial language containing syntactic structures with which they had no prior experience (English words in Persian syntax, e.g., "Yesterday Charlie at the supermarket milk

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Phillip Hamrick, Language and Cognition Research Laboratory, Department of English, Kent State University.

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Correspondence concerning this article should be addressed to Phillip Hamrick, Language and Cognition Research Laboratory, Department of English, Kent State University, 113 Satterfield Hall, Kent, OH 44242. E-mail: philliphamrick@gmail.com

Table 1
Syntactic Structures and an Example Core Sentence Placed in Each Structure

Label	Syntactic structure	Example
A	TEMPORAL PHRASE – SUBJECT – PREPOSITIONAL PHRASE – OBJECT – VERB	Earlier today the farmer at the market tomatoes sold.
B	TEMPORAL PHRASE – SUBJECT – OBJECT – PREPOSITIONAL PHRASE – VERB	Earlier today the farmer tomatoes at the market sold.
C	TEMPORAL PHRASE – VERB – SUBJECT – PREPOSITIONAL PHRASE – OBJECT	Earlier today sold the farmer at the market tomatoes.

Note. Structures A, B, and C were used in the exposure phase for the experimental group.

bought") under incidental learning conditions (i.e., without being forewarned of a test) and were then given an unexpected recognition memory judgment test. Following the assumptions that (a) declarative memory contributes to recognition memory performance (e.g., Squire, Wixted, & Clark, 2007), and that (b) declarative memory supports early syntax learning (Ullman, 2001, 2004), it was predicted that participants would acquire recognition memory for novel syntactic structures.

Method

Participants

Volunteer undergraduates (17 women, 10 men; mean age = 19.1 years, range = 18 to 24) who were all native speakers of English gave informed consent. Participants were randomly assigned to either an experimental (n = 14) or control (n = 13) group. There were no significant differences between groups in age, sex, handedness, or number of languages spoken (all ps > .05). No participants had previously learned or studied Persian.

Materials

Exposure phase stimuli. The experiment employed the semi-artificial language paradigm in which words from participants' native language are placed into syntactic structures from another language (e.g., Rebuschat & Williams, 2012). The advantage of this method is that it circumvents pretraining participants on vocabulary before exposing them to more complex language. The experimental group's stimuli consisted of English words and the following syntactic categories: TEMPORAL PHRASE, SUBJECT NOUN PHRASE, VERB PHRASE, OBJECT NOUN PHRASE, and PREPOSITIONAL PHRASE. These were placed into three Persian syntactic structures (labelled A, B, and C), illustrated in Table 1. Participants read a total of 96 sentences comprised of 32 "core" sentences placed in each of the three training structures. Thus, participants were exposed to each core sentence three times, once in each target structure with no differences in their lexical (word forms) or semantic (meaning) content.[1]

Control participants read the same 32 core sentences as the experimental participants; however, the syntactic structures in the control condition were pseudorandomized. Ninety-six sentences were created for the control exposure phase by pseudorandomly reordering the syntactic categories above (excluding Persian and recognition memory test structures). Of the 96 syntactic structures, there were no repetitions of a whole structure (e.g., a given structure never occurred more than once). As in the experimental group, control participants read each of the 32 core sentences three times each. However, instead of reading each core sentence once in each of the three target syntactic patterns from Persian, the controls read the core sentences across 96 different, nonrepeating syntactic structures. In short, this manipulation ensured that control participants were exposed to the same core sentences the same number of times, with the only factor differing between groups being the presence or absence of Persian syntactic structures. To illustrate, the core sentence "Yesterday Charlie bought milk at the supermarket" would appear once each in structures A, B, and C for the experimental group, and once each in three randomly selected control structures for the control group, for example, "Yesterday milk Charlie bought at the supermarket" (TEMPORAL PHRASE – OBJECT – SUBJECT – VERB – PREPOSITIONAL PHASE), "Charlie milk bought at the supermarket yesterday" (SUBJECT – OBJECT – VERB – PREPOSITIONAL PHRASE – TEMPORAL PHRASE), and "Yesterday bought at the supermarket milk Charlie" (TEMPORAL PHRASE – VERB – PREPOSITIONAL PHRASE – OBJECT – SUBJECT). After a single use, none of these pseudorandom control structures would ever appear again during the exposure phase or in the recognition memory test.

Recognition memory test stimuli. The aim of the recognition memory test was to isolate an effect of memory for syntax beyond any contributions of lexical and semantic information. To achieve this, participants were instructed to discriminate old (previously seen) from new (previously unseen) sentences. Crucially, the terms "old" and "new" are relative in that they only describe the old–new status of syntax from the perspective of the experimental group. The recognition memory test consisted only of core sentences (i.e., words and meanings) from the exposure phase. This made all recognition memory test sentences equally old for both groups, in the sense that all participants had read the same core sentences before. Recognition memory test items only differed in whether they followed the three "grammatical" Persian syntactic structures from the experimental group's exposure phase (old items) or "ungrammatical" structures (new items; see Table 2). Thus, the only information available to experimental participants for discriminating old from new sentences was whether those sentences had been seen in the *exact* target syntactic structures from the exposure phase. Importantly, the control group was given the same

[1] Although this increases control over the stimuli, it removes semantic or pragmatic influences from the syntactic structures themselves. Given increased theoretical emphasis on the meaningful nature of syntax (e.g., Culicover & Jackendoff, 2006; Goldberg, 2006), this may be considered a limitation.

Table 2
Recognition Memory Test Sentences for the Experimental and Control Groups

Early or late	Old or new	Syntactic structure	Example
Early	Old	TEMPORAL PHRASE – SUBJECT – PREPOSITIONAL PHRASE – OBJECT – VERB	Over the weekend the musician for charity a concert gave.
	Old	TEMPORAL PHRASE – SUBJECT – OBJECT – PREPOSITIONAL PHRASE – VERB	Last month the model a party for her birthday threw.
	Old	TEMPORAL PHRASE – VERB – SUBJECT – PREPOSITIONAL PHRASE – OBJECT	This morning picked the farmer for his neighbor some vegetables.
	New	TEMPORAL PHRASE – PREPOSITIONAL PHRASE – OBJECT – SUBJECT – VERB	Some time ago for his patient some medicine the doctor prescribed.
	New	PREPOSITIONAL PHRASE – SUBJECT – TEMPORAL PHRASE – OBJECT - VERB	In our class this past week the scientist the formula explained.
	New	TEMPORAL PHRASE – VERB – OBJECT – SUBJECT – PREPOSITIONAL PHRASE	Recently stopped the car the policeman for speeding.
Late	Old	TEMPORAL PHRASE – SUBJECT – PREPOSITIONAL PHRASE – OBJECT – VERB	Yesterday the photographer at the wedding some pictures took.
	Old	TEMPORAL PHRASE – SUBJECT – OBJECT – PREPOSITIONAL PHRASE – VERB	Earlier today the athlete his position on the team lost.
	Old	TEMPORAL PHRASE – VERB – SUBJECT – PREPOSITIONAL PHRASE – OBJECT	Some time ago fired the boss at the store an employee.
	New	SUBJECT – TEMPORAL PHRASE – VERB – PREPOSITIONAL PHRASE – OBJECT	The waitress this past week left on the table her tip.
	New	TEMPORAL PHRASE – PREPOSITIONAL PHRASE – SUBJECT – OBJECT – VERB	Over the weekend in the museum the artist her work unveiled.
	New	TEMPORAL PHRASE – VERB – PREPOSITIONAL PHRASE – SUBJECT – OBJECT	Yesterday found in the park the boy a cell phone.

recognition memory test as the experimental group. However, the controls had not encountered any of the test syntactic structures during their exposure phase. Their pseudorandomly selected structures were chosen so that they never saw any of the structures that appeared in the recognition memory test. Thus, for the control group, all recognition memory test items were equally old in terms of their lexical and semantic content and equally new in terms of their syntax.

The recognition memory test was organized into two blocks. The first block contained core sentences presented sometime within the final 18 trials of the exposure phase (late items). These late items were tested first to give a more immediate measure of recognition memory with minimal memory decay or interference. The second block contained core sentences presented sometime within the first 18 trials of the exposure phase (early items). These early items were tested last to provide a measure of longer-term recognition memory in the face of potential memory decay and interference from the intervening trials. Each recognition memory test block consisted of the presentation of three old sentences and three new sentences. Core sentences used in the recognition memory test were only used once each in order to minimise interference effects across test items due to lexical and/or semantic overlap.

Procedure

Participants were tested individually in a quiet labouratory. They were told that they were participating in a study about reading comprehension under "unusual circumstances." They were informed that, in their case, "unusual circumstances" meant that they would be reading scrambled sentences.

Exposure phase. Participants were instructed to read each sentence for meaning as though they were reading a book, article, or blog. After reading each sentence, the computer prompted participants to indicate how easy or difficult it was to read that sentence on a scale from 1 (*very easy*) to 6 (*very difficult*).[2] Each number corresponded to a relabeled keyboard key (i.e., A = 1, D = 2, G = 3, J = 4, L = 5, quote key = 6). Sentences were presented using a self-paced noncumulative moving window design. Sentences were segmented at syntactic category boundaries (e.g., Yesterday | Charlie | at the supermarket | milk | bought), and participants pressed the space bar to advance through each sentence fragment. Therefore, each space-bar key press corresponded with the presentation of a new syntactic category constituent (for an illustration, see Figure 1).[3] The exposure phase consisted of 96 trials. Each trial consisted of the presentation of a fixation cross, followed by a sentence, and then an ease/difficulty of reading judgment. Sentences were presented in a pseudorandom order, with the early and late recognition memory test items always occurring somewhere within first and last 18 exposure phase trials, respectively. All other sentences were presented in random order for each participant. Participants were not informed that there would be any kind of test after the exposure phase. The exposure phase took an average of approximately 20 min to complete.

[2] Subjective ease-of-reading measures were collected for another study, reported in Hamrick (2013). However, it is important to stress that these measures revealed no significant differences between experimental and control groups, and neither group demonstrated any significant differences in ease of reading during the course of the exposure phase.

[3] The noncumulative moving window design was chosen to provide fine grained reaction time data between each syntactic category transition for another study reported in Hamrick (2013). However, it is worth noting that there were no significant reaction time differences between groups during the exposure phase.

Event	Display				
Space Bar Press	Yesterday	--------	--------------	--------	----------
Space Bar Press	-------------	Charlie	--------------	--------	----------
Space Bar Press	-------------	--------	at the store	--------	----------
Space Bar Press	-------------	--------	--------------	milk	----------
Space Bar Press	-------------	--------	--------------	--------	bought

Figure 1. Example of the noncumulative moving-window self-paced reading design.

Recognition memory test phase. After the exposure phase, participants were then told that their next task would be to read more sentences, but this time they would be asked to indicate whether or not they had seen each sentence before using another scale from 1 (*I have seen this sentence before and I am very sure*) to 6 (*I have not seen this sentence before and I am very sure*) (see Figure 2). Participants were also told that half of the test sentences would be old (i.e., exactly the same as the sentences they just read) and the other half would be new (i.e., not exactly the same as the sentences they just read). Sentences were again presented using a self-paced noncumulative moving window design, with each space-bar key press corresponding to the presentation of a new syntactic category constituent. On average, the recognition memory test took five minutes to complete.

Results

Recognition memory difference scores were computed for each participant by subtracting his or her mean rating for old items from his or her rating for new items. Each participant was given two difference scores—a difference score for early items and a difference score for late items. The results are illustrated in Figure 3a.

A mixed ANOVA on difference scores with group (experimental, control) and source (early, late) as factors revealed a significant effect of group, $F(1, 25) = 6.41$, $p = .01$, $\eta_p^2 = .21$, but no effect of source, $F(1, 25) = 0.89$, $p = .35$, and no interaction, $F(1, 25) = 0.22$, $p = .64$. The experimental group had significantly better recognition memory discrimination than controls on both late items, $t(25) = 2.13$, $p = .04$, $d = .85$, and early items, $t(25) = 2.00$, $p = .05$, $d = .76$. Within the experimental group, there was no significant difference in recognition memory discrimination for late and early items, $p = .33$. Thus, experimental participants had recognition memory for recently presented sentences as well as sentences they had not seen since the first part of the exposure phase, which was an interval of approximately 20 min.

Now some have argued that recognition memory tests can be contaminated by implicit priming (e.g., Shanks & Johnstone, 1999) if participants use their own processing speed as a familiarity heuristic (e.g., they perceive faster processing as indicating higher familiarity). In the present context, if participants judged old versus new sentences on the basis of such a heuristic, then they should be faster at reading sentences they judged to be old, regardless of whether those sentences were actually old or not (see Figure 3b). Participants' mean reading times (RTs) in milliseconds for late items judged old ($M = 15{,}379$, $SD = 6{,}052$) was faster than late items judged new ($M = 16{,}448$, $SD = 5{,}816$), but this difference was not significant, $t(13) = 0.79$, $p = .44$, 95% CI [−4,001, 1,892]. Mean RTs for early items judged old ($M = 13{,}984$, $SD = 4{,}642$) were slower than early items judged new ($M = 13{,}879$, $SD = 4{,}117$), but this difference was not significant, $t(13) = 0.15$, $p = .87$, 95% CI [−1,343, 1,553]. Taken together, the results indicate no significant influence of implicit priming on the recognition memory test results, suggesting that the recognition memory test was measuring recollection and/or familiarity.

Conclusions

The present study demonstrates that adults exposed to novel syntactic structures under incidental learning conditions are able to discriminate between previously seen and unseen sentences exclusively on the basis of the surface syntactic cues. This extends previous findings for memory for surface syntax in several ways. First, consider that Gurevich et al. (2011) found incidental verbatim memory for syntax but did not control for closed class items or slight semantic differences stemming from

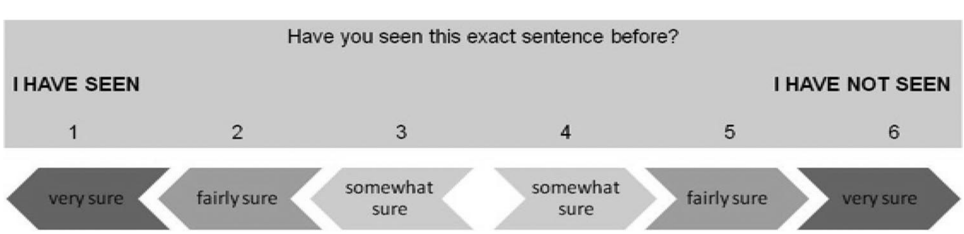

Figure 2. Recognition memory test rating prompt.

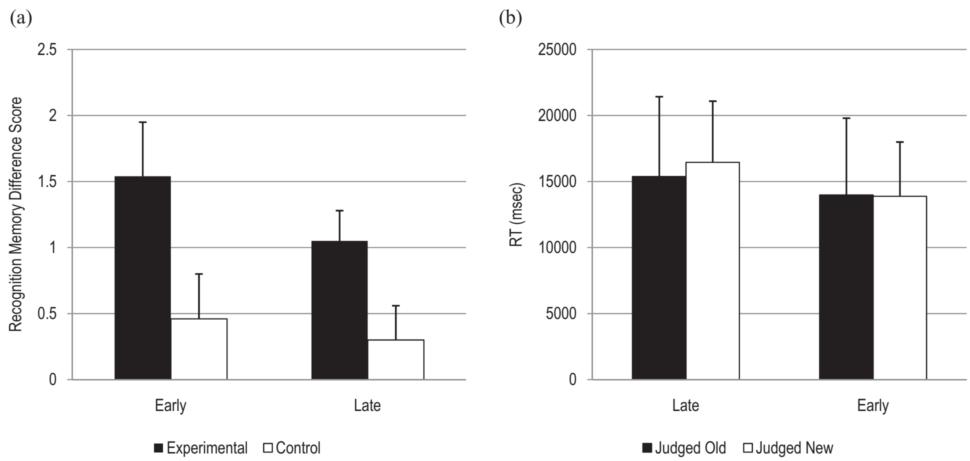

Figure 3. (a) Mean difference scores (+*SE*) on the recognition memory test. Participants responded to six early items and six late items. (b) Mean reading times (+*SD*) in milliseconds for recognition memory test items judged to be old or new, regardless of their actual old–new status.

the use of different syntactic structures.[4] By comparison, and by virtue of using a semiartificial language, the present study was able to expose participants to *exactly* the same words and meanings in both old and new items, leaving surface syntax as the only cue for discriminating old from new sentences in the recognition memory test. Second, to the author's knowledge, this study is also the first to report evidence for recognition memory specifically for nonnative syntactic structures. Finally, by looking at recognition memory in the context of incidental learning, the present study also extends previous work in implicit learning that has demonstrated above-chance recognition memory for material in artificial grammar studies (e.g., Shanks & Johnstone, 1999) and SRT task studies (e.g., Perruchet, Bigand, & Benoit-Gonin, 1997) to the domain of naturalistic language syntax, which has been scarcely investigated in implicit learning research (e.g., Rebuschat & Williams, 2012).

Inasmuch as recognition memory task performance is taken as an index of declarative memory (Squire et al., 2007), the present results are consistent with theories of language that posit a role for declarative memory for syntax in adults (e.g., Ullman, 2001, 2004); however, the present results do not unambiguously demonstrate whether memory for syntax was due to declarative or nondeclarative (e.g., procedural or implicit) memory (e.g., Ferreira, Bock, Wilson, & Cohen, 2008). Although priming effects were ruled out, other sources of nondeclarative memory could have influenced the results. Additionally, it is also unclear whether recognition memory task performance in the present study was supported by recollection or familiarity processes or both. Given the ongoing debate over the relationships between the processes supporting recognition memory (i.e., recollection, familiarity, fluency, and priming), and the actual memory systems supporting those processes (i.e., declarative and nondeclarative memory), it will be important to determine whether recognition memory for syntax is driven by recollection or a familiarity-based signal and to what extent these processes are declarative or nondeclarative. Such work on the component processes of recognition memory for language would complement ongoing neurocognitive research looking at the memory systems underlying linguistic syntax (for an overview, see Morgan-Short & Ullman, 2012).

There are a few limitations to the present study that may prevent strong generalisation. For one, it is possible that participants were better at passively memorising information due to increased attentional levels induced by the unusual nature of the semiartificial stimuli. It is also possible that the recognition memory effects reported here stemmed from greater processing demands arising from the forced alignment between English words (which carry their own syntactic properties) and Persian word order (which carries its own unique syntactic properties). However, it is important to remember that although such confounds might explain the present findings, they could not explain prior evidence of verbatim memory for language from English native speakers exposed to natural English (e.g., Anderson, 1974; Gurevich et al., 2011), and so do not altogether undermine the possibility of memory for syntax. Although future research is needed to address these issues, the present results nevertheless suggest that simply reading sentences containing novel syntactic structures triggers memorization in adults, even when they are not deliberately trying to memorise. This finding suggests that fundamental memory processes like those investigated in recognition memory and implicit learning research may be involved in incidental learning of novel syntax.

Résumé

Il est généralement admis que la mémoire de reconnaissance pour la syntaxe de surface du langage n'est pas robuste, en particulier lorsqu'on la compare à la mémoire de l'essentiel (voir Potter & Lombardi, 1998; Sachs, 1967). Néanmoins, il a été rapporté que la mémoire de reconnaissance pour la syntaxe de surface existe et qu'elle peut être remarquablement robuste (voir Gurevich, Johnson & Goldberg, 2011). Toutefois, la plupart des études ont porté sur la mémoire de reconnaissance de structures syntaxiques des

[4] Thanks to an anonymous reviewer for pointing this out.

langues maternelles des participants. Donc, on connaît peu sur la mémoire des structures syntaxiques nouvelles (non maternelles). Des adultes ont été exposés, dans des conditions d'apprentissage incident, à un langage semi-artificiel composé de mots anglais placés dans des structures syntaxiques non anglaises dérivées du perse. On leur a alors administré un test de mémoire de reconnaissance auquel ils ne s'attendaient pas. Les participants ont fait preuve d'une nette mémoire de reconnaissance des structures syntaxiques nouvelles. Dans l'ensemble, les résultats suggèrent que la mémoire pour la syntaxe de surface peut s'acquérir dans des conditions d'apprentissage incident, ce qui est conforme aux résultats d'études sur l'apprentissage utilisant des stimuli non linguistiques. Les résultats suggèrent en outre que les processus de mémoire de base, tels que ceux dont il est question dans la littérature sur la mémoire de reconnaissance, pourraient contribuer à l'apprentissage incident des nouvelles structures syntaxiques, ce qui est compatible avec certaines des actuelles approches neurocognitives à l'égard du langage (voir Ullman, 2004).

Mots-clés : mémoire de la reconnaissance, syntaxe, apprentissage incident, apprentissage implicite

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