Original Article

QJEP

Quarterly Journal of Experimental Psychology
1–22

Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/17470218241298250
qjep.sagepub.com
Sage

The lexical boost is not an automatic part of sentence production: Evidence from Japanese structural priming

Franklin Chang[1] and **Saki Tsumura**[2,3]

Abstract

The lexical boost is an increase in structural priming with overlapping elements like verbs. Residual activation priming theories argue that the boost is an automatic side effect of sentence planning. In contrast, explicit memory theories of the boost argue that it is the result of a non-automatic explicit memory retrieval. These theories were contrasted in Japanese by including a prime memory task in a structural priming study. Structural priming was found for both datives and passives, but no lexical boost was found, and one possible reason was that explicit memory for the prime structure was weak. In a follow-up study, priming was found in a sentence-completion task, but there was no lexical boost. The existence of abstract priming and the lack of a lexical boost in these studies falsify theories that argue that verb overlap automatically creates a boost under conditions that exhibit abstract priming.

Keywords

Structural priming; Japanese; lexical boost; sentence production

Received: 29 May 2024; revised: 25 September 2024; accepted: 14 October 2024

A key phenomenon for studying syntactic processing is structural priming, which is a tendency to reproduce the sentence structure of previously experienced sentences (Bock, 1986; Pickering & Ferreira, 2008). For example, after reading the double-object dative prime sentence "John gave Mary a book," a person might be more likely to describe a target picture using a similar double-object dative structure like "The girl threw the dog the bone" rather than the prepositional dative "The girl threw the bone to the dog." Since the words and meanings can be different between prime and target sentences, it is thought that priming involves abstract syntactic structures (Bock, 1989; Bock & Loebell, 1990). However, it has also been found that when the verb overlaps between the prime and target, the priming effect is larger, which is called the lexical boost (Pickering & Branigan, 1998). That is, if the prime and target both had the verb "threw," then the priming effect would be boosted over the case where the prime has a different verb like "gave."

The first theory to explain the lexical boost was the account of Pickering and Branigan (1998), who argued that structural priming was due to residual activation in a network used for sentence production. They argued that sentence production involved selecting combinatorial nodes for particular structures (NP-NP for the double-object dative and NP-PP for the prepositional dative). During the processing of the prime, the node for the structure of the prime sentence would become activated, and some residual activation would be automatically left in the node. This residual activation would then make it easier for the node to be reactivated later when the target sentence was produced. In this way, the theory could explain abstract structural priming. To explain the lexical boost, they argued that lemma nodes for the prime verb would also become activated, and these verb nodes have links to the combinatorial nodes for the structures that they are compatible with (the verb "give" can occur in the double-object, but not the intransitive structure). As with abstract priming, activation of the verb-combinatorial node link automatically leaves residual activation in the

[1]Department of English Studies, Kobe City University of Foreign Studies, Kobe, Japan
[2]The University of Tokyo, Tokyo, Japan
[3]Fukuoka University, Fukuoka, Japan

Corresponding author:
Franklin Chang, Department of English Studies, Kobe City University of Foreign Studies, 9 Chome-1 Gakuen Higashimachi, Nishi Ward, Kobe 651-2102, Hyogo, Japan.
Email: chang.franklin@gmail.com

link. If the prime and target had the same verb, the residual activation in this link would create a lexical boost. In this work, we will focus on priming research using production paradigms. Similar activation mechanisms have been proposed to explain comprehension-to-comprehension priming in studies using reading times, but since these studies can differ greatly from production studies (e.g., comprehension priming sometimes only appears with lexical overlap, Tooley & Traxler, 2010), it is not clear whether the same mechanisms are involved.

An alternative account of priming was offered by Chang et al. (2006). They developed a connectionist model where structural priming was due to implicit learning about the prime sentence, which led to small changes in syntactic representations that strengthened the preference for the structure of the prime. This learning mechanism could explain a range of abstract structural priming effects, but it was unable to explain the larger and variable lexical boost effects. Therefore, they proposed that the lexical boost was due to another mechanism. One proposal was that the lexical boost was due to explicit memory, where the verb on the target would remind the participant of the prime sentence and that explicit memory would bias them to reuse the structure (Chang et al., 2012). This dual-mechanism account, where abstract priming is due to implicit learning and the lexical boost is due to explicit memory, contrasts with accounts that use similar residual activation mechanisms for both priming and the boost.

There is evidence for differences in the nature of abstract priming and the lexical boost. It has been found that abstract priming persists over time and the processing of additional filler sentences (Bock et al., 2007; Bock & Griffin, 2000), but the lexical boost dissipates rapidly after a few filler sentences (Branigan & McLean, 2016; Hartsuiker et al., 2008). This difference can be explained by a residual activation mechanism if a faster decay is associated with verb-combinatorial node links. Further evidence for differences comes from studies with children that show abstract priming without a lexical boost (and vice versa), which suggests that these phenomena can dissociate over development (Donnelly et al., 2024; Kholodova et al., 2023; Kumarage et al., 2022; Peter et al., 2015; Rowland et al., 2012). This can be explained with residual activation by assuming that there are parameters or knowledge that change as children age. Thus, it is possible to explain the differences between abstract priming and the lexical boost without positing the use of distinction mechanisms like explicit memory.

The evidence for the role of explicit memory in the lexical boost is mixed. One claim of the explicit memory account is that priming can be sensitive to overlap in elements other than the verb. Scheepers et al. (2017) found evidence that overlap in content words (e.g., agents, recipients) could create a boost in priming. However, work by Carminati et al. (2019) did not find those overlap effects, and they argue that only special *syntactic head* elements can create a lexical boost. Syntactic heads are syntactic categories that characterise the phrase that they are part of (e.g., a verb phrase is headed by a verb). Kantola et al. (2023) tested for lexical boost effects where there was overlap in non-dative matrix verbs on the dative alternation and found that overlap in non-head verbs does not create a lexical boost. While the explicit memory account could be sensitive to overlap in elements other than the head verb, it differs from the residual activation account in that explicit memory is not an automatic process, and some of the variation in results across studies could be due to differences in strategic processing in different populations. Support for this comes from van Gompel et al. (2023), who found that a subject overlap effect occurred when the whole prime sentence was visible on the screen, and therefore, results from the work of Scheepers et al. could be explained if their participants were more likely to strategically recall the whole sentence. Since the explicit memory account is an optional mechanism that depends on various factors like motivation or strategic processing, it is compatible with variation in the lexical boost across studies.

Other studies have examined how memory features might influence priming. Zhang et al. (2020) carried out two studies. The first study was a normal implicit structural priming task that manipulated verb overlap. The second study used the same materials but asked participants to explicitly remember each prime sentence and use it in their target description. They found that abstract structural repetition was stronger in the explicit memory task than in the implicit priming task, suggesting that explicit memory involves different mechanisms compared to abstract priming. However, they found a similar magnitude for the lexical boost in both tasks, suggesting that the lexical boost in the implicit task could involve the same explicit memory mechanisms as the explicit task. They also manipulated working-memory load on the assumption that strategic lexical boost effects could be more greatly affected by working-memory load than automatic abstract priming. They only found some weak hints that lexical boost effects were influenced by the memory load. One possible reason for the weakness of these results is that abstract priming also appears to depend on explicit memory to some degree (Bernolet et al., 2016; Coumel et al., 2024). So while explicit memory could explain some aspects of priming, it has been difficult to isolate the degree that it is involved in the lexical boost.

The inconclusive evidence for the role of explicit memory in the boost may be due in part to the use of languages where the verb appears in a salient position early in sentences. It may be useful to look at verb-final languages like Japanese, which have been shown to have different sentence-processing features (Arai, 2012; Arai & Mazuka, 2014; Tanaka et al., 2007; Yamashita & Chang, 2001). Japanese is a verb-final language where arguments of the verb are marked by case-marked particles (*ga* = NOMinative, *ni* = DATive, *o* = ACCusative). The dative structural alternation is implemented by changing the linear order of case-marked arguments (scrambling). For example, the sentence "the girl told the detective her honest opinion" could be expressed by the *ga-ni-o* sentence in (1), while the sentence "the girl told her honest opinion to the detective" might match the *ga-o-ni* sentence in (2). Although the *ga-ni-o* order in (1) is more frequent (canonical), the *ga-o-ni* order is also easily elicited in experiments.

1.	shoujo	ga	tantei	ni	socchokuna	iken	o	nobeta
	girl	NOM	detective	DAT	honest	opinion	ACC	told
2.	shoujo	ga	socchokuna	iken	o	tantei	ni	nobeta
	girl	NOM	honest	opinion	ACC	detective	DAT	told

Using the Japanese dative alternation, which only varies in the linear order of the phrases, production studies have found abstract priming (Chang et al., 2022). When lexical overlap was manipulated, both abstract priming and boost effects have been found (Deng et al., 2013).

Many Japanese priming studies have used transitive structures (Deng & Nakamura, 2015; Deng et al., 2007, 2008, 2011). The transitive sentence "the brat burned the tree branch" could be expressed with the active *ga-o* form in (3) or the passive *ga-ni* form in (4). This alternation involves changes in function assignment because in the accusative *o*-marked object, "tree branch" in the active sentence becomes the nominative *ga*-marked subject of the passive. In a study looking at verb overlap with changes in function assignment (active vs passive structures), Jin et al. (2013) found abstract priming and a lexical boost. Scrambling of phrases is also common in transitives with the *o-ga* sentence in (5) being the scrambled version of the *ga-o* sentence in (3), and the *ni-ga* sentence in (6) being the scrambled version of the *ga-ni* sentence in (4). In a study that manipulated verb overlap with scrambled structures, Deng and Nakamura (2015) found priming without the boost, which suggests that linear order changes may be less sensitive to verb overlap.

3.	warugaki	ga	niwakinoeda	o	moyashita
	brat	NOM	tree branch	ACC	burned
4.	niwakinoeda	ga	warugaki	ni	moyasareta
	tree branch	NOM	brat	DAT	burned(passive)
5.	niwakinoeda	o	warugaki	ga	moyashita
	tree branch	ACC	brat	NOM	burned
6.	warugaki	ni	niwakinoeda	ga	moyasareta
	brat	DAT	tree branch	NOM	burned(passive)

Sentence-production theories have argued that function assignment and linearisation (scrambling) take place at different stages within the production system (Bock & Levelt, 1994). However, Pickering et al. (2002) tested priming for scrambled structures in English and argued that function assignment and linearisation distinctions in priming are encoded in independent combinatorial nodes in one stage. This implies that a residual activation theory of Japanese priming should have combinatorial nodes for *ni-o* and *o-ni* structures to explain the dative abstract priming found in the study by Deng et al. (2013). To explain the boost that they found, there would need to be links between verb lemma nodes and the combinatorial nodes.

A hypothetical network for a Japanese speaker is depicted in Figure 1 with the combinatorial nodes *ni-o* and *o-ni* at the bottom, and the verbs "give" and "throw" at the top. Residual activation values are placed in the figure to illustrate how residual activation could influence production (e.g., $RA_{ni\text{-}o} = 0.2$). If the participant has experienced several *ni-o* and *o-ni* primes in the experiment, then there is residual activation in each combinatorial node. However, if the most recent prime was an *o-ni* structure, then the residual activation in the corresponding node should be a little higher ($RA_{o\text{-}ni} = 0.3$), and this would create abstract priming. In this example, the verbs "give" and "throw" have not appeared frequently in the experiment, so most of the links between the verbs and the combinatorial nodes have low values (e.g., $RA_{THROW,o\text{-}ni} = 0.04$). If the most recent prime had the verb "give" in the *o-ni* structure, then there should be a larger residual activation in the link between the verb and combinatorial node ($RA_{GIVE,o\text{-}ni} = 0.1$). If the target trial also has the verb "give," then the likelihood of using the *o-ni* structure will be boosted by the residual activation in the link.

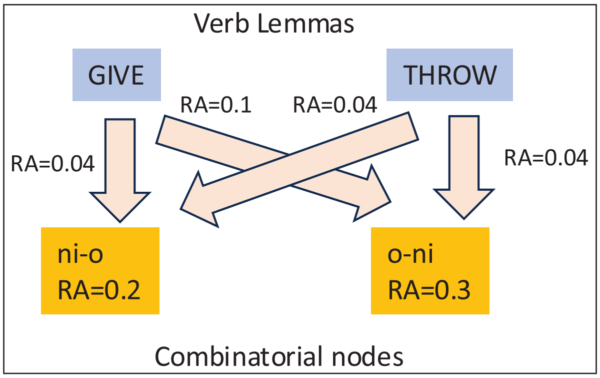

Figure 1. Residual activation model for Japanese.

This Japanese residual activation account argues that spreading activation during sentence planning leaves residual activation in nodes and links, and the lexical boost arises automatically when verbs overlap. In contrast, the explicit memory account argues that the lexical boost is due to the retrieval of the prime sentence from memory, and this memory reactivates the sentence structure in long-term memory. Since this memory retrieval is optional and depends on the motivation to retrieve the prime, it should be possible to increase the likelihood of the lexical boost by requiring participants to explicitly remember the prime sentence on some trials. The first experiment tests this account by adding a memory task to a Japanese priming study to see if it modulates the lexical boost.

Experiment 1: Examining the role of explicit memory in the lexical boost in Japanese.

To examine the role of explicit memory in priming, we first created a Japanese structural priming writing task using dative and transitive structures. Since Japanese uses several writing scripts (e.g., *hiragana, katakana, and kanji*), writers first type in their Japanese text using the Roman alphabet, then they select among several Japanese scripts that are compatible with it (e.g., typing *kousei* will display *kanji* characters like 構成 "structure" and 校正 "proofreading," as well as *hiragana* こうせい and *katakana* コウセイ). While young college-educated students are fluent in typing in this way, older participants may be slower at this process. To remove variation in typing skill from our study, we used a button-pressing task with buttons that were labelled with the target words. On the dative target trials, participants saw a pseudorandom order of buttons with arguments from the target sentence without case-marking particles (e.g., *socchokuna iken*, *nobeta*, *tantei*, *shoujo*), as well as a set of case-marking particle buttons. By clicking these buttons, they could create a sentence like the *ga-ni-o* order in (1) or the *ga-o-ni* order in (2). Before the target was a dative prime trial, where participants saw a prime sentence on the screen and had to recreate that sentence by using the buttons on the screen. For example, the prime sentence "the lawyer expressed/told the clerk the reason" was presented in either *ni-o* or *o-ni* order, and it could have either the same verb or a different verb from the prime (Table 1).

For the transitive items, we examined the priming of the linear order of arguments with passive verbs. This avoids the strong bias for canonical *ga-o* word order with verbs in the active voice. For passive targets, participants saw buttons for the arguments (e.g., *moyasareta*, *niwakinoeda*, *warugaki*), and they needed to make sentences like the *ga-ni* order in (4) or the *ni-ga* order in (6). This was preceded by a passive prime which could appear in *ga-ni* or *ni-ga* order with either the same or a different verb (e.g., "the poetry manuscript was burned/criticised by the critic"; Table 2).

If participants use the prime structure more when generating the target sentence in the different-verb condition, then they will have exhibited abstract structural priming. If participants show greater priming in the same-verb condition than in the different-verb condition, that will be evidence for a lexical boost.

Previous studies like those of Zhang et al. (2020) have examined priming and explicit memory in separate experiments with different participants. In the present study, we manipulated explicit memory retrievals within participants by adding a memory task to some trials. In the *no-memory* condition, participants just did the normal prime reproduction and target description tasks. In the *memory* condition, participants were given a cue that they were going to be tested on their memory for the prime sentence and therefore they should try to memorise the prime. The target description was followed by a memory recall task, where participants had the same buttons for the words from the prime trial, and they had to reproduce the prime sentence from memory. The reason that the memory task followed the target production was to make the prime-target tasks as similar as possible in the memory and no-memory conditions, which allowed us to compare priming in those two conditions. If explicit memory is important for the lexical boost, then we should expect a greater lexical boost effect in the memory condition, where participants were asked to explicitly remember the prime sentence for the later memory test. In contrast, if the lexical boost is an automatic outcome of spreading activation as assumed by residual activation theories, then an extra explicit memory task will not influence the boost.

Data availability

The stimuli and scripts for the statistics analysis for both studies are available in our OSF archive https://osf.io/9r7fp/.

Method

Participants. Eighty participants were recruited from an online Japanese crowd-worker website called Crowdworks

Table 1. Examples of dative prime stimuli for Exp. 1(highlighting is used to show change of word order, bold font shows overlapping verbs).

Verb	Structure	Example						
same	ni-o	bengoshi lawyer	ga NOM	jimuin clerk	ni DAT	riyuu reason	o ACC	**nobeta** expressed
same	o-ni	bengoshi lawyer	ga NOM	riyuu reason	o ACC	jimuin clerk	ni DAT	**nobeta** expressed
different	ni-o	bengoshi lawyer	ga NOM	jimuin clerk	ni DAT	riyuu reason	o ACC	oshieta told
different	o-ni	bengoshi lawyer	ga NOM	riyuu reason	o ACC	jimuin clerk	ni DAT	oshieta told

Table 2. Examples of passive prime stimuli for Exp. 1(highlighting is used to show change of word order, bold font shows overlapping verbs).

Verb	Structure	Example				
Same	ga-ni	shinogenkou poetry manuscript	ga NOM	bungakuhyouronka critic	ni DAT	**moyasareta** burned(passive)
Same	ni-ga	bungakuhyouronka critic	ni DAT	shinogenkou poetry manuscript	ga NOM	**moyasareta** burned(passive)
differed	ga-ni	shinogenkou poetry manuscript	ga NOM	bungakuhyouronka critic	ni DAT	hihyousareta criticised(passive)
different	ni-ga	bungakuhyouronka critic	ni DAT	shinogenkou poetry manuscript	ga NOM	hihyousareta criticised(passive)

(crowdworks.jp). Their ages ranged from 21 to 69 years (32 women, 48 men). Their highest educational degree varied from university (53), junior college (3), vocational school (9), and high school (15). The work was conducted with the formal approval of the Ethics Review Committee for Experimental Research with Human Subjects at Kobe City University of Foreign Studies. Since this website did not restrict the study to native speakers of Japanese, participants were given a series of culture and Japanese language multiple-choice questions, and two participants were excluded for having scores less than 65% on these questions.

Stimuli. Twenty-four dative prime-target pairs were created. Primes and targets had two animate arguments for the agent and recipient and one inanimate argument for the patient. Noun arguments were designed to be unique across all of the items. Target patient arguments had a modifier to make them longer as it has been found that Japanese speakers are more willing to use non-canonical *o-ni* order with longer patient phrases (Yamashita & Chang, 2001). Verbs could be in present or past tense. Each prime could appear in two structures (*ni-o* or *o-ni*). Each target could have either the same or a different verb with the prime. To make the dative items more distinct from the passive items, the prime subjects were marked with the topic marker *wa*, which is often used with agents. Twenty-four passive prime-target pairs were also created. Each sentence had two arguments, and primes could appear in the *ga-ni* or *ni-ga* order. Verbs were in passive form in either present or past tense. Forty-eight language and culture questions were created to identify native speakers of Japanese, and each question had four answers.

Dative and passive task groups were created with each group consisting of a prime task, a target task, a memory task (depending on the condition), and then a language and culture question. Groups were alternated such that datives were fillers for passive groups and vice versa. Eight lists were created to counterbalance the order of prime, verb overlap, memory, and items. In addition, the position of content words on the screen can influence the word order in sentences if speakers adopt strategies like generating left-to-right or top-to-bottom. To reduce these effects, we counterbalanced the position of content words in the target task. They were shown in two rows (top-left, top-right, bottom-left, bottom-right). For the dative target, the verb always appeared in the top-left and the agent in the bottom-right. The patient and recipient alternated between top-right and bottom-left counterbalanced across lists to reduce strategies such as always producing by rows or columns. For the passive targets, the verb was in top-left, and the other two arguments alternated between top-right and bottom-left. The words in prime and memory trials were randomly assigned to the button positions.

Procedure. The experiment used a button-based production method to make sentences for the prime, target, and memory tasks. Two rows of buttons were shown in the centre of the screen with buttons for the particles (*ga, ni, o, wa*) in orange on the left and buttons for the content words in red

Figure 2. Prime button–based production task with memory task cue in Exp. 1.

on the right. Above the buttons was a prompt "Sentence": where the sentence produced by clicking the buttons was shown. There was a Clear button that would clear the generated text if they wanted to start over. When they were finished, they pressed the Next button to go to the next trial. The Next button was only active if all of the content words had been added to the sentence.

The prime task displayed the prime sentence above the prompt for their sentence, and they were supposed to copy that sentence. When they were in the memory condition, there was also an image of a head with an arrow that was the cue that they would need to reproduce the prime later in the memory task (Figure 2). The target task had the words from the target sentence, and they had to produce a sentence by pressing the buttons. The no-memory condition had just the prime and target, but in the memory condition, the target was followed by the memory task, where they would produce the prime sentence from memory by pressing the buttons. After each prime-target pair (or the memory trial), they were given a language and culture question and had to select one of the four answers.

At the start of the experiment, participants were given three practice trials (two with the memory task), and there were detailed instructions on the screen for each task. After the practice trials, the instructions were shortened to provide a short reminder of each task. All of the text on the screen was in a natural mixture of Japanese scripts (*kanji*, *hiragana*, *katakana*). To reduce distractions, the whole experiment was done in full-screen. We used the Gorilla Experiment Builder (www.gorilla.sc) to create and host our experiment (Anwyl-Irvine et al., 2020). The system required participants to use a computer rather than a phone or tablet, and they had to connect from a computer in Japan.

Coding. The target sentences produced by the participants were coded for their structure using search and replace rules. In the datives, patients are inanimate, but agents and recipients are both animate, and it is possible to exchange them. Therefore, rather than coding the given role of the argument, we coded the animacy of the argument (AN=animate, IN=inanimate). The verb was coded as VERB. The topic particle *wa* was converted into the subject particle *ga* as both these forms are commonly used to mark agents. Participants produced the canonical *ni-o* order (ANga-ANni-INo-VERB) 1,311 times, and the non-canonical *o-ni* order (ANga-INo-ANni-VERB) for 433 times. There were 128 other forms that were excluded from the analysis. This included 42 grammatical scrambled orders other than our target structures (e.g., ANni-ANga-INo-VERB). Japanese is an argument-omission language, where all arguments of a verb can be omitted (e.g., ANga-ANni-VERB). Furthermore, it is common to omit particles in casual speech (e.g., ANga-ANni-IN-VERB). There were 82 cases where an argument or a particle was omitted. The remaining four other forms were errors mostly involving extra particles.

For the passives, a similar process was used, but we coded the arguments based on their thematic role in our original stimuli (AG=agent, PA=patient). The most common responses were the canonical passive form PAga-AGni-VERB, which was produced 1,100 times, and the scrambled version AGni-PAga-VERB, which was produced 409 times.

4.	niwakinoeda	ga	warugaki	ni	moyasareta
	tree-branch	NOM	brat	DAT	burned(passive)
7.	niwakinoeda	o	warugaki	ni	moyasareta
	brat	ACC	tree-branch	DAT	burned(passive)

One complication is that there are two kinds of passives in Japanese. The *ga-ni* form in (4) is a direct passive which is similar to an English passive in that it marks the patient as a subject by adding the nominative *ga* particle. There is another indirect *o-ni* passive as shown in (7), where the patient is marked with the accusative particle *o* (Hoshi,

Table 3. Mixed model memory results for both dative and passives in Exp. 1.

Terms	Beta	*SE*	lowCI	uppCI	z/Chisq	Df	*p*-value
Intercept	.010	0.188	−0.262	0.198	0.055		.956
Type	−1.270	0.273	−1.195	−0.319	11	1	<.001*
Order	.710	0.153	0.916	1.356	108	1	<.001*
Type:Order	.881	0.223	0.445	1.318	16	1	<.001*

2017). Indirect passives add an additional person who was negatively affected by the action. For example, the sentence in the *o-ni* sentence in (7) would be appropriate if the speaker was negatively affected by the burning action (e.g., the speaker was supposed to protect the tree from damage). This could be made explicit by adding a *wa*-marked argument marking the speaker (*watashi*, "I") as the one who was negatively affected by the action (e.g., *watashi wa niwakinoeda o warugaki ni moyasareta*). As Japanese allows all arguments of a verb to be omitted, the omission of subject would create the *o-ni* form in (7). Since participants were given a selection of particles to use in their sentence, some participants produced indirect passives with an omitted *wa*-marked argument (AGni-PAo-VERB 168 times, PAo-AGni-VERB 32 times) or an omitted *ni*-marked agent (AGga-PAo-VERB 77 times, PAo-AGga-VERB 3 times). Since indirect passives have an additional argument (the person who is negatively affected by the action), their syntactic structure differs from that of the direct passive, so we have excluded these structures from our analysis. In addition, there were 84 other forms that did not belong to the aforementioned groups. Of these, there were 17 cases of particle omission. Instead of producing a sentence, participants sometimes described the picture with a noun phrase (e.g., PAni-VERB-AG, 18 cases). A few items had reversible roles, and some participants produced sentences that differed from our given roles (45 cases). The remaining items were errors with extra particles (four cases). All codings were checked by a native speaker of Japanese (the second author) while blind to the prime and overlap conditions for each form.

Results

To examine how the memory task might influence the lexical boost, we first looked at the memory accuracy of the prime sentence. To examine whether this is the case, we examined how often the sentence produced in the memory task matched the sentence presented on the prime. A logistic mixed-effect model was fitted to the memory accuracy for the dative and passive data combined with the type (dative, passive) and order (canonical, non-canonical) crossed (Table 3). When reproducing the prime, participants will have a bias to use canonical order when they do not remember the original prime (canonical dative order is *ni-o* and canonical passive order is *ga-ni*), and therefore, the non-canonical order is a better measure of their ability to remember the structure that they saw on the prime. For the passive, there are two possible orders when both arguments are produced (*ga-ni* or *ni-ga*), so chance is 50%. To use the intercept to test whether memory for passive order was above chance, we used treatment coding to code type (dative=1, passive=0) and order (canonical=1, non-canonical=0). Random intercepts for participants and items were included, and the maximal model based on the data had no random slopes (Barr et al., 2013). Likelihood ratio tests using analysis of variance (ANOVA) were used to test for the effects of each term (*p*-values were based on chi-square, except for intercept which used Wald z-scores). In this article, results are reported in tables with the beta estimate, standard error, confidence interval, chi-square, degrees of freedom, and *p*-value (Table 3). Significant rows are marked with an asterisk symbol(*). Figures will use violin bar graphs, where the bar shows the average results for each combination of conditions, and the violin lines show the distribution of average results for participants (Figure 3).

The intercept in this model is not significant based on the z-score–based *p*-value and confidence interval, suggesting that the memory of the non-canonical passive order prime (*ni-ga*) was not above chance (Table 3). There was also a main effect of type, as dative accuracy was lower than 0.5 (Figure 3). There was a main effect of order and an interaction of type and order, which is due to the fact that non-canonical orders have lower accuracy, and this is especially true in datives. The lower accuracy in datives is expected as Japanese is a relatively-free word order language with at least six possible orders (*ga-ni-o*, *ga-o-ni*, *ni-ga-o*, *ni-o-ga*, *o-ga-ni*, *o-ni-ga*), and its accuracy is numerically higher than the dative chance level if these six orders were equally likely (17%). If performance was only based on the memory of the prime sentences, the accuracy for the non-canonical and canonical orders would be the same. The difference between them is due to the bias for using canonical order when the prime cannot be retrieved. The fact that passive and dative memory accuracy for non-canonical primes was near their respective chance levels demonstrates that explicit memory for the order of the prime was not strong.

The next analysis examined how dative priming and the boost was influenced by the memory task. The dependent measure was the production of the non-canonical order

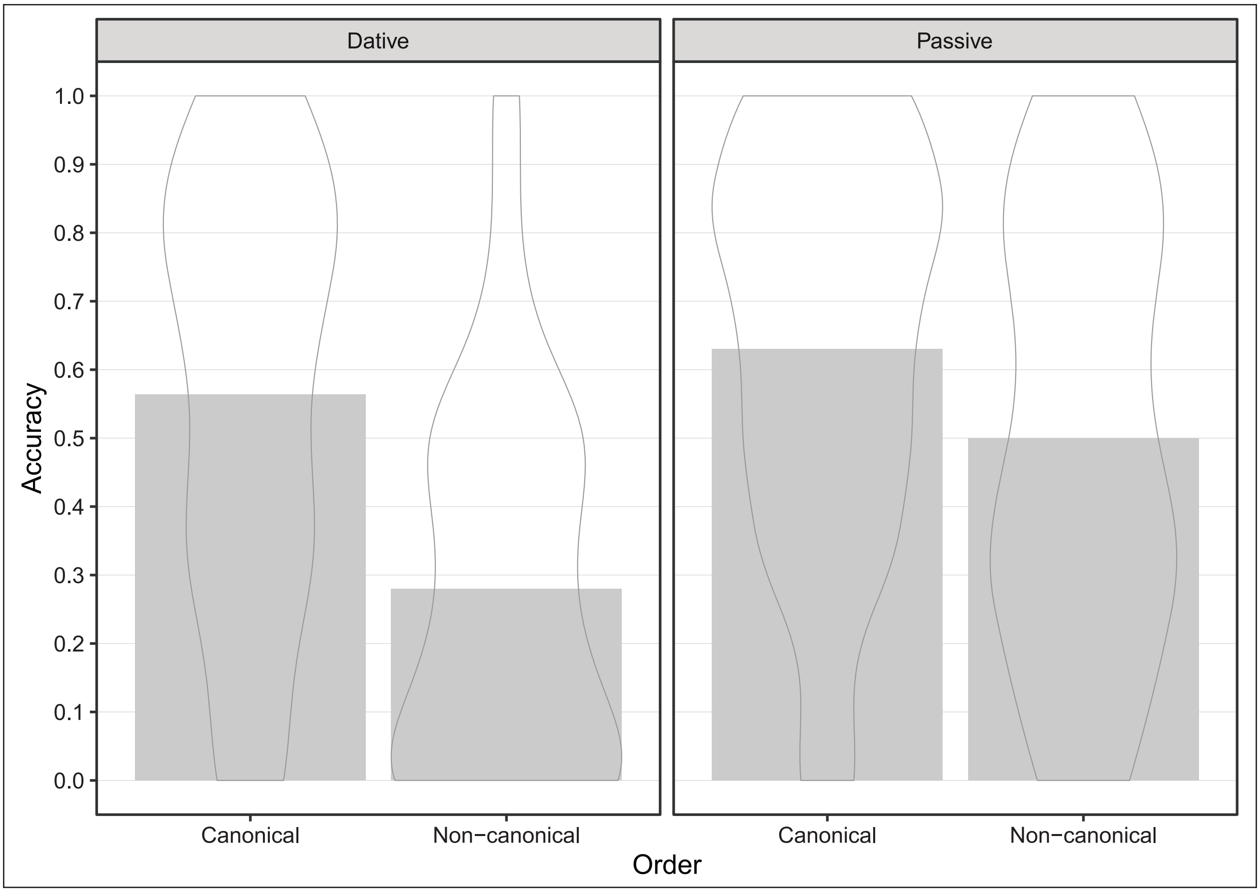

Figure 3. Memory accuracy for the prime for dative and passives for Exp. 1.

(ANga-INo-ANni-VERB = 1) relative to the canonical order (ANga-ANni-INo-VERB = 0, other forms were NA). A logistic mixed-effect model was fitted to the data with prime (*o-ni, ni-o*), verb overlap (same, different), and memory task (memory, no-memory) crossed (Table 4). For all the remaining models in this article, variables were sum coded. Random intercepts for participants and items were included, and the maximal model based on the data had no random slopes for either participants or items (Barr et al., 2013). Likelihood ratio tests using ANOVA were used to test for the effects of each term.

There was a main effect of priming, where *o-ni* orders were 14% more likely after *o-ni* primes than after *ni-o* primes (Figure 4). There was also an interaction of verb overlap and memory task, where *o-ni* production was higher for the different-verb condition than for the same-verb condition in the no-memory task, and the pattern was reversed in the memory task. All other main effects and interactions were non-significant. Critically, there was no lexical boost (interaction of verb overlap and prime, highlighted row in Table 4), and in fact, the estimate was negative, so the magnitude of priming in the same-verb condition was numerically smaller (14%) than the magnitude in the different-verb condition (15%). Thus, even if this interaction could be made significant, this anti-lexical boost effect would not support existing theories of the boost.

The second analysis examined priming in the passive construction. The dependent measure was the production of the non-canonical order (AGni-PAga-VERB = 1) relative to the canonical order (PAga-AGni-VERB = 0, other forms were NA). A logistic mixed-effect model was fitted to the data with prime (*ni-ga*, *ga-ni*), verb overlap (same, different), and memory task (memory, no-memory) crossed (Table 5). Random intercepts for participants and items were included, and the maximal model based on the data had no random slopes for either participants or items.

There was a main effect of priming, where *ni-ga* orders were 29% more likely after *ni-ga* primes than after *ga-ni* primes (Figure 5). All other main effects and interactions were non-significant. In particular, there was no lexical boost in this study (highlighted row in Table 5) although the magnitude of priming was slightly larger in the same-verb condition (31%) than that in the different-verb condition (26%). The violin plots are thinner in the no-memory condition than in the memory condition in the passive data (Figure 5). The violin plots are based on participant means, and the thinner bars are because some participants did not produce any direct-passive *ga-ni* or *ni-ga* structures out of the three chances for each combination of task, verb, and

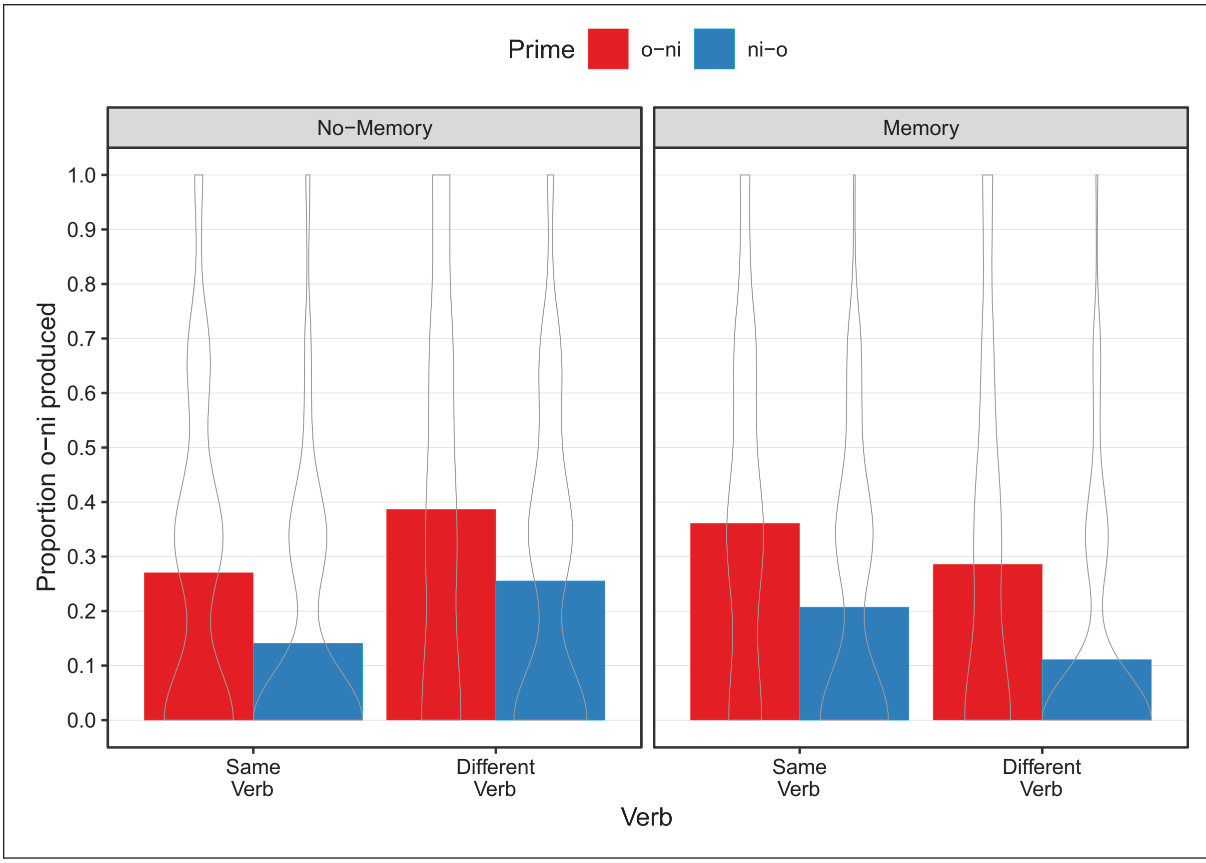

Figure 4. Production of o-ni datives by prime, verb overlap, and memory task for Exp. 1.

Table 4. Dative model with prime, verb overlap, and memory task crossed for Exp. 1 (the row related to the lexical boost is highlighted).

Terms	Beta	*SE*	lowCI	uppCI	Chisq	Df	*p*-value
Prime	.971	0.128	0.683	1.168	57	1	<.001*
Verb	−.097	0.126	−0.361	0.111	1	1	.306
Memory	−.129	0.126	−0.364	0.108	1.1	1	.293
Prime:Verb	−.061	0.252	−0.490	0.468	0.0018	1	.966
Prime:Memory	.127	0.252	−0.343	0.616	0.3	1	.582
Verb:Memory	1.476	0.253	0.932	1.902	33	1	<.001*
Prime:Verb:Memory	−.604	0.504	−1.592	0.385	1.4	1	.236

Significant rows are marked with an asterisk symbol(*).

prime. While seven participants did not produce these structures in the memory task, there were 17 participants in the no-memory conditions who did not produce these structures. In contrast, production of target dative structures was high with only one participant in the memory task and two participants in the no-memory conditions not producing the target structures.

The present study examined structural priming in Japanese datives and passives, and abstract priming was found for the linear order of case-marked arguments in both structures. The goal of the study was to examine the effect of explicit memory on the lexical boost, but for both datives and passives, a boost was not found. One possible explanation for the lack of a boost was the low accuracy in the participant's ability to explicitly remember the order of arguments of the prime in the memory task. Under the explicit memory account, the lexical boost is due to the cued recall of the prime in the verb overlap condition. If participants cannot accurately remember the prime, even when explicitly asked to do so, then there should be no lexical boost because the memory of the structure is too weak.

Most theories of the boost do not depend on explicit memory and instead predict a lexical boost due to automatic sentence-production mechanisms. Reitter et al.

Table 5. Passive model with prime, verb overlap, and memory task crossed for Exp. 1 (the row related to the lexical boost is highlighted).

Terms	Beta	*SE*	lowCI	uppCI	Chisq	Df	*p*-value
Prime	1.823	0.144	1.541	2.105	188	1	<.001*
Verb	.223	0.138	−0.015	0.503	3.4	1	.0658
Memory	.093	0.138	−0.188	0.329	0.28	1	.594
Prime:Verb	.153	0.275	−0.384	0.693	0.31	1	.577
Prime:Memory	−.121	0.275	−0.660	0.418	0.19	1	.663
Verb:Memory	−.204	0.275	−0.730	0.305	0.64	1	.423
Prime:Verb:Memory	−.057	0.550	−1.135	1.021	0.011	1	.918

Significant rows are marked with an asterisk symbol(*).

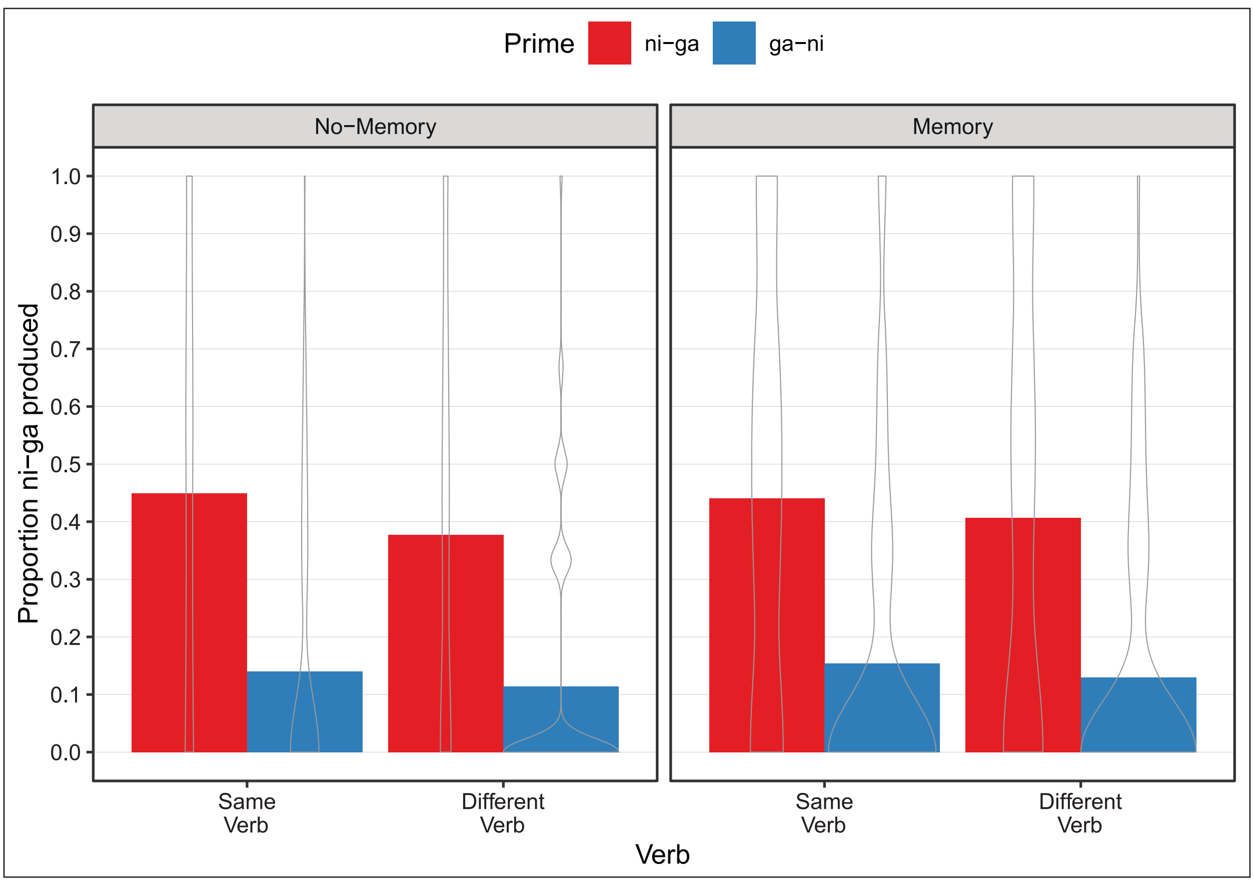

Figure 5. Production of ni-ga passives by prime, verb overlap, and memory task for Exp. 1.

(2011) argued through their model that abstract priming was due to base-level learning, and the lexical boost was due to associative learning of the link between the verb and the structure. Averaged over both double-object and prepositional datives, this model exhibited abstract priming of 5.9% and a lexical boost of 90.2% (see the OSF archive for details for this calculation). Thus, this associative learning mechanism predicts that the lexical boost should be about 15 times as big as abstract priming due to base-level learning. That prediction is at odds with the average lexical boost effect found in the meta-analysis by Mahowald et al. (2016), who argued that priming increased the use of a structure by 13% while priming with verb overlap increased it by 27% (boost is about two times as big as that in abstract priming, see also the developmental meta-analysis in the study by Kumarage et al., 2024). It is hard to imagine how the massive lexical boost predicted by associative learning would disappear in Japanese.

Another dual-mechanism account is the dynamic systems theory of priming by Malhotra et al. (2008). In this model, abstract priming is due to a long-term adaptation mechanism akin to Hebbian learning. To create the lexical boost, the model quickly binds verbs and structural nodes using a biologically-plausible neural mechanism that also causes the lexical boost to decay quickly. Since this model is based on universal biological/neural mechanisms of the human brain, it predicts that Japanese brains should also use these mechanisms to automatically create a lexical boost with verb overlap.

Several theories of the lexical boost make use of mechanisms similar to the residual activation mechanisms in the original Pickering and Branigan (1998) model (Carminati et al., 2019; Fukumura & Yang, 2024; Kantola et al., 2023). Although these theories differ from each other in various ways, they all argue that residual activation is automatically left in nodes and links as a side effect of sentence processing. Other theories like that of Momma (2023) adopt different linguistic assumptions but argue nonetheless that the representations that create the lexical boost (elementary trees) are required to produce a sentence. Although these theories do not specifically model verb-final languages like Japanese, there is no mechanism in these theories that could exhibit a boost in some Japanese studies (Deng et al., 2013; Jin et al., 2013), but not others (Deng & Nakamura, 2015), including the present study. In particular, all the aforementioned models predict that if participants, task, and stimuli are appropriate for exhibiting an abstract structural priming effect, then there should automatically be a lexical boost if a head verb overlaps between the prime and target. Thus, the lack of a lexical boost in Japanese appears to falsify the automatic residual activation assumptions of these theories.

Although the results appear to be at odds with several theories of the lexical boost, it is also the case that the results in this study were unexpected as the study was designed to look at the way explicit memory might influence the lexical boost. Thus, it is better to first replicate the results in a new study using methods that are closer to those used in previous studies of the lexical boost.

Experiment 2: Testing whether a lexical boost occurs in Japanese.

To provide a stronger test of whether Japanese has a lexical boost, we made several changes to the method used in Exp. 1. First, we removed the memory task because that task has not been used in previous English studies that have found the lexical boost. Second, we changed the task into a sentence-completion task that mimics the method used in the English study of the lexical boost by Pickering and Branigan (1998). In their study, the prime trials had a preamble like "The racing driver showed the torn overall" that would bias participants to write a prepositional dative sentence completion. Then the target trials would have a preamble like "patient showed" which allowed participants to write either a prepositional dative or a double-object structure. In our Japanese version, the dative prime trials could have a preamble with a *wa*-marked agent and a *ni*-marked recipient (e.g., *bengoshi wa jimuin ni*), which is biased for a *ni-o* completion, or an *o*-marked patient which is biased for an *o-ni* completion (e.g., *bengoshi wa riyuu o*). The target trials had just the *wa*-marked agent as a preamble (e.g., *shoujo wa*), and participants could use either *o-ni* or *ni-o* completions. In both prime and target, we showed the words that they should use in their completion, and since this included the verb, we could control whether the verb was overlapping between the prime and the target. Our method is similar to the random word array method in the English studies of Scheepers et al. (2017) and Carminati et al. (2019, Exp. 5). In addition, Deng et al. (2013) used a similar sentence-completion method with Japanese datives and found both abstract priming and a lexical boost.

Since the lack of a lexical boost is a null effect, it is important to ensure that we have enough power to find a lexical boost if it exists. To estimate the power for a lexical boost in Japanese, it is necessary to have an estimate for the coefficient of the boost, and here we adopt the same coefficient that was found in Exp. 1 for abstract priming. This implements the implicit assumption in the Pickering and Branigan (1998) account that the same amount of residual activation is left in nodes and links during spreading activation. Since the priming effect was smaller in the dative study in Exp. 1, we used this more conservative dataset for our power analysis. We fit a new logistic regression model with verb and prime crossed with random intercepts for subjects and items (no random slopes to reduce non-convergence in the power analysis). The model's interaction coefficient for the lexical boost was set to the same value as the model's coefficient for priming. Using the powerSim function in the simr library (Green & MacLeod, 2016), we evaluated the power level for this model for 80 participants. The analysis found a power level of 0.965, which means that we had sufficient power to find a lexical boost with 80 participants if the boost is due to the same mechanism as abstract priming. In addition, this power level is similar to the ones reported in the power analysis by Mahowald et al. (2016; their Figure 12). The coefficient of the boost in our simulation was 0.9268443, and they found that the simulated power level for 24 items and 80 participants for the coefficient of 1 was greater than 0.8.

We preregistered our assumptions for this test (https://osf.io/h7f6y). To ensure that participants were native speakers of Japanese, we required that participants had scores of 65% or above on the language and culture multiple-choice questions. To remove participants who were not engaging with the task, we required them to produce more than 50% target structures on the dative study.

Method

Participants. Recruited from the same Crowdworks site, we collected data from a new set of 84 participants. Although our power analysis only required 80 participants, an additional five participants were collected to replace any participants who were excluded due to our criteria. However, since

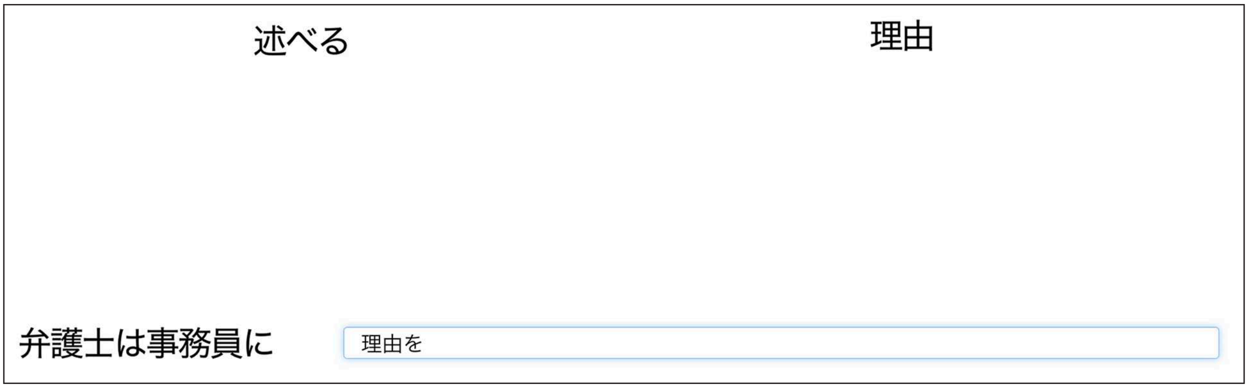

Figure 6. Prime sentence-completion task for Exp. 2.

no participants had language/culture scores less than 65% or target structure production scores of less than 50%, all participants were included in the data analysis except for one participant who did the study four times. Their ages ranged from 18 to 63 years (38 women, 46 men). Their highest educational degree varied from university (51), junior college (5), vocational school (7), and high school (21). The work was conducted with the formal approval of the Ethics Review Committee for Experimental Research with Human Subjects at Kobe City University of Foreign Studies.

Stimuli. The stimuli were mostly the same as those in Exp. 1, but some items were changed to make them more natural. Noun arguments were designed to be unique across all the items in the experiment. Verbs could be in present or past tense. Each target could have either the same or a different verb with the prime. The dative *ni-o* primes consisted of a two-argument preamble (e.g., *bengoshi wa jimuin ni*) and the remaining content elements (e.g., *riyuu*, *oshieta*). The *o-ni* prime consisted of the preamble (e.g., *bengoshi wa riyuu o*) and the remaining content elements (e.g., *jimuin*, *oshieta*). The dative target consisted of a one-argument preamble (e.g., *shoujo wa*) and the remaining content elements (e.g., *socchokuna iken, nobeta, tantei*). The *ga-ni* passive prime consisted of a one-argument preamble (e.g., *shinogenkou ga*) and the remaining content elements (e.g., *moyasareta, bungakuhyouronka*). The *ni-ga* passive prime consisted of a one-argument preamble (e.g., *bungakuhyouronka ni*) and the remaining content elements (e.g., *moyasareta, shinogenkou*). The passive target had no preamble, and participants just saw the content elements (e.g., *moyasareta, warugaki, niwakinoeda*).

Counterbalancing of the position of content words was done to reduce strategic effects. Content words were shown in two rows (top-left, top-right, bottom-left, bottom-right). For the dative target, the agent was presented in the preamble, and the other content elements were randomly placed into the four positions. For the dative prime, the preamble had the agent and either the patient or recipient, so the verb and the remaining argument were randomly placed into the top two positions. For the passive targets, the verb and the two arguments were randomly assigned to the four positions. For the passive primes, the verb and the argument that was not in the preamble were assigned randomly to the top two positions.

Procedure. The prime and target trials both use a sentence-completion methodology (Figure 6). Participants were shown a preamble (e.g., *bengoshi wa jimuin ni*) and the content words for the sentence they should write (e.g., *riyuu*, *nobeta*). They were asked to complete the preamble making a sentence with the given words as well as any function elements like particles that were needed. The preamble was shown on the lower left part of the screen, and next to it was a text box where the participant could complete the sentence. Above the text box were the two rows for the arguments that should be used in their sentence.

At the top of the page, instructions were provided to remind participants that they should complete the sentence with the words on the screen and to press Enter to go to the next trial. After each target task, the participants answered a multiple-choice language and culture question. The experiment was done in full-screen in the Gorilla online system (www.gorilla.sc). The system required participants to use a computer in Japan.

Coding. The target sentences typed by the participants were coded for their structure using search and replace rules. Since participants typed their responses, we accepted changes related to the arguments. Participants sometimes used shortened descriptions or changed the written form. Incorrect but phonologically related forms were treated as spelling errors and also coded as correct forms. The topic particle *wa* was converted into the subject particle *ga* as both these forms are commonly exchanged. Since the lexical boost depends on overlap in verb lemmas, we did not allow any changes to verbs except for changes in tense/aspect/politeness-related morphology.

For the dative items, we coded the arguments in terms of animacy of the argument (allowing changes of agent and recipient). Participants produced the canonical *ni-o* order (ANga-ANni-INo-VERB) 1,271 times, and the

Table 6. Dative model with prime and verb overlap crossed in Exp. 2 (the row related to the lexical boost is highlighted).

Terms	Beta	SE	lowCI	uppCI	Chisq	Df	p-value
Prime	.688	0.113	0.466	0.907	38	1	<.001*
Verb	−.079	0.112	−0.292	0.143	0.44	1	.506
Prime:Verb	.096	0.223	−0.341	0.534	0.18	1	.669

Significant rows are marked with an asterisk symbol(*).

non-canonical *o-ni* order (ANga-INo-ANni-VERB) for 549 times. There were 196 other forms, which included omissions, non-target scrambled structures, noun phrases, and errors.

For the passive items, a similar process was used, but we coded the arguments based on their thematic role in our original stimuli (AG = agent, PA = patient). The most common responses were the canonical passive form PAga-AGni-VERB which was produced 822 times, and the scrambled version AGni-PAga-VERB, which was produced 223 times. Participants also produced indirect passive forms without a *ga*-marked subject (AGni-PAo-VERB, 577 times, PAo-AGni-VERB, 126 times) and forms without a *ni*-marked agent (AGga-PAo-VERB, 44 times, PAo-AGga-VERB 4 times). In addition, there were 220 other forms that included role reversals, omissions, noun phrases, and some errors. All codings were checked by a native Japanese speaker (the second author) while blind to the prime and verb overlap conditions for each form.

Results

The first analysis examined how dative priming was influenced by the lexical boost. The dependent measure was the production of the non-canonical order (ANga-INo-ANni-VERB = 1) relative to the canonical order (ANga-ANni-INo-VERB = 0, other forms were NA). A logistic mixed-effect model was fitted to the data with prime (*o-ni, ni-o*) and verb overlap (same, different) crossed (Table 6). Random intercepts for participants and items were included, and the maximal model based on the data had no random slopes for either participants or items.

As can be seen in Figure 7, there was a main effect of priming (12%), but no interaction of verb and prime (highlighted row in Table 6, the same-verb condition priming of 13% was numerically higher than the different-verb condition priming of 11%). The lack of a lexical boost replicates the dative results from Exp. 1 in a free writing paradigm.

The second analysis examined passive priming. The dependent measure was the production of the non-canonical order (AGni-PAga-VERB = 1) relative to the canonical order (PAga-AGni-VERB = 0, other forms were NA). A logistic mixed-effect model was fitted to the data with prime (*ga-ni, ni-ga*) and verb overlap (same, different) crossed (Table 7). Random intercepts for participants and items were included, and the maximal model based on the data had no random slopes for either participants or items.

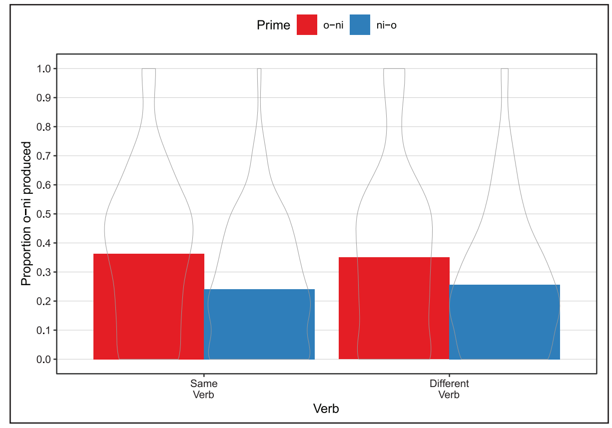

Figure 7. Production of o-ni datives by prime and verb overlap in Exp. 2.

Table 7. Passive model with prime and verb overlap crossed in Exp. 2 (the row related to the lexical boost is highlighted).

Terms	Beta	SE	lowCI	uppCI	Chisq	Df	p-value
Prime	.364	0.168	0.011	0.664	3.9	1	.047*
Verb	.374	0.167	0.067	0.715	5.4	1	.0197*
Prime:Verb	−.293	0.331	−0.942	0.355	0.76	1	.384

Significant rows are marked with an asterisk symbol(*).

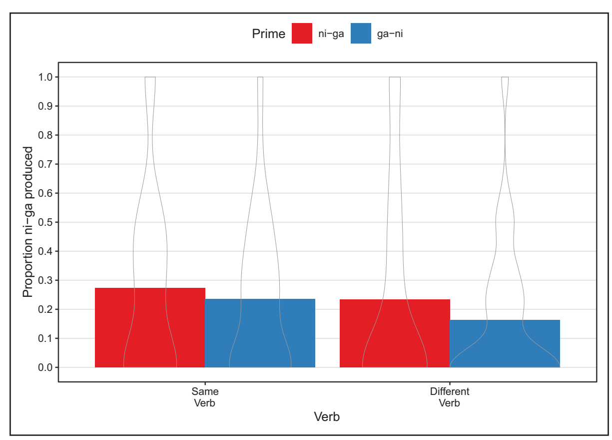

Figure 8. Production of ni-ga passives by prime and verb overlap in Exp. 2.

There was a main effect of prime, where *ni-ga* orders were 4% more common after *ni-ga* primes than after *ga-ni* primes (Figure 8). There was also a main effect of verb, where the *ni-ga* order was more common after same-verb primes than after different-verb primes. As in Exp. 1, there was no lexical boost (highlighted row in Table 7). Numerically, priming was greater in the different-verb condition (6%) than in the same-verb condition (2%). This anti-lexical boost effect means that even with enough power to make this effect significant, this result would still be difficult to explain within existing theories.

Table 8. Dative model with prime, verb overlap, and experiment crossed for combined Exp. 1 and Exp. 2 data (the row related to the lexical boost is highlighted).

Terms	Beta	*SE*	lowCI	uppCI	Chisq	Df	*p*-value
Prime	.797	0.105	0.558	0.927	63	1	<.001*
Verb	−.453	0.104	−0.476	−0.112	9.9	1	.00169*
Exp	.316	0.208	−0.134	0.667	1.7	1	.193
Prime:Verb	.159	0.207	−0.254	0.479	0.36	1	.55
Prime:Exp	−.206	0.208	−0.563	0.236	0.64	1	.423
Verb:Exp	.746	0.208	0.334	1.139	13	1	<.001*
Prime:Verb:Exp	−.126	0.414	−0.938	0.686	0.092	1	.762

Significant rows are marked with an asterisk symbol(*).

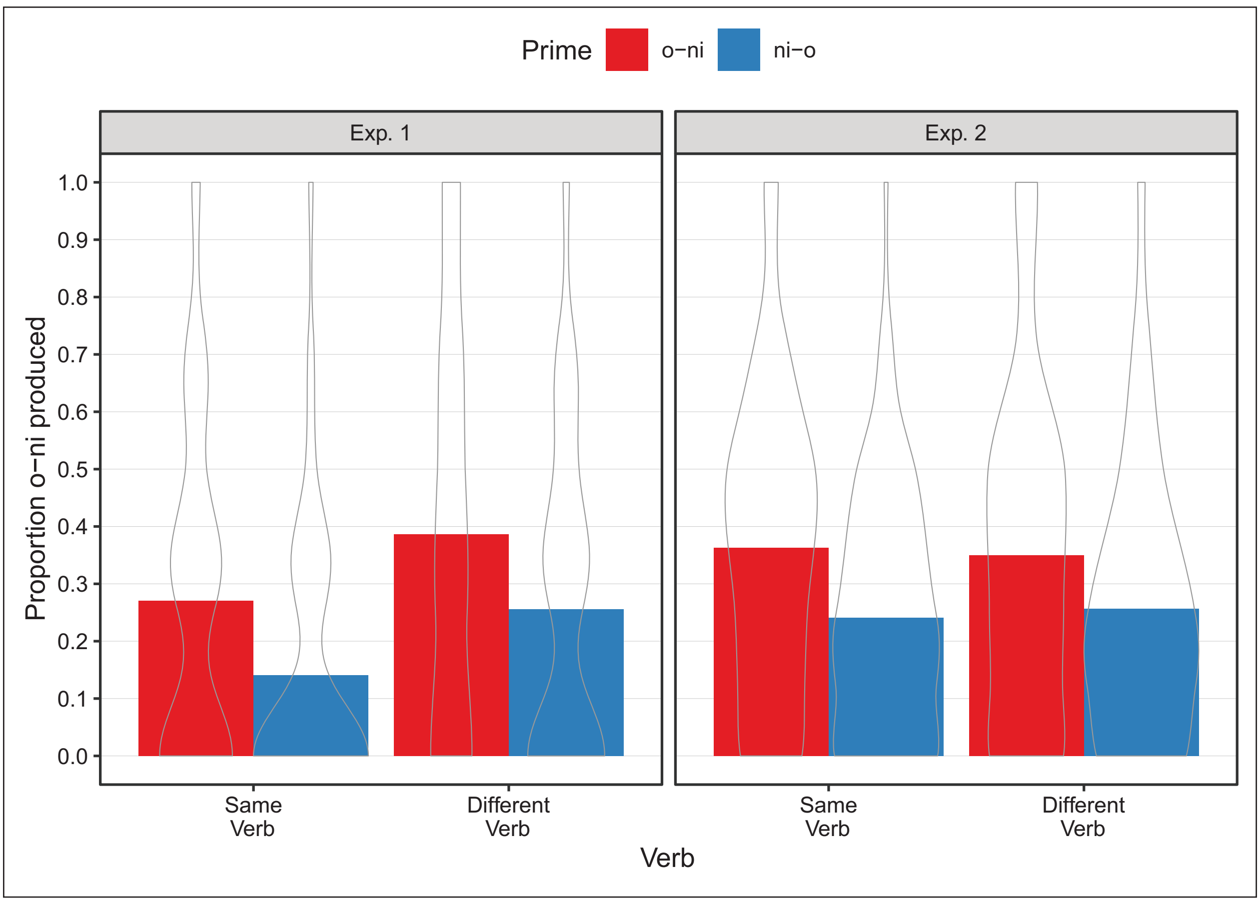

Figure 9. Production of o-ni datives by prime, verb overlap, and experiment for combined data of Exp. 1 and Exp. 2.

Combined analysis

In two studies, no lexical boost was found in Japanese. Since this is a null effect, it is useful to combine the data for both studies, which should increase the power to find a significant lexical boost effect. Since Exp. 2 did not have a memory condition, we combined the data from that experiment with the no-memory condition from Exp. 1. A logistic mixed-effect model was fitted to the dative data with prime (*o-ni, ni-o*), verb overlap (same, different), and experiment (Exp. 1, Exp. 2) crossed (Table 8). Random intercepts for participants and items were included, and the maximal model based on the data had no random slopes for either participants or items.

There was a main effect of priming where *o-ni* orders were 13% more common after *o-ni* primes (Figure 9). There was also a main effect of verb overlap where *o-ni* orders were less common in the same-verb condition, but this is modulated by a verb by experiment interaction, where *o-ni* orders were less common in the same-verb condition in Exp. 1 than in Exp. 2. Numerically, priming was greater in the same-verb condition (13%) than in the

Table 9. Passive model with prime, verb overlap, and experiment crossed for combined Exp. 1 and Exp. 2 data (the row related to the lexical boost is highlighted).

Terms	Beta	*SE*	lowCI	uppCI	Chisq	Df	*p*-value
Prime	1.115	0.134	0.760	1.249	66	1	<.001*
Verb	.345	0.131	0.129	0.608	8.9	1	.00279*
Exp	−.133	0.232	−0.638	0.241	0.76	1	.382
Prime:Verb	−.063	0.260	−0.605	0.352	0.26	1	.608
Prime:Exp	−1.521	0.266	−2.064	−1.026	36	1	<.001*
Verb:Exp	.050	0.261	−0.491	0.527	0.0049	1	.944
Prime:Verb:Exp	−.463	0.521	−1.484	0.557	0.79	1	.375

Significant rows are marked with an asterisk symbol(*).

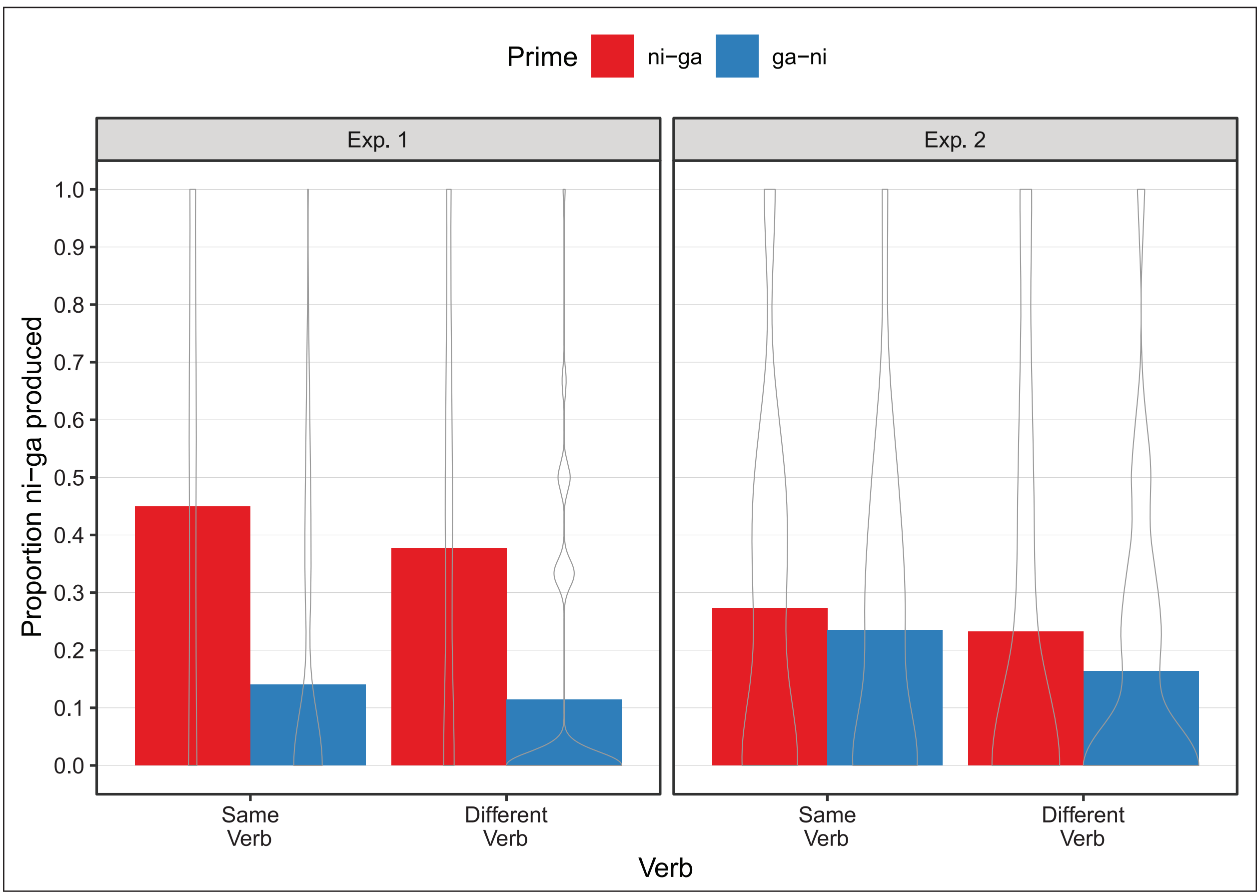

Figure 10. Production of ni-ga passives by prime, verb overlap, and experiment for combined Exp. 1 and Exp. 2 data.

different-verb condition (12%), but this verb by prime interaction was not significant (highlighted row in Table 8), so there was no lexical boost in the combined dataset.

We also examined the use of *ni-ga* orders with passive verbs. A logistic mixed-effect model was fitted to the passive data with prime (*ga-ni, ni-ga*), verb overlap (same, different), and experiment (Exp. 1, Exp. 2) crossed (Table 9). Random intercepts for participants and items were included, and the maximal model based on the data had no random slopes for either participants or items.

There was a main effect of priming where *ni-ga* orders were 15% more common after *ni-ga* primes (Figure 10), but this is modulated by a prime by experiment interaction, where this priming effect was smaller in Exp. 2 (4%) than in Exp. 1 (29%). This interaction was not seen in the dative data, so the passive items were more sensitive to the differences in the procedure in the two studies. One reason for this difference in passives is that participants produced more indirect passives in typing than in button-pressing, and this meant that there was a greater loss of trials in Exp. 2 (48%)

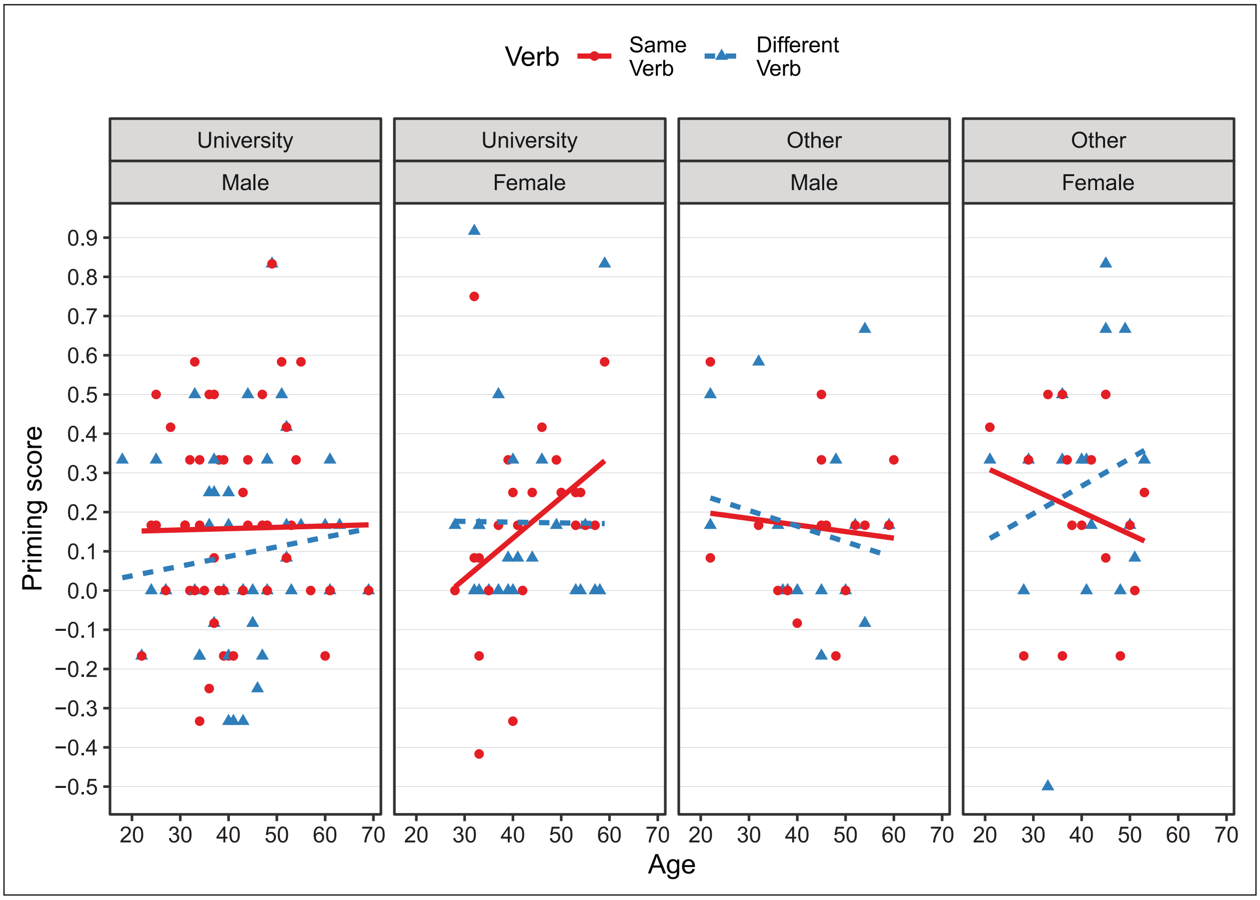

Figure 11. Priming score by verb overlap, age, gender, and university status in combined data of Exp. 1 and Exp. 2.

than in Exp. 1 (19%). In contrast for datives, non-target trials were only slightly higher for typing (10%) than those for button-pressing (6%). There was also a main effect of verb overlap where *ni-ga* orders were more common in the same-verb condition. Overall, there was numerically more priming in the same-verb condition (16%) than in the different-verb condition (15%). However, there was no interaction of prime and verb (highlighted row in Table 9), and therefore, there was no lexical boost with passives in the combined dataset.

While most previous studies of the lexical boost used university student samples, the present studies used data collected from participants over the internet. Lexical boost effects have been found in online studies (Momma, 2023), but it is not known if participant variables influence priming. To examine whether these factors impacted the results, an exploratory analysis was performed using participant variables of age (18–69 years), gender, and whether they had attended a 4-year university. For each participant, we calculated their mean proportion of the target structure for each prime- and verb-overlap condition crossed separately for datives and passives. We computed a priming score by subtracting the different-prime condition proportion from the same-prime condition proportion for both same and different verbs. We averaged the mean priming score for datives and passives together for each level of overlap. Some participants did not produce target structures for one cell, and hence, it was not possible to compute their priming scores, so these participants were excluded (there were 127 participants remaining). Figure 11 shows priming scores by age separated by gender and university status.

A regression model was applied to predict priming scores based on age, gender, and university status (centred or sum coded). There were no main effects, and interactions were significant, which suggests that for the most part, priming is not that sensitive to participant variables across a wide range of online participants.

Another exploratory analysis was done to look at the time spent writing the target sentence. The time to produce the target might be important because it is known that the lexical boost can dissipate quickly, and therefore, a lexical boost may only be present in the fastest trials. To examine this issue, reaction times for each trial were log-transformed to remove the skew in the data, and outlier log reaction times that were two standard deviations above or below the mean for each experiment and type were removed (the data set had 7,426 trials after filtering).

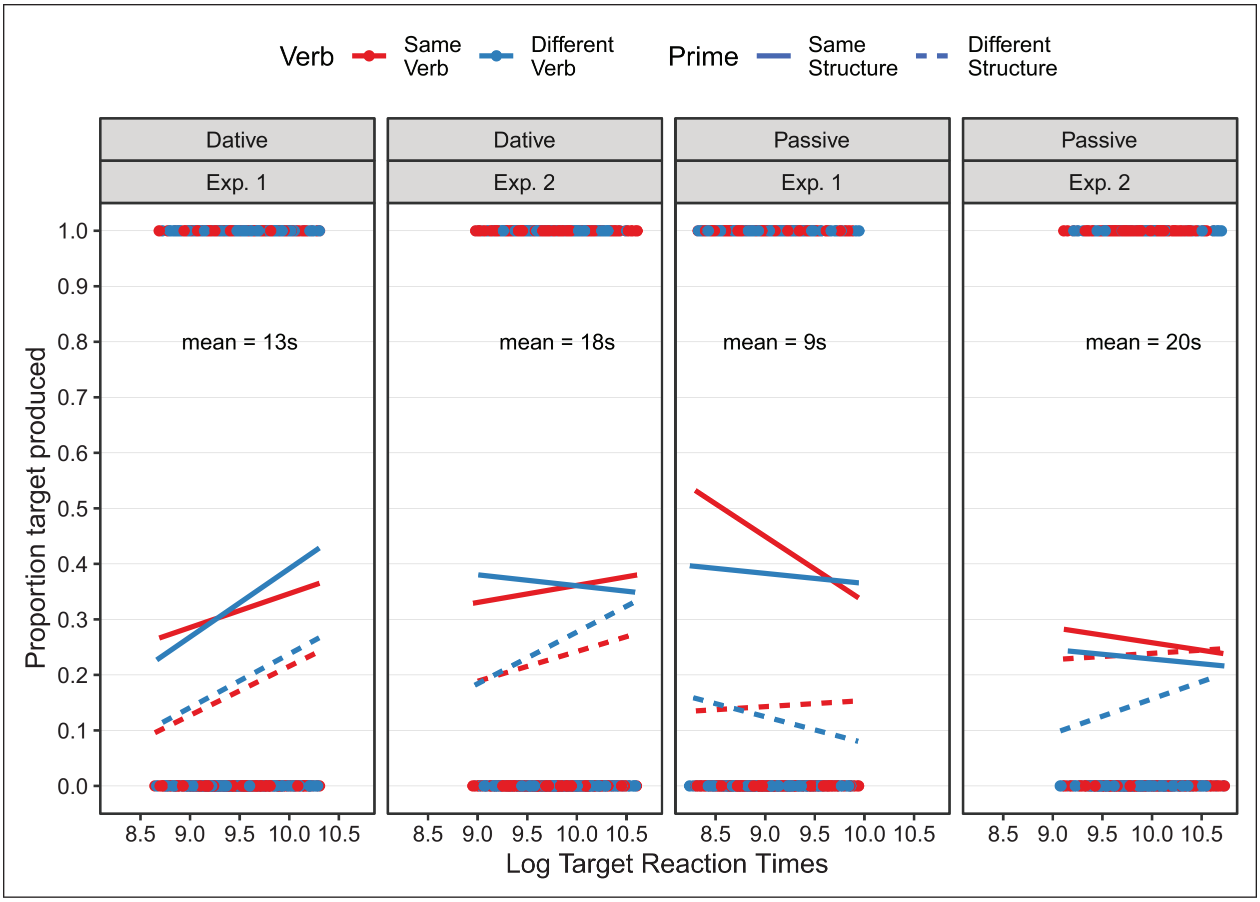

Figure 12. Production of target by prime, verb overlap, and log target reaction time in combined data of Exp. 1 and Exp. 2.

Figure 12 shows the proportion of the target structures on the y-axis and the log reaction time on the x-axis. Individual data points are shown by points on 0 or 1 on the y-axis, and these points were used to fit regression lines for prime and verb overlap.

While Figure 12 shows the difference in the log reaction time across the sentence types and experiments, it is more informative to remove task-specific and structure-specific variation from the data to see how variation in the time to respond was related to priming. Thus, the log reaction times were centred separately for dative and passives in each experiment. A logistic regression model was fitted to the target structure produced with centred log reaction time, prime, and verb overlap crossed. In terms of interactions with log reaction time, there was an interaction with prime ($\beta=-.51$, $SE=0.202$, $z=-2.5$, $p=.011$), which means that priming was reduced when participants took longer to write the target sentence. There was also a four-way interaction of log reaction time, prime, verb overlap, and experiment ($\beta=-1.65$, $SE=0.808$, $z=-2$, $p=.041$), which is due to the fact that there appears to be a lexical boost in the fast reaction times for Exp. 1, but this effect weakens and reverses as participants take longer in that study.

A similar analysis was done using the reaction times to produce the prime. The same process to log transform and filter the data was applied to the prime reaction times (the dataset had 7,486 trials after filtering). Figure 13 shows the proportion of the target structures produced for different log prime reaction times.

A logistic regression model was fitted to the structure produced with centred log prime reaction time (separately for each study and sentence type), prime, and verb overlap crossed. There was no main effects or interactions with centred log reaction time, so the time spend on writing the prime did not seem to influence priming on the target.

These exploratory analyses provide some useful data points for designing future studies. The participant analysis suggested that the large variation in age and education in online studies did not strongly influence priming. In general, the button-pressing task seems to have several advantages such as greater passive priming and less data loss. This task also exhibited a trend towards a lexical boost in participants who responded quickly on the target, so future studies should test and confirm that result. Since the participants who were slow to produce the target exhibited an apparent anti-lexical boost, this mixed pattern is consistent with the overall lack of a lexical boost that was

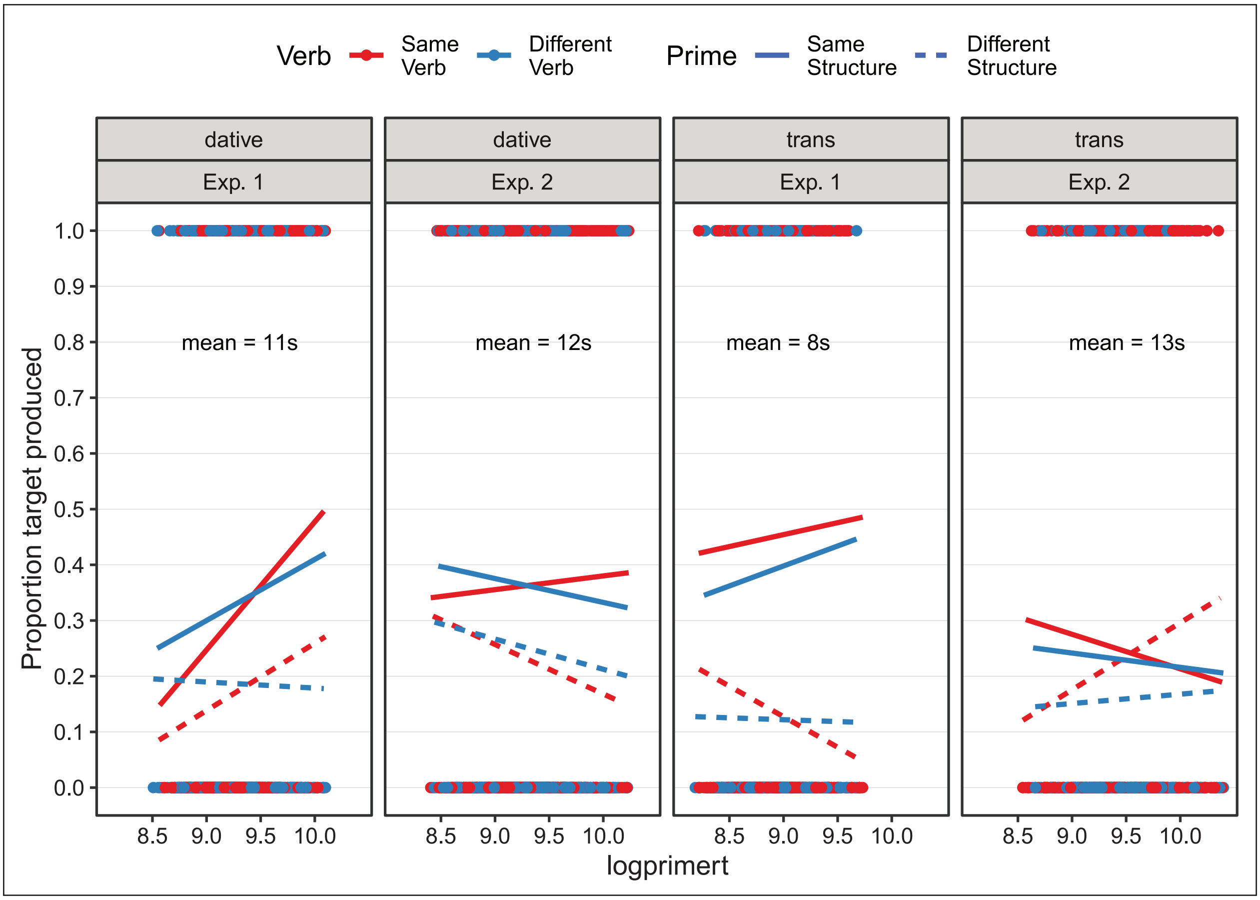

Figure 13. Production of target by prime, verb overlap, and log prime reaction time in combined data of Exp. 1 and Exp. 2.

found even with the greater power provided by the combined analysis.

Discussion

Some theories of structural priming argue that the lexical boost is an automatic product of the mechanisms of sentence production (Pickering & Branigan, 1998), while other theories suggest that it is due to an optional mechanism such as explicit memory (Chang et al., 2012). To contrast these theories in our first study, we manipulated memory while testing structural priming and the lexical boost in Japanese. We found a priming effect in datives and passives, but there was no lexical boost effect, and this meant that it was not possible to examine the role of explicit memory in the boost. The second study focused on the lexical boost using a preamble completion method that was similar to English studies that have found a lexical boost. Here again, we found abstract priming, but no lexical boost.

Since the lack of a lexical boost in both studies is a null effect, it is critical to ensure that we had sufficient power to find a significant effect. For the second study, a power analysis was done on the assumption that the lexical boost was supported by the same residual activation mechanisms and parameters as abstract priming. That analysis suggested that there was sufficient power in Exp. 2 to find a significant effect. Furthermore, a lexical boost effect was not found in two separate attempts (dative, passive) with the combined dataset of 162 participants. Finally, dative priming in Exp. 1 and passive priming in Exp. 2 exhibited anti-lexical boost patterns. With greater power, these patterns could become significant, but the direction of the effect would still argue against theories that predict positive lexical boost effects.

The lack of a lexical boost in a study with abstract priming is at odds with theories where the same residual activation mechanism supports abstract structural priming and the lexical boost (Pickering & Branigan, 1998). While other theories have proposed changes to these mechanisms (Carminati et al., 2019; Fukumura & Yang, 2024; Kantola et al., 2023; Malhotra et al., 2008; Momma, 2023; Reitter et al., 2011), these theories would still predict priming and a lexical boost for the conditions in our studies (overlapping verbs). In general, as long as the task, stimuli, and participants are appropriate to create abstract priming, these theories predict that a lexical boost will occur with overlapping syntactic heads. These theories do not provide

Table 10. Summary of studies without a lexical boost (highlighted rows) and related studies.

Study	Type	Modality	Language	Features	Priming	Boost
Jin et al. (2013)	Transitive	Spoken	Japanese	Picture description, Function assignment	Yes	Yes
Deng and Nakamura (2015)	Transitive	Spoken	Japanese	Picture description, Linearisation	Yes	No
Deng et al. (2013)	Dative	Spoken	Japanese	Sentence completion, Linearisation	Yes	Yes
Chang et al. (2022)	Dative	Written	Japanese	Sentence completion, Exp. 2, Linearisation	Yes	No
Hartsuiker et al. (2008)	Dative	Spoken	Dutch	Exp. 4, Lag 0, Session 1	Yes	Yes
Hartsuiker et al. (2008)	Dative	Written	Dutch	Exp. 4, Lag 0, Session 1	Yes	Yes
Hartsuiker et al. (2008)	Dative	Spoken	Dutch	Exp. 4, Lag 0, Session 2	Yes	Yes
Hartsuiker et al. (2008)	Dative	Written	Dutch	Exp. 4, Lag 0, Session 2	Yes	No
Chang et al. (2015)	Dative	Spoken	German	Prime verb second	Yes	Yes
Chang et al. (2015)	Dative	Spoken	German	Prime verb final	Yes	No

a mechanism that can change the lexical boost based on language or task features.

Previous Japanese studies have found lexical boost effects in datives (Deng et al., 2013) and transitives (Jin et al., 2013). These studies, as well as most previous Japanese priming studies, use an oral picture description task, which is different from the button-clicking writing method in Exp. 1 or the typing sentence-completion method in Exp. 2. While it is possible that the written modality played a role in the lack of a lexical boost effect in the present studies, Deng and Nakamura (2015) used an oral picture description paradigm, but they did not find a lexical boost in Japanese. Furthermore, studies in English and other languages have found similar priming effects in spoken and written tasks (Cleland & Pickering, 2006; Hartsuiker et al., 2008; Hartsuiker & Westenberg, 2000), and therefore, theories of priming do not make strong claims about the role of modality on priming. While the lexical boost appears in both written and spoken studies, it appears to be more variable in written tasks. In their Exp. 4, Hartsuiker et al. (2008) examined how priming and lexical boost might change over lag in separate spoken/written sessions. In contrast to the lexical boost in Session 1, Session 2 exhibited a lexical boost in the spoken modality, but not the written modality (there they found an anti-lexical boost pattern for lag 0 and lag 2). While it seems that the relationship between modality and priming is not strong, modality may be a factor that can add variability to the lexical boost.

Another feature that might be important for the boost is the position of the verb at the end of the sentence in Japanese. In incremental accounts of Japanese sentence production (Chang, 2009), structural choices are often made at a choice point, which is the position in a sentence where the two structures diverge. In the dative alternation *ga-ni-o* and *ga-o-ni*, the choice point would be the choice of the argument after the ga-marked subject. However, some studies find lexical boost effects in Japanese (Deng et al., 2013; Jin et al., 2013) and other verb-final languages like Basque (Santesteban et al., 2015), which suggests that verb-final position does not block lexical boost effects. In languages like German where verbs can appear before or after the choice point, it has been found that verb overlap in verb-final position does not create a boost in verb-second target descriptions (Chang et al., 2015). Thus, verb position may also be a factor that influences the lexical boost.

Another possible factor is that the present study examined alternations that varied in the linear order of phrases (scrambling). Deng and Nakamura (2015) did not find a lexical boost when testing priming with linearisation of phrases in transitives (*ga-o* vs *o-ga*), but in a similar study, Jin et al. (2013) found a lexical boost when using changes in function assignment (active *ga-o* vs passive *ga-ni*). However, no large differences between function assignment and linearisation in priming have been found in studies in English (Pickering et al., 2002), and Deng et al. (2013) found abstract priming and boost with Japanese datives that only differed in the linear order of phrases. Furthermore, Garcia et al. (2023) found abstract priming and a lexical boost in Tagalog using a transitive alternation that differed in the linear order of the arguments, but only when its voice matched the voice of the target verb. Thus, priming of linear order can be boosted by overlap in verbs, but it may be weaker than the effect in studies that use function assignment.

As mentioned earlier, there are several tasks and languages that have exhibited abstract priming without a lexical boost. For many of these studies, there are conditions in the same study or similar studies that do find the boost, which suggests that the problem is not simply a lack of power. This is summarised in Table 10 where studies that did not find a boost (highlighted in grey) are preceded by similar studies that did find a boost. Jin et al. (2013) found a boost in Japanese, while Deng and Nakamura (2015) did not in a similar study, and this suggested that the boost may be weaker for linearisation processes. However, Deng et al. (2013) found a lexical boost in the dative alternation, which suggests that boost effects can appear with alternations that only differ in linear order. In contrast to that study, in our dative priming study in Exp. 2, we did not find a boost in a written sentence-completion study, which suggests that modality may be a factor. Hartsuiker et al. (2008) did find a lexical boost in writing in Session 1 of their Exp. 4, but not in Session 2, which suggests that factors related to the session (e.g., fatigue) could be important. However, they did find a lexical boost in a spoken task for both sessions, so any session effects would need to depend on modality. Furthermore, in a study with one session, Chang et al. (2015) did not find a lexical boost when the prime verb was in verb-final position, but they did find a boost when the prime verb was in verb-second position. Since all these studies found abstract priming, the variation in the lexical boost suggests that it may be more susceptible to factors like modality, function assignment/linearisation, session, and verb position.

The greater variability in the boost is more compatible with the way that multiple factors can influence explicit memory as opposed to the automatic mechanisms that support spreading activation (Hartsuiker et al., 2008). In explicit memory accounts, the overlapping verb in the target is a memory cue that can remind the participant of the prime (Chang et al., 2012; Zhang et al., 2020). However, explicit retrieval of the prime is effortful and may depend on the participant's motivation and working-memory resources. This study provided some evidence that explicit memory could play a role in explaining the difference in the lexical boost across languages. In Exp. 1, we found that memory for non-canonical word order in Japanese primes was weak (dative 27%, passive 50%). This means that even if our participants retrieved the prime from explicit memory, that memory might not have a strong trace of the structural information and that could explain why it did not create a lexical boost. In contrast, Dutch speakers show higher explicit memory for the prime, even at lag 6 (dative 68.2%, passives 71.9%; Bernolet et al., 2016), which suggests that there may be differences in Western languages that support memory for the structure of the prime (e.g., function assignment). Thus, the lack of a lexical boost in this study and the robust lexical boost effects in English and Dutch might be related to the ease of explicitly remembering the prime structure in each language.

The explicit memory literature provides some hints about how multiple factors can influence the boost. Research has shown that explicit memory for words and sentences is influenced by reader goals (Van Den Broek et al., 2001) and emotional moods (Storbeck & Clore, 2005), which suggest that these motivational factors could influence the boost. There is evidence that explicit memory for word lists is weaker when tested in a written versus spoken output modality (Tattersall & Broadbent, 1991), which may account for some of the differences due to modality in the boost. Furthermore, list memory is better when memory cues occur before the list relative to cues that occur after the list (Horton & Petruk, 1980), which may help to explain the more robust evidence for the boost in languages with verbs in earlier positions. In children, implicit memory is relatively stable, while explicit memory develops substantially due to the greater use of strategies and metamemory (Murphy et al., 2003), and these changes in explicit memory could help to explain the variability in the lexical boost in development (Donnelly et al., 2024; Kholodova et al., 2023; Kumarage et al., 2022; Peter et al., 2015; Rowland et al., 2012). While the explicit memory account of the lexical boost is underspecified compared to theories that argue it is an automatic outcome of overlap in syntactic heads, one advantage is that it is a mechanism with a large neural and behavioural literature, as opposed to a specialist account that is designed to explain one linguistic phenomenon.

The lexical boost is an intuitive phenomenon in sentence production. It is necessary to activate verbs and structures to produce sentences, and it is natural to imagine that residual activation is left in verb-structure links, which can create a lexical boost. Thus, it is surprising to find several studies including the present one which do not exhibit the boost. All these studies were carried out in languages other than English, and perhaps that was part of the reason that the ramifications of the lack of a boost for production theory were not recognised. If a robust and motivated effect like the lexical boost is not found in every language, then there may be other intuitive theoretically-motivated psycholinguistic phenomena that are also not universal. If that is true, it has important implications for how language-specific learning can change the nature of language processing.

Author contributions

Author roles were classified using the Contributor Role Taxonomy (CRediT; https://credit.niso.org/) as follows: Franklin Chang—conceptualisation, investigation, formal analysis, funding acquisition, writing–original draft, and writing–review & editing. Saki Tsumura—conceptualisation, investigation, writing–original draft, and writing–review & editing

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was supported by grants 19K12733, 23K00488, and 20H01263 from the Japanese Society for the Promotion of Science.

ORCID iD

Franklin Chang https://orcid.org/0000-0003-1142-1911
Saki Tsumura https://orcid.org/0009-0008-7761-5077

References

Anwyl-Irvine, A. L., Massonnié, J., Flitton, A., Kirkham, N., & Evershed, J. K. (2020). Gorilla in our midst: An online behavioral experiment builder. *Behavior Research Methods*, *52*(1), 388–407. https://doi.org/10.3758/s13428-019-01237-x

Arai, M. (2012). What can head-final languages tell us about syntactic priming (and vice versa)? *Language and Linguistics Compass*, *6*(9), 545559. https://doi.org/10.1002/lnc3.353

Arai, M., & Mazuka, R. (2014). The development of Japanese passive syntax as indexed by structural priming in comprehension. *Quarterly Journal of Experimental Psychology*, *67*(1), 60–78. https://doi.org/10.1080/17470218.2013.790454

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

Bernolet, S., Collina, S., & Hartsuiker, R. J. (2016). The persistence of syntactic priming revisited. *Journal of Memory and Language*, *91*, 99–116. https://doi.org/10.1016/j.jml.2016.01.002

Bock, K. (1986). Syntactic persistence in language production. *Cognitive Psychology*, *18*(3), 355–387. https://doi.org/10.1016/0010-0285(86)90004-6

Bock, K. (1989). Closed-class immanence in sentence production. *Cognition*, *31*(2), 163–186. https://doi.org/10.1016/0010-0277(89)90022-X

Bock, K., Dell, G. S., Chang, F., & Onishi, K. H. (2007). Persistent structural priming from language comprehension to language production. *Cognition*, *104*(3), 437–458. https://doi.org/10.1016/j.cognition.2006.07.003

Bock, K., & Griffin, Z. M. (2000). The persistence of structural priming: Transient activation or implicit learning? *Journal of Experimental Psychology: General*, *129*(2), 177–192. https://doi.org/10.1037/0096-3445.129.2.177

Bock, K., & Levelt, W. J. M. (1994). Language production: Grammatical encoding. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 945–984). Academic Press.

Bock, K., & Loebell, H. (1990). Framing sentences. *Cognition*, *35*(1), 1–39. https://doi.org/10.1016/0010-0277(90)90035-I

Branigan, H. P., & McLean, J. F. (2016). What children learn from adults' utterances: An ephemeral lexical boost and persistent syntactic priming in adult-child dialogue. *Journal of Memory and Language*, *91*, 141–157. https://doi.org/10.1016/j.jml.2016.02.002

Carminati, M. N., van Gompel, R. P. G., & Wakeford, L. J. (2019). An investigation into the lexical boost with nonhead nouns. *Journal of Memory and Language*, *108*, 104031. https://doi.org/10.1016/j.jml.2019.104031

Chang, F. (2009). Learning to order words: A connectionist model of heavy NP shift and accessibility effects in Japanese and English. *Journal of Memory and Language*, *61*(3), 374397. https://doi.org/10.1016/j.jml.2009.07.006

Chang, F., Baumann, M., Pappert, S., & Fitz, H. (2015). Do lemmas speak German? A verb position effect in German structural priming. *Cognitive Science*, *39*(5), 1113–1130. https://doi.org/10.1111/cogs.12184

Chang, F., Dell, G. S., & Bock, K. (2006). Becoming syntactic. *Psychological Review*, *113*(2), 234272. https://doi.org/10.1037/0033-295X.113.2.234

Chang, F., Janciauskas, M., & Fitz, H. (2012). Language adaptation and learning: Getting explicit about implicit learning. *Language and Linguistics Compass*, *6*(5), 259–278. https://doi.org/10.1002/lnc3.337

Chang, F., Tsumura, S., Minemi, I., & Hirose, Y. (2022). Abstract structures and meaning in Japanese dative structural priming. *Applied Psycholinguistics*, *43*(2), 411–433. https://doi.org/10.1017/S0142716421000576

Cleland, A. A., & Pickering, M. J. (2006). Do writing and speaking employ the same syntactic representations? *Journal of Memory and Language*, *54*(2), 185–198. https://doi.org/10.1016/j.jml.2005.10.003

Coumel, M., Muylle, M., Messenger, K., & Hartsuiker, R. J. (2024). The role of explicit memory across second language syntactic development: A structural priming study. *Language Learning*, *74*, 402–435. https://doi.org/10.1111/lang.12604

Deng, Y., Arai, M., & Hirose, Y. (2013). Lexical boost for syntactic priming in a head-final language is bound to the verb but not to pre-head constituents in Japanese. *Technical Report of IEICE (Thought and Language)*, *113*(174), 69–74.

Deng, Y., & Nakamura, C. (2015). Word order priming in Japanese: The role of verb repetition. *Technical Report of IEICE (Thought and Language)*, *115*(176), 61–64.

Deng, Y., Ono, H., & Sakai, H. (2007). Syntactic priming effect and prediction mechanism in Japanese sentence production: Examination using sentence completion task with active/passive sentences. *Technical Report of IEICE (Thought and Language)*, *107*(138), 29–34.

Deng, Y., Ono, H., & Sakai, H. (2008). Priming effects in Japanese passive sentence production: Evidence from picture-description task in dialogue. *Technical Report of IEICE (Thought and Language)*, *108*(184), 55–59.

Deng, Y., Ono, H., & Sakai, H. (2011). Grammatical function assignment and word order determination in Japanese sentence production: Evidence from structural priming effects in a picture description task. *Technical Report of IEICE (Thought and Language)*, *111*(170), 25–30.

Donnelly, S., Rowland, C., Chang, F., & Kidd, E. (2024). A comprehensive examination of prediction-based error as a mechanism for syntactic development: Evidence from syntactic priming. *Cognitive Science*, *48*(4), e13431. https://doi.org/10.1111/cogs.13431

Fukumura, K., & Yang, F. (2024). Interactive structure building in sentence production. *Cognitive Psychology*, *148*, 101616. https://doi.org/10.1016/j.cogpsych.2023.101616

Garcia, R., Roeser, J., & Kidd, E. (2023). Finding your voice: Voice-specific effects in Tagalog reveal the limits of word order priming. *Cognition*, *236*, 105424. https://doi.org/10.1016/j.cognition.2023.105424

Green, P., & MacLeod, C. J. (2016). SIMR: An R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution*, *7*(4), 493–498. https://doi.org/10.1111/2041-210X.12504

Hartsuiker, R. J., Bernolet, S., Schoonbaert, S., Speybroeck, S., & Vanderelst, D. (2008). Syntactic priming persists while the lexical boost decays: Evidence from written and spoken dialogue. *Journal of Memory and Language*, *58*(2), 214–238. https://doi.org/10.1016/j.jml.2007.07.003

Hartsuiker, R. J., & Westenberg, C. (2000). Word order priming in written and spoken sentence production. *Cognition*, *75*(2), B27–B39. https://doi.org/10.1016/S0010-0277(99)00080-3

Horton, K. D., & Petruk, R. (1980). Set differentiation and depth of processing in the directed forgetting paradigm. *Journal of Experimental Psychology: Human Learning and Memory*, *6*(5), 599. https://doi.org/10.1037/0278-7393.6.5.599

Hoshi, H. (2017). Passives. In N. Tsujimura (Ed.), *The handbook of Japanese linguistics* (pp. 191–235). Wiley-Blackwell. https://doi.org/10.1002/9781405166225.ch7

Jin, L., Deng, Y., Arai, M., & Hirose, Y. (2013). Structural priming in Japanese passive sentence production: The role of verb repetition. *Technical Report of IEICE (Thought and Language)*, *113*(174), 75–79.

Kantola, L., van Gompel, R. P., & Wakeford, L. J. (2023). The head or the verb: Is the lexical boost restricted to the head verb? *Journal of Memory and Language*, *129*, 104388. https://doi.org/10.1016/j.jml.2022.104388

Kholodova, A., Peter, M., Rowland, C. F., Jacob, G., & Allen, S. E. M. (2023). Abstract priming and the lexical boost effect across development in a structurally biased language. *Languages*, *8*(4), 264. https://doi.org/10.3390/languages8040264

Kumarage, S., Donnelly, S., & Kidd, E. (2022). Implicit learning of structure across time: A longitudinal investigation of syntactic priming in young English-acquiring children. *Journal of Memory and Language*, *127*, 104374. https://doi.org/10.1016/j.jml.2022.104374

Kumarage, S., Donnelly, S., & Kidd, E. (2024). A meta-analysis of syntactic priming experiments in children. *Journal of Memory and Language*, *138*, 104532. https://doi.org/10.1016/j.jml.2024.104532

Mahowald, K., James, A., Futrell, R., & Gibson, E. (2016). A meta-analysis of syntactic priming in language production. *Journal of Memory and Language*, *91*, 5–27. https://doi.org/10.1016/j.jml.2016.03.009

Malhotra, G., Pickering, M., Branigan, H., & Bednar, J. A. (2008). On the persistence of structural priming: Mechanisms of decay and influence of word-forms. *Proceedings of the Annual Meeting of the Cognitive Science Society*, *30*(30), 657–662.

Momma, S. (2023). Grammatical dependencies shape compositional units in sentence production. *Cognition*, *240*, 105577. https://doi.org/10.1016/j.cognition.2023.105577

Murphy, K., Mckone, E., & Slee, J. (2003). Dissociations between implicit and explicit memory in children: The role of strategic processing and the knowledge base. *Journal of Experimental Child Psychology*, *84*, 124–165. https://doi.org/10.1016/S0022-0965(03)00002-X

Peter, M., Chang, F., Pine, J. M., Blything, R., & Rowland, C. F. (2015). When and how do children develop knowledge of verb argument structure? Evidence from verb bias effects in a structural priming task. *Journal of Memory and Language*, *81*, 1–15. https://doi.org/10.1016/j.jml.2014.12.002

Pickering, M. J., & Branigan, H. P. (1998). The representation of verbs: Evidence from syntactic priming in language production. *Journal of Memory and Language*, *39*(4), 633–651. https://doi.org/10.1006/jmla.1998.2592

Pickering, M. J., Branigan, H. P., & McLean, J. F. (2002). Constituent structure is formulated in one stage. *Journal of Memory and Language*, *46*(3), 586–605. https://doi.org/10.1006/jmla.2001.2824

Pickering, M. J., & Ferreira, V. S. (2008). Structural priming: A critical review. *Psychological Bulletin*, *134*(3), 427–459. https://doi.org/10.1037/0033-2909.134.3.427

Reitter, D., Keller, F., & Moore, J. D. (2011). A computational cognitive model of syntactic priming. *Cognitive Science*, *35*(4), 587–637. https://doi.org/10.1111/j.1551-6709.2010.01165.x

Rowland, C. F., Chang, F., Ambridge, B., Pine, J. M., & Lieven, E. V. M. (2012). The development of abstract syntax: Evidence from structural priming and the lexical boost. *Cognition*, *125*(1), 49–63. https://doi.org/10.1016/j.cognition.2012.06.008

Santesteban, M., Pickering, M. J., Laka, I., & Branigan, H. P. (2015). Effects of case-marking and head position on language production? Evidence from an ergative OV language. *Language, Cognition and Neuroscience*, *30*(9), 1175–1186. https://doi.org/10.1080/23273798.2015.1065335

Scheepers, C., Raffray, C., & Myachykov, A. (2017). The lexical boost effect is not diagnostic of lexically-specific syntactic representations. *Journal of Memory and Language*, *95*, 102–115. https://doi.org/10.1016/j.jml.2017.03.001

Storbeck, J., & Clore, G. L. (2005). With sadness comes accuracy; With happiness, false memory: Mood and the false memory effect. *Psychological Science*, *16*(10), 785–791. https://doi.org/10.1111/j.1467-9280.2005.01615.x

Tanaka, J., Tamaoka, K., & Sakai, H. (2007). Syntactic priming effects on the processing of Japanese sentences with canonical and scrambled word orders. *Cognitive Studies*, *14*(2), 173–191. https://doi.org/10.11225/jcss.14.173

Tattersall, A. J., & Broadbent, D. E. (1991). Output buffer storage and the modality of recall. *The Quarterly Journal of Experimental Psychology Section A*, *43*(1), 1–18. https://doi.org/10.1080/14640749108400996

Tooley, K. M., & Traxler, M. J. (2010). Syntactic priming effects in comprehension: A critical review. *Language and Linguistics Compass*, *4*(10), 925937. https://doi.org/10.1111/j.1749-818X.2010.00249.x

Van Den Broek, P., Lorch, R. F., Linderholm, T., & Gustafson, M. (2001). The effects of readers' goals on inference generation and memory for texts. *Memory & Cognition*, *29*(8), 1081–1087. https://doi.org/10.3758/BF03206376

van Gompel, R. P. G., Wakeford, L. J., & Kantola, L. (2023). No looking back: The effects of visual cues on the lexical boost in structural priming. *Language, Cognition and Neuroscience*, *38*, 1–10. https://doi.org/10.1080/23273798.2022.2036782

Yamashita, H., & Chang, F. (2001). "Long before short" preference in the production of a head-final language. *Cognition*, *81*(2), B45–B55. https://doi.org/10.1016/S0010-0277(01)00121-4

Zhang, C., Bernolet, S., & Hartsuiker, R. J. (2020). The role of explicit memory in syntactic persistence: Effects of lexical cueing and load on sentence memory and sentence production. *PLOS ONE*, *15*(11), e0240909. https://doi.org/10.1371/journal.pone.0240909