Finding your voice:

Voice-specific effects in Tagalog reveal the limits of word order priming

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Abstract

The current research investigated structural priming in Tagalog, a symmetrical voice language containing rich verbal morphology that results in changes in mapping between syntactic positions and thematic roles. This grammatically rare feature, which results in multiple transitive structures that are balanced in terms of the grammatical status of their arguments, provides the opportunity to test whether word order priming is sensitive to the voice morphology of the verb. In three sentence priming experiments (*N*s = 64), we manipulated whether the target-verb prompt carried the same voice as the verb in the prime sentence. In all experiments, priming occurred only when the prime and target had the same voice morphology. Additionally, we found that the strength of word order priming depends on voice: stronger priming effects were found for the voice morpheme associated with a more flexible word order. The findings are consistent with learning-based accounts where language-specific representations for syntax emerge across developmental time. We discuss the implications of these results in the context of Tagalog's grammar. The results reveal the value of crosslinguistic data for theory-testing, and the value of structural priming in determining the representational nature of linguistic structure.

Keywords: structural priming; word order; Tagalog; lexical boost; voice

1. Introduction

A core aim of psycholinguistics is to uncover the architecture of the language faculty in a manner that links performance to linguistic representation. One key method for studying the deployment of linguistic representations during language production is *structural priming* (Bock, 1986; Branigan & Pickering, 2017), which takes advantage of the fact that speakers tend to re-use constructions they have previously heard. For example, speakers are more likely to use a passive sentence such as *the cat is being chased by the dog* after hearing another passive sentence like *the suspect is being followed by the policeman* than after an equivalent active sentence (i.e., *the policeman followed the suspect*). Since the two passive sentences do not contain open class lexical overlap, a priming effect is typically taken to indicate the presence of an abstract representation of the English passive structure.

While the utility of priming for identifying the representational properties of the system is not in question, the nature and scope of the representations within psycholinguistic theory remain unclear. A key source of evidence in this endeavour is data from typologically-diverse languages, the study of which tests the limits of theoretical approaches built upon a fairly small and non-representative sample of languages. Notably, psycholinguistics has drawn heavily from English and a handful of other well-studied languages (Anand et al., 2011; Jaeger & Norcliffe, 2009; Kidd & Garcia, 2022), which are not representative of the linguistic diversity present in natural language (Evans & Levinson, 2009). In this study, we investigated priming in Tagalog, an understudied language spoken primarily in the Philippines. Of particular interest is Tagalog's typologically rare symmetrical voice system (Foley, 2008; Riesberg et al., 2019), which is characterised by the presence of more than one basic transitive structure that are equally marked with verbal and nominal morphology without argument demotion (i.e., in the English passive, the agent is demoted to an oblique argument). Across three priming studies, we show that the pattern of priming across voices is different and, crucially, voice-dependent in ways that challenge existing theories of priming. Additionally, the pattern of results also provides empirical evidence bearing upon linguistic theory concerning language change in Austronesian languages, underlining the utility of priming as a method for studying the dynamics of language at the individual and, by implication, the population level.

1.1 Tagalog

Tagalog is a Western Austronesian language with around 28 million speakers across the globe (Eberhard et al., 2022). In Tagalog, the voice-marking on the verb assigns the thematic role of the subject—the argument marked by *ang*[1] (see 1-4; Himmelmann, 2005). In the agent voice (AV), the verb infix -*um*- marks the subject as the agent (1, 2). In the patient voice (PV), the infix -*in*- assigns the subject the patient role (3, 4). Aside from the patient voice, there are also other undergoer voices where the *ang*-phrase is a recipient, instrument or beneficiary. Non-subject arguments or adjuncts are marked by *ng* or *sa*. Tagalog is canonically verb-initial, with a relatively free post-verbal argument order (Schachter, 2015), resulting in both agent-initial (1, 3) and patient-initial (2, 4) orders in the different voices.

[1] There is still a debate on which argument is the subject in Tagalog. There are proposals that in the agent voice, the *ang*-phrase is the subject, while in the patient voice, the *ng*-phrase is the subject (Carrier-Duncan, 1985). However, there are many syntactic processes that can only apply to the *ang*-phrase (Kroeger, 1993a). For example, floated quantifiers have to be interpreted as referring to the *ang*-phrase. It is also only the *ang*-phrase which can be clefted, relativized, or be inverted in an *ay* non-verb-initial construction.

(1) Agent voice agent-initial	S<**um**>isipa	ang	oso	ng	palaka
	<AV>[2]kick	SBJ	bear	NSBJ	frog
(2) Agent voice patient-initial	S<**um**>isipa	ng	palaka	ang	oso
	<AV>kick	NSBJ	frog	SBJ	bear
(3) Patient voice agent-initial	S<**in**>isipa	ng	oso	ang	palaka
	<PV>kick	NSBJ	bear	SBJ	frog
(4) Patient voice patient-initial	S<**in**>isipa	ang	palaka	ng	oso
	<PV>kick	SBJ	frog	NSBJ	bear
	"The/A bear is kicking the/a frog."				

In Tagalog's voice system, the change in verb morphology also changes the mapping between syntactic functions and thematic roles. For example, an agent voice patient-initial sentence (2) can potentially prime another patient-initial sentence *or* an *ang*-last sentence. In the agent voice, both these orders point to the same structure. However, given a patient voice target, the speaker would have to switch the order of syntactic functions in the prime, in order to produce a patient-initial sentence (4), or if the speaker follows the order of syntactic functions of the agent voice prime, a patient voice agent-initial sentence (3) will be produced instead.

There is evidence suggesting that the order of post-verbal arguments in Tagalog depends, to some extent, on the verb's morphological voice: corpus and experimental work show that the agent voice allows a great deal of flexibility, whereas in the patient voice there is a clear (though not absolute) preference for the agent-first sentence (Garcia et al., 2018, 2021; Garcia & Kidd, 2020). These usage patterns are driven by two preferences. The first is a general *ang*-last

[2] AV refers to agent voice, PV to patient voice, SBJ to subject, and NSBJ to non-subject.

preference, where the prominent syntactic argument appears clause final (Kroeger, 1993b). The second is a preference to place agents first, following the verb (see Riesberg et al., 2019). In the agent voice, where the *ang*-phrase marks the agent (1, 2), there is tension between the two preferences, which results in more flexible word order in this voice. In contrast, in the patient voice, the two preferences converge, such that sentences like (3) are more common than (4).

Riesberg et al. (2019) suggested that this tension between *ang*-last and agent-first ordering may drive language change towards agent-first word order preferences in symmetrical voice languages, with the *universal agent-first* preference eventually winning out diachronically (i.e., over historical time). This leads to an intriguing hypothesis at the intersections of psycholinguistics, typology, and language change: if a language like Tagalog allows more variation of argument order in the agent voice than in the patient voice, then we should see stronger priming in the agent voice than in the patience voice, due to the countervailing influences of the *ang*-last and agent-first preference in the agent voice. Note that this is quite different from the *inverse frequency effect* generally observed in the syntactic priming literature (e.g., see Pickering & Ferreira, 2008): low frequency alternations such as the passive in active-passive alternation prime more than subtler differences such as priming for double objects in dative alternations. Instead, the suggestion is that flexibility in the ordering of core arguments differs across voice, and where that flexibility is licensed by competing grammatical preferences, priming may be higher in magnitude and act as a driver of diachronic change. The prediction is consistent with Jäger and Rosenbach's (2008) suggestion that priming at the level of the individual acts as a driver of language change.

1.2 Mechanism underlying structural priming

There are different theoretical explanations for structural priming phenomena. According to Pickering and Branigan (1998), priming originates from the residual activation that sentences leave in the combinatorial nodes of their structures. In their theory, the base form of the verb (lemma: Levelt, 1989) is linked to syntactic properties such as tense or number inflection, and to the structure the verb is in (e.g., prepositional dative or double object structure). For example, the English prepositional dative prime sentence *The racing driver showed the torn overall to the helpful mechanic* leaves residual activation in the lemma SHOW, in the combinatorial prepositional dative node, and in the link between the lemma and prepositional dative nodes. This increases the likelihood for another prepositional dative structure to be used. When the prime and target verbs have different lemmas, only the residual activation of the prepositional dative node causes priming. When the prime and target contain the same verb, activation in both the lemma and prepositional dative node result in an additive effect, causing the *lexical boost*. More importantly, Pickering and Branigan argue that since it is the unspecified/uninflected form of the verb (lemma) that is linked to the prepositional dative combinatorial node, and not the inflected form of the verb (for tense, aspect or number), varying the inflection of the verb does not affect the magnitude of priming.

Pickering and Branigan (1998) presented data from English that were consistent with this account: participants produced more prepositional datives *The patient showed the [object] to the [beneficiary]* after reading a prepositional dative prime compared to a double object prime *The patient showed the [beneficiary] the [object]*, regardless of whether the verbs in prime and target were in the same tense (prime: *showed* – target: *showed*) or in a different tense (prime: *showed* –

target: *shows*). They also observed a lexical boost effect, in which priming was larger in magnitude when prime and target shared the same verb.

These results, however, may be specific to English. Chang et al. (2015) tested the predictions of the account in German-speaking adults. Word order variations in German are sensitive to verbal tense/aspect. Specifically, past tense verbs occur after the subject (in the *verb second* or V2 word order), as in (5). However, in the perfective aspect, the lexical verb moves to the end of the sentence, as in (6).

(5) Der Rechtsanwalt **schickte** den Vertrag an den Klienten

"The lawyer **sent** the contract to the client"

(6) Der Rechtsanwalt **hat** den Vertrag an den Klienten **geschickt**

"The lawyer **has sent** the contract to the client"

The residual activation account locates the lexical boost at the level of the lemma. As both sentences have the same verb lemma, it predicts the same pattern of priming (i.e., the same magnitude) across sentences containing verb-second (sentence 5) or verb-final (6) lexical verbs. However, Chang et al.'s (2006) Dual-path model makes an alternative prediction: The model learns language-specific grammatical representations via a serial recurrent network that attempts to predict the next word in a sentence and updates its knowledge when the model predictions are not met. Thus, abstract knowledge emerges from locally recurring lexical patterns via *implicit learning* (for other accounts of priming that explain abstract priming via learning processes see Jaeger & Snider, 2013; Reitter et al., 2011). For German, the prediction is that the model acquires separate structural representations for verb-second and verb-final structures, in addition to general verb-independent structural knowledge (see Chang et al., 2015, p. 11). Thus, priming should be strongest when prime and target share the verb-second and verb-final pattern. This is what the authors found in human adult participants.

The difference in results across English and German reveal the value in crosslinguistic comparisons for theory testing, even in closely related languages. The pattern of results raises an important question concerning grammatical representation in symmetrical voice systems like that of Tagalog. Firstly, do uninflected verbs, which are ungrammatical but do appear in naturalistic speech in some contexts (Garcia & Kidd, 2022), constitute lemmas, and thus, can priming occur at this level? If this is the case, it would suggest that in symmetrical voice systems there is a unitary transitive structure in which voice marking induces valency changes.[3] The implication is that the residual activation account would predict that priming would be observed across voice types. For example, if a Tagalog agent voice *kick-ng-ang* (patient-initial) prime sentence leaves residual activation in the verb lemma KICK, in the *ng-ang* node, and in the link between KICK and the *ng-ang* node, it would increase the likelihood for another *ng-ang* sentence to be used regardless of the voice of the target verb. Note that a *ng-ang* sentence in the agent voice is patient-initial but agent-initial in the patient voice, so activation of a *ng-ang* node results in different thematic role order depending on the voice-marking on the verb.

Secondly, and in contrast to the unitary account, each voice may constitute a separate transitive structure, such that there is no priming at the lemma level. The prediction is that priming would be voice-specific, a hypothesis that we interpret to be consistent with the Chang et al. (2006) model, as it learns structure by mapping event roles onto word sequences, which it

[3] There are indeed analyses of Tagalog voice which connect the structures in a unitary account (e.g., Aldridge, 2012, 2017; De Guzman, 1988; Mithun, 1994; Payne, 1982). However, it is unclear whether this account would make a directional prediction, since the argument is that the undergoer (i.e., patient) voice is syntactically basic.

refines across its development via error-based learning. Thus, it will learn the mapping between V-NP-NP sequences, and because these mappings change depending on voice, the model will induce separate syntactic frames for different voices (effectively treating each voice-marked variant as a separate lexical entry). This is broadly consistent with ‘symmetrical voice’ analyses of Philippine-type Austronesian languages[4] (Himmelmann, 2002, 2005; Foley, 2008; Riesberg, 2014; for review see Chen & McDonnell, 2019), and is consistent with on-line parsing data reported by Garcia et al. (2021), who showed a voice-driven asymmetry in children’s and adults’ ability to predict argument roles from voice-inflected verb plus noun marker combinations.

There is currently one previous priming study on Tagalog, which focused on children but also collected an adult comparison group. In that study, Garcia and Kidd (2020) manipulated the order of agent and patient in descriptions of actions between two animals (prime sentence) as well the voice of the target verb prompts, and found no evidence for priming of word order in their sample of adult participants. However, as the experiment was designed for children, it is unclear if the results were observed because priming is impossible in Tagalog, or if it was due to the fact that any effect was obscured in adults because of the significant methodological changes required to test young children. For example, given that the method involved the description of pictures and was presented to the participants as a study that was to be conducted with children, the adult participants may have ignored the prime sentences. In the current study, we used a different paradigm that is more typical of adult-focused priming studies, and which required the participants to engage with the prime sentence.

[4] Not all Austronesian languages have the symmetrical voice feature (Chen & McDonnell, 2019).

1.3 Current research

In three structural priming experiments, we investigated how voice morphology affects word order priming. Our main aim was to use structural priming to determine the representational nature of the Tagalog transitive structure. Accordingly, we determined whether priming occurred across different voices. This question naturally bears upon different explanations of priming. If, following residual activation accounts (Pickering & Branigan, 1998), priming occurs at the lemma level, we expect priming across voice, which would be consistent with the possibility that the transitive has a unitary representational structure. However, if different voice alternations constitute separate structures, as is assumed by the symmetrical voice analyses of Austronesian voice (Chen & McDonnell, 2019; Foley, 2008; Himmelmann, 2002, 2005; Riesberg, 2014), and as predicted by the Chang et al. (2006) computational model of sentence production, priming effects are only expected when prime and target verbs are marked with the same voice affixes.

Our study also informs Riesberg et al.'s (2019) proposal that, due to a preference to place agents early in a sentence (i.e., the Universal Agent Hypothesis), Tagalog agent voice sentences have more flexible word order patterns because of the countervailing influence of the *ang*-last preference. This predicts greater priming of patient-initial order in the agent voice than in the patient voice. Moreover, Riesberg et al. argue that the universal agent-first preference will eventually win out diachronically. Thus, the results also bear upon Jäger and Rosenbach's (2008) argument that priming at the individual level plays a key role in language change via implicit learning.

These predictions were tested across three experiments where we manipulated whether the target verb prompt had the same voice as the verb in the prime sentence. In Experiment 1, we tested whether Tagalog speakers could be primed to produce patient-initial sentences given agent or patient voice targets, while the primes were consistently in the agent voice. In Experiment 2, we used patient voice-marked primes instead of agent voice-marked primes. In our pre-registered Experiment 3, we used both agent voice and patient voice primes while keeping the target sentences in the agent voice.

2. Experiment 1: Agent voice primes

2.1 Method

2.1.1 Participants

We tested a total of 85 Tagalog-speakers from Greater Manila Area (50 females, 35 males) with a median age of 28 years (SD = 4.73, range: 18–35); none reported a present or past diagnosis of a speech or language impairment or psychological / neurological illness. Participants who contributed less than 20 trials (n = 11) were excluded from the data analysis, as were participants who had completed the experiment previously (n = 6), failed to follow the instructions (n = 3), or scored lower than 60% (n = 1) in the comprehension check (a sentence-picture matching task; see below). We recruited more participants to replace the excluded ones, in order to meet our target of 64 participants, thereby satisfying our counterbalancing requirements (4 participants in each list). Participants who finished the experiment received a P250 voucher (€3.40) for a convenience store chain via email as compensation.

2.1.2 Design and Materials

The priming experiment comprised a sentence-picture matching and a sentence completion task. In a 2 x 2 x 2 design, we crossed prime order (i.e., thematic role order of the prime sentence: agent-initial, patient-initial), target voice (i.e., voice-marking of the target verb: agent voice, patient voice), and lexical overlap between prime and target verbs (verb overlap, no verb overlap; see Table 1 for a full item). The dependent variable was whether participants used a patient-initial or an agent-initial word order in the sentence completion task.

Table 1. Sample item for the target verb "tickling" given a target picture of a monkey tickling a dog, and prime pictures involving a bear and a frog in Experiment 1. The prime sentence in the lexical overlap condition translates to "The bear is tickling a frog", while the prime sentence in the no overlap condition translates to "The bear is kicking a frog".

Lexical overlap	Prime word order	Target voice	Prime sentence	Target prompt ("tickling")
overlap	agent-initial	agent voice	Kumikiliti ang oso ng palaka.	Kumikiliti
		patient voice		Kinikiliti
	patient-initial	agent voice	Kumikiliti ng palaka ang oso.	Kumikiliti
		patient voice		Kinikiliti
no overlap	agent-initial	agent voice	Sumisipa ang oso ng palaka.	Kumikiliti
		patient voice		Kinikiliti
	patient-initial	agent voice	Sumisipa ng palaka ang oso.	Kumikiliti
		patient voice		Kinikiliti

The succession of windows presented during a trial is shown in Figure 1. Every trial started with a fixation cross in the center of the screen (presented for 400ms) before the prime sentence was displayed. A button-click triggered the presentation of a picture that either did or did not match the previous sentence. Underneath the picture were 'Match' or 'Mismatch' buttons, which participants selected to indicate whether the picture corresponded to the prime sentence or not. The picture matched the prime in 50% of all trials (all experimental items and

25% of fillers). Answering the sentence-picture matching task started the audio recorder and triggered the presentation of another fixation cross on top of the screen. After 400ms, the cross was replaced by the target prompt, a verb either in agent or patient voice. After 750ms, the target picture was displayed underneath the target prompt. Participants were asked to use the target prompt in a simple sentence to describe the picture. Clicking the ‘Stop’ button finished the trial.

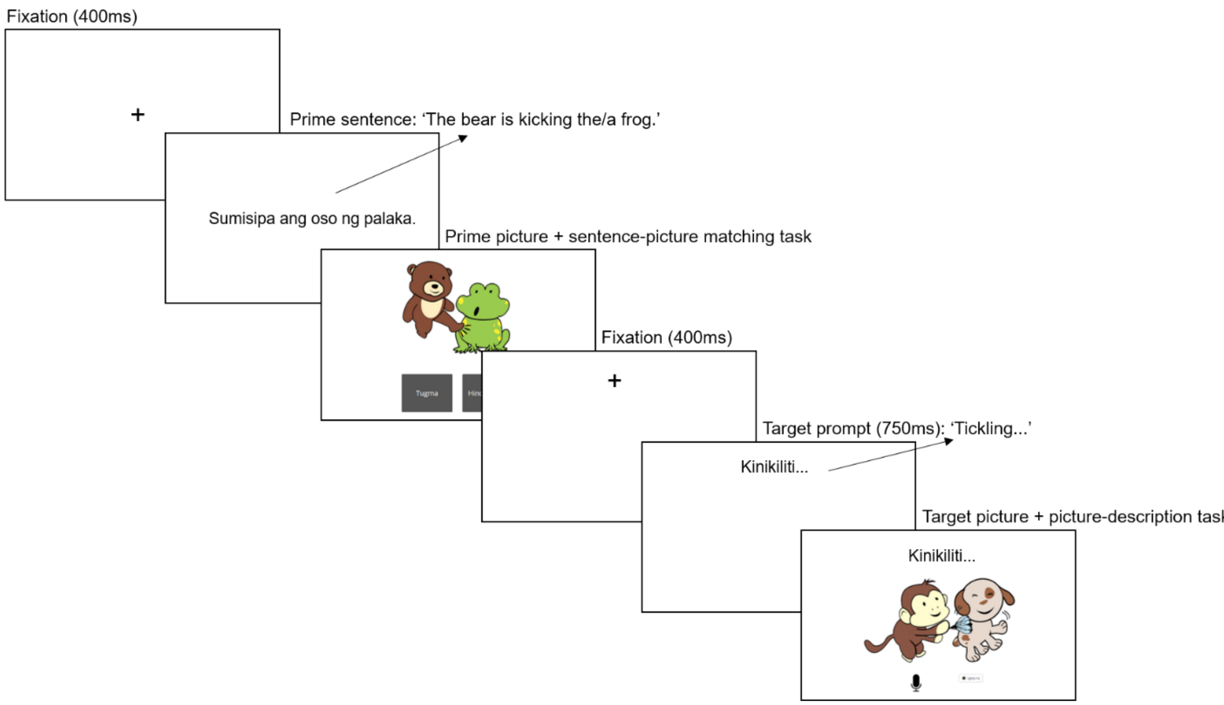

Figure 1. Sample of an experimental trial in Experiment 1.

To create a total of 32 items, we used sixteen verbs in prime-target pairs (see https://osf.io/wc2xz for a complete list of items). Sixteen different animals were used as agents and patients in the sentences: eight were used exclusively in the primes, and the other eight exclusively in the target sentences, such that there was no overlap in the noun phrases of prime and target sentences. Each verb occurred with 6 animal pairs (4 pairs for prime sentences, 2 pairs for target sentences), with each animal occurring equally often as an agent and as a patient. All test and filler pictures were created in the same style by a professional artist.

The items were distributed across 16 Latin square lists (prime order, target voice, lexical overlap, direction of action), such that each participant encountered each item only once and all conditions the same number of times. Verbs were paired such that each target verb occurred either with itself as prime (lexical overlap condition) but with a different animal pair, or with another prime verb (no overlap condition). For example (see Table 1), the prime verb *tickle* was used with the target prompt *kick* in the condition without lexical overlap or with itself as target prompt. All verbs in prime sentences were in the agent voice (Experiment 2 tested the same prime sentences in patient voice, Experiment 3 had both agent and patient voice prime sentences). Every verb appeared in all conditions. Both prime and target picture always showed the same direction of the depicted action (left to right, or right to left). We counterbalanced for direction of action to control for possible confounds.

Sixty-four fillers and six practice trials were added to the items. Half of the filler images were simple pictures such as a dirty towel or a filled glass. The other half involved one or two of the animals either performing a transitive action with an inanimate object (e.g., a lion eating a lime) or were depicted next to each other without performing an action (e.g., a cow located next to a pig). Half of these were used as 'prime' pictures (i.e., a description of the picture was provided to the participants to mimic the transitive prime-target procedure), and the other half as target pictures. For a quarter of filler prime pictures (16), a matching sentence involving adjectives were created (e.g., *Madumi ang tuwalya* 'The towel is dirty' for a picture of a dirty towel). For the rest of the filler prime pictures (48), a mismatching sentence was created (e.g., *Kulay pula ang kamatis* 'The tomato is red' for a picture of a red watermelon). Fillers were distributed so that 50% of all trials showed a matching sentence-picture pair and the other 50% did not.

2.1.3 Procedure

The experiment was conducted online via Gorilla (Anwyl-Irvine et al., 2020), a web-based environment for creating and deploying experiments.[5] We set the target number of participants to 64 on Gorilla, recruiting participants by sharing the experiment link via social media. The experiment could be accessed via the internet through a laptop / computer, tablet, or smartphone.

First, participants' microphones were tested using Gorilla's microphone check function. Those who did not have a functional microphone were automatically excluded from the experiment. Participants with working microphones were asked to read a short passage aloud (the first half of the revised *Halo-Halo Espesyal*, Ligot et al., 2004). This recording was used to identify and exclude non-native speakers of Tagalog (as judged by the first author who is a native speaker of Tagalog) from the sample. After the reading aloud task, participants were randomly assigned to one Latin square list for the priming experiment. Instructions were presented on the screen, followed by a short video clip showing two sample trials similar to the fillers. Participants were presented with four practice trials. They were instructed that there would be a break every 5 minutes. Every experimental trial was intervened by two fillers; the same prime and/or target verb never occurred in the same block of 12 trials (8 blocks in total). Presentation order was randomized within and across blocks. One experimental session took approximately 30 minutes.

[5] The experiment is openly shared at https://app.gorilla.sc/openmaterials/283351

For interested readers, we discuss the advantages and the challenges involved in conducting unsupervised web-based experiments in Garcia et al. (2022). Here, we also argue that the growing popularity of web-based experiments provides an opportunity to increase the diversity of linguistic research, as it facilitates data collection from understudied populations.

2.1.4 Data analysis

Audio-recordings were transcribed by the first author, a native speaker of Tagalog who was blind to the corresponding prime sentences to the participants' productions. Each production was then labelled as being agent-initial or patient-initial. Accuracy in the sentence-picture matching was recorded automatically by Gorilla.

The data—whether the participant responded with a patient-initial or agent-initial word order—were analysed using a Bayesian mixed-effects model (e.g. Gelman et al., 2014; McElreath, 2016). We used a Bernoulli distribution with logit-link function to analyse the binomial responses as a probability to produce patient-initial sentences rather than agent-initial (patient-initial = 1, agent-initial = 0). Model predictors were main effects of prime order (levels: agent-initial, patient-initial), voice of target verb (levels: agent voice, patient voice), lexical overlap of prime and target verbs (levels: verb overlap, no verb overlap), and all two- and three-way interactions. All predictors were sum-coded, so model coefficients represent the effect magnitude independently of other predictors' levels (Brehm & Alday, 2022; Schad et al., 2020). We fitted the model with a maximal random effects structure (Barr et al., 2013; Bates et al., 2015), including random intercepts for participants and items with by-participant and by-item slopes for all main effects and interactions.

We obtained Bayes Factors (henceforth, BF) for each predictor. BFs were calculated using the Savage-Dickey method (see, e.g., Dickey et al., 1970; Wagenmakers et al., 2010). As a rule of thumb, a BF of 3 indicates weak evidence, a BF larger than 5 indicates moderate support and a BF larger than 10 indicates strong evidence for a statistically meaningful effect (e.g., Baguley, 2012; Jeffreys, 1961; Lee & Wagenmakers, 2014); that is, the evidence in favor of the alternative hypothesis over the null hypothesis, given the data. For example, if the alternative hypothesis is two times more likely than the null hypothesis, then the BF would take on the value 2. Additionally, a BF smaller than 0.33 is taken as evidence against the alternative hypothesis (Wagenmakers et al. 2018).[6] In addition to BFs, we report the most probable posterior parameter value (the estimated population mean) as well as the 95% probability interval (henceforth, PI) which is the interval that contains the true parameter value with a probability of 95% (Kruschke et al., 2012).

The R (R Core Team, 2020) package brms (Bürkner, 2017, 2018) was used to model the data using the probabilistic programming language Stan (Carpenter et al., 2016; Hoffman & Gelman, 2014). Models were run with 10,000 iterations on 3 chains with a warm-up of 5,000 iterations and no thinning. Model convergence was confirmed by the Rubin-Gelman statistic (Gelman & Rubin, 1992) and inspection of the Markov chain Monte Carlo chains. R-scripts and data are available on OSF: https://osf.io/76m3k/.

[6] For all predictors, we used weakly informative priors with a normal distribution centered around 0 with a variance of 2, hence favoring the null hypothesis. We chose weakly informative priors favoring the null (see McElreath, 2016) as the Savage-Dickey method is sensitive to prior information. Weak priors are recommended when there is little prior information available about the parameter of interest (McElreath, 2016).

2.2 Results

Prior to the analysis, we excluded trials with missing recordings or where the participant changed the voice of the target prompt (49 trials, 2%), and trials in which the sentence-picture matching response was incorrect (194 trials, 9%).[7] The results of the Bayesian mixed-effects model are summarised in Table 2. The main effect of prime order demonstrates structural priming: more patient-initial productions were observed after reading a patient-initial sentence. There was strong evidence for a main effect of target voice, supporting more patient-initial productions for agent voice verb prompts than patient voice verb prompts. Evidence for all other predictors was negligible.

The estimated population means and PIs for all conditions are shown in Figure 1. The plot highlights two features of the results that are not captured by Table 2. First, priming effects can only be seen for agent voice target verbs but not for patient voice target verbs, and the priming effect appears to be stronger for the lexical overlap condition than for the no lexical verb overlap condition. Second, the patient voice target verb conditions show that the probability of observing patient-initial productions for patient voice verb prompts is virtually zero. In other words, the model estimates in Table 2 might be misguided, at least to some extent, by the absence of patient-initial productions in the patient voice condition.

To address the possibility that the floor effect in the patient voice condition is overshadowing effects in the agent voice condition, we removed the patient voice condition from the data and refit the model with main effects and the interaction of prime order and lexical overlap, but without the voice predictor. We reproduced the prime order effect observed in Table

[7] Including trials with incorrect responses to the sentence-picture match task showed similar results with only minor numeric differences. All results and additional analyses are reported in the R-markdown file reported at https://osf.io/39rdw.

2 even without the patient voice trials (Estimate = -2.86, PI = [-3.82, -1.96], BF > 100). No evidence was found for a main effect of lexical overlap (Estimate = -0.22, PI= [-1.12, 0.69], BF = 0.25). However, there was converging evidence for the lexical overlap by order interaction (Estimate = 1.06, PI = [0.23, 1.87], BF = 5.43), which we did not observe in the full analysis before. This interaction revealed a larger word order priming effect (i.e., more patient-initial sentences for patient-initial primes compared to agent-initial primes) for target verbs in agent voice that were identical to the target verb (Estimate = 2.11, PI = [1.49, 2.79]) than for lexically non-identical prime verbs (Estimate = 0.89, PI = [0.36, 1.45]). No such evidence was found for patient voice target verbs, neither in the lexical overlap condition (Estimate = 0.45, PI = [-1.38, 2.21]) nor in the no-overlap condition (Estimate = 0.92, PI = [-0.49, 2.33]).

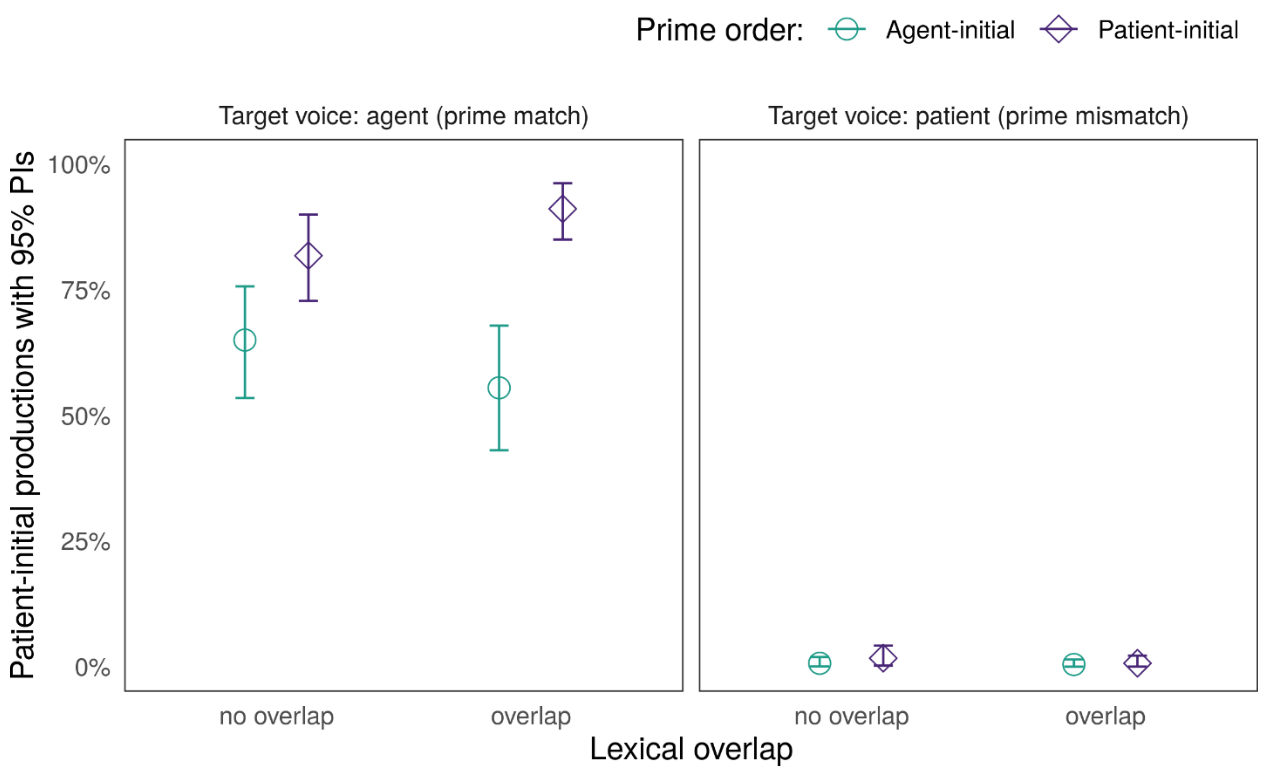

Figure 2. Inferred population means with 95% probability intervals (PIs) in Experiment 1.

Table 2. Main effects and interactions of the patient-initial productions in Experiment 1 (agent voice primes) with coefficients shown on the logit scale.

Predictor	Estimate	Lower	Upper	BF
Main effects				
Target voice	9.15	3.34	14.61	> 100
Prime order	-3.88	-5.71	-2.01	> 100
Lexical overlap	0.01	-1.76	1.76	0.45
Interactions				
Target voice × Prime order	-1.45	-3.22	0.37	1.64
Target voice × Lexical overlap	-0.49	-2.36	1.41	0.56
Prime order × Lexical overlap	0.79	-0.89	2.41	0.66
Target voice × Prime order × Lexical overlap	1.28	-0.37	2.96	1.34

Note. Upper and lower indicate the bounds of 95% probability intervals (PIs). Bayes Factors (BFs) indicate the evidence in favor of the alternative hypothesis.

2.3 Discussion

In Experiment 1, we tested whether word order priming occurs within and/or across voice in Tagalog, with a focus on determining whether agent voice primes lead to word order priming in agent and patient voice targets. Priming in this instance was voice-specific: we observed word order priming and lexical boost effects for agent voice targets where both prime and target verbs were inflected with the agent voice infix *-um-*; however, these effects were not observed for patient voice target verbs that mismatched the voice of the prime verb (i.e., agent voice). The pattern of results is thus consistent the suggestion that V-NP-NP sequences in the two voices constitute distinct transitive structures, as argued by symmetrical voice analyses of Austronesian (Chen & McDonnell, 2019; Himmelmann, 2002, 2005; Foley, 2008; Riesberg, 2014) and by Chang et al.'s (2006) learning-based computational model of production. They are inconsistent with the possibility that the different voices are linked in any important way, either through derivation from a basic form (Aldridge, 2012, 2017; De Guzman, 1988; Payne, 1982; Mithun, 1994) or from priming occurring at the level of uninflected verb lemmas (Pickering & Branigan, 1998).

Since we only used agent voice primes, we do not have any evidence for whether across-voice priming can occur from the patient voice to the agent voice, and whether, following Riesberg et al. (2019), priming in the patient voice is lower in magnitude than in the agent voice. Therefore, in Experiment 2 we tested a new sample of participants, but this time with patient voice primes.

3. Experiment 2: Patient voice primes

Experiment 2 was largely identical to Experiment 1, with the exception that prime verbs were inflected for the patient voice. This manipulation allowed us to test two possibilities. Firstly, it allowed us to test if priming only occurs with agent voice targets because of its greater word order flexibility in comparison to the patient voice (Garcia et al., 2018; Garcia & Kidd, 2020). On this possibility, priming is possible across voice (i.e., if patient voice sentences primed agent voice targets), but was not found in Experiment 1 because of grammatical preferences which constrain variable choice in the language (i.e., the patient voice patient-initial structure violates both agent-first and *ang*-last order preferences proposed for Tagalog, while the patient voice agent-initial structure satisfies both, thus priming from agent voice primes to patient voice targets is less likely to be observed). This pattern of results would also be consistent with the residual activation account (Pickering & Branigan, 1998), as it would entail priming of word order from a patient voice prime to an agent voice target. It would also be consistent with unitary analyses of the Austronesian voice, where the claim is that the patient voice is the basic form from which the agent voice is derived (Aldridge, 2012, 2017; De Guzman, 1988; Mithun, 1994; Payne, 1982).

The second possibility, following symmetrical voice analysis of Austronesian voice (Chen & McDonnell, 2019; Himmelmann, 2002, 2005; Foley, 2008; Riesberg, 2014), and the Dual-path model (Chang et al., 2006; Chang et al., 2015), is that priming was not observed because of a voice mismatch. This means that we should see the opposite pattern of results than observed in Experiment 1—patient voice sentences prime patient voice targets only, and there should be no priming given agent voice targets.

3.1 Method

3.1.1 Participants

We recruited a total of 110 Tagalog-speakers from Greater Manila Area (83 females, 28 males). The sample had a median age of 26 years (SD = 6.41, range: 18–61). None reported having been previously diagnosed with any speech or language impairments, or psychological or neurological illness. As in Experiment 1, we excluded participants who contributed less than 20 trials (n = 15), had completed the experiment before (n = 15), did not satisfy the inclusion criteria (n = 8), failed to follow the instructions in other ways (n = 4), or scored lower than 60% (n = 4) in the attention-check task (sentence-picture match task). We replaced excluded participants, in order to obtain data from our target of 64 participants (4 participants in each list).

3.1.2 Design, Materials, and Procedure

Design, materials, and procedure were the same as used in Experiment 1. Prime sentences were in patient voice instead of agent voice as used in Experiment 1 (see https://osf.io/wc2xz for a complete list of the items).

3.2 Results

Data analysis followed the same methods as in Experiment 1. We removed trials with missing recordings or incorrect voice (31 trials, 2%), and incorrect sentence-picture matching (225 trials, 11%).

Table 3 summarises the results of the Bayesian mixed-effects model on the probability of using a patient-initial sentence. There was strong evidence for a main effect of target voice, showing more patient-initial productions for agent voice prompts than patient voice prompts. There was also a main effect of prime order, which indicates that, overall, there were more patient-initial productions for patient-initial primes. In contrast to Experiment 1, we observed a main effect of lexical overlap indicating more patient-initial sentences when the same verb appeared in the prime sentence and in the target prompt. There was converging evidence for two-way interactions of prime order and target voice, and prime order and lexical overlap. Evidence for the target voice by lexical overlap interaction was negligible. Importantly, there was substantial support for the three-way interaction of lexical overlap, prime order, and target voice.

The estimated population means and PIs for all conditions are shown in Figure 3. From the posterior, we calculated the differences between the patient-initial and agent-initial prime conditions to evaluate priming effects involved in the three-way interaction. Word order priming was found for patient voice verbs, matching the voice of the prime, in the lexical overlap condition only (lexical overlap: Estimate = 3.58, PI = [1.93, 5.30]; no lexical overlap: Estimate = 0.95, PI = [-0.76, 2.56]). No word order priming was found for the agent voice target prompts (mismatching the voice of the prime verb; lexical overlap: Estimate = 0.02, PI = [-0.69, 0.74]; no lexical overlap: Estimate = -0.17, PI = [-0.82, 0.46]). In other words, priming effects observed in Experiment 1 disappeared when the voice of the prime did not match the voice of the target prompt.

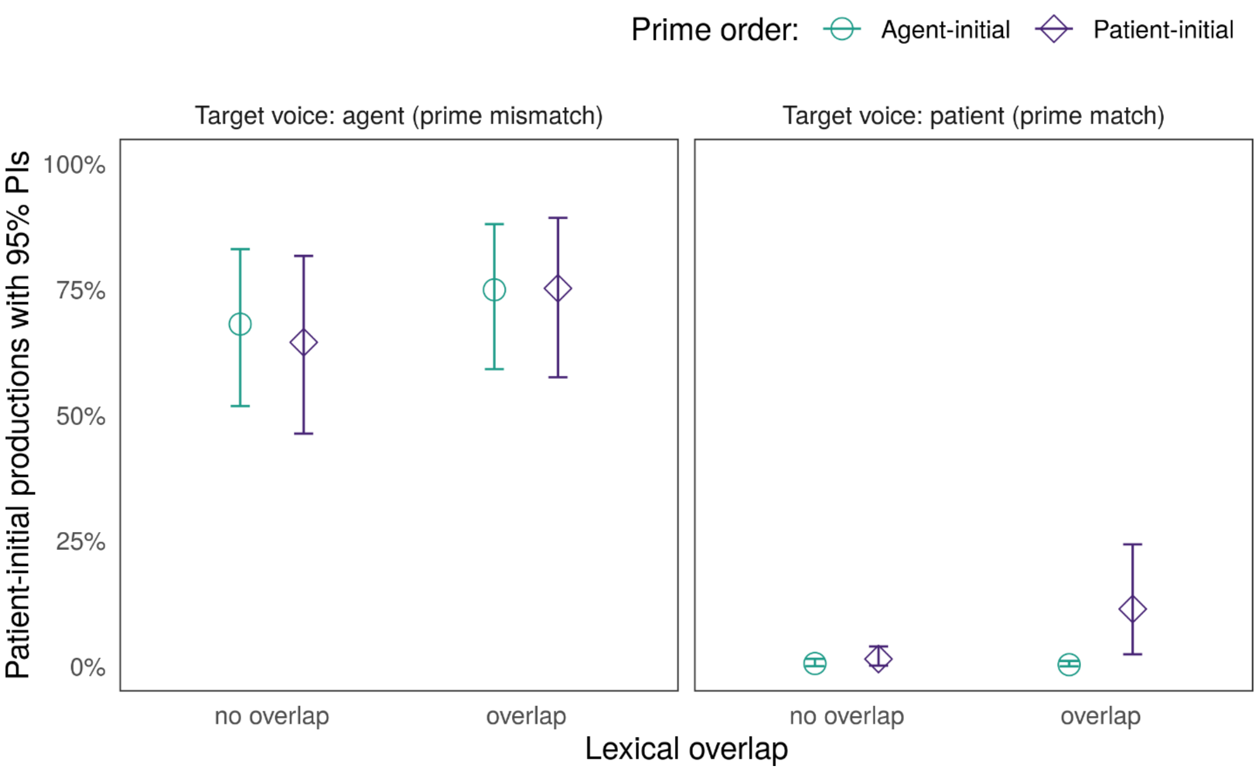

Figure 3. Inferred population means with 95% probability intervals (PIs) in Experiment 2.

Table 3. Main effects and interactions of the patient-initial productions in Experiment 2 (patient voice primes) with coefficients shown on the logit scale.

Predictor	Estimate	Lower	Upper	BF
Main effects				
Target voice	8.16	4.42	11.68	> 100
Prime order	-3.16	-5.03	-1.18	55.5
Lexical overlap	-2.44	-4.17	-0.71	15.84
Interactions				
Target voice × Prime order	3.53	1.36	5.58	92.07
Target voice × Lexical overlap	0.84	-0.85	2.55	0.72
Prime order × Lexical overlap	2.05	0.38	3.72	6.86
Target voice × Prime order × Lexical overlap	-1.76	-3.38	-0.11	3.69

Note. Upper and lower indicate the bounds of 95% probability intervals (PIs). Bayes Factors (BFs) indicate the evidence in favor of the alternative hypothesis.

3.3 Discussion

Experiment 2 tested whether the priming effects in Experiment 1 were due to the differences in word order flexibility of the two voices, or to a clash between prime and target voice. Experiment 2 revealed a different pattern of results to Experiment 1. The most important finding for Experiment 2 was that the priming effect in agent voice sentences—observed in Experiment 1—disappeared. This demonstrates that a voice mismatch between prime and target verbs does not result in an increased number of patient-initial utterances (prime verb was inflected with the patient voice infix -*in*- while the target verb was inflected with the agent voice infix -*um*-). Additionally, we found evidence for priming effects in patient voice sentences (voice matching the prime), which was not observed in Experiment 1. This supports the hypothesis that priming is conditional on verb-voice match and is not limited to the agent voice. The results are thus consistent with the argument that the two voices constitute separate syntactic structures.

Patient voice priming in Experiment 2 was different to agent voice priming found in Experiment 1. Notably, it was only found in the verb overlap condition, which raises questions regarding how abstract priming was in Experiment 2. There are at least two explanations of the lexical boost effect. The residual activation account explains lexical boost as the additional activation of the verb at the lemma level boosting the priming effect (Kantola et al., 2023; van Gompel et al., 2022), which attributes both forms of priming—abstract word-order priming and lexical boost—to a single mechanism. However, there is evidence against this explanation: for example, abstract priming and lexical-boost effects decay on different time schedules, with the lexical boost being particularly short-lived (Bernolet et al., 2016; Hartsuiker et al., 2008; Mahowald et al., 2016). Abstract priming and the lexical boost effects also emerge asynchronously in childhood and have different developmental trajectories (Kumarage et al., 2022; Rowland et al., 2012). These differences have led to the suggestion that abstract priming is attributable to implicit learning and lexical boost is associated with explicit memory (Bock & Griffin, 2000; Chang et al., 2000; 2006; Scheepers et al., 2017).

On this dual mechanism account, the patient voice priming effect may be qualitatively different to the priming observed in the agent voice, driven by explicit rather than implicit processes. We suspect the difference derives from the relative rigidity found in patient voice, which has a large preference for agent-initial and *ang*-last ordering. While patient-first ordering is not ungrammatical in the patient voice, it is dispreferred because it violates these two ordering preferences. In this respect, the result is comparable with priming effects reported for ungrammatical sentences by Ivanova et al. (2012), who found priming of ungrammatical verb-construction combinations only when the prime and target had the same lexical verb but not when they differed. The generalisation is that priming that pulls in the direction of ungrammatical or strongly dispreferred sentences likely requires a form of explicit awareness not typical of regular priming effects. This asynchrony in priming is consistent with the prediction we derived from Riesberg et al. (2019), that priming in the agent voice should be larger in magnitude than in the patient voice. In fact, it appears that it may also be mechanistically different. We return to this issue in the General Discussion.

4. Experiment 3: Pre-registered experiment manipulating agent and patient voice primes with agent voice targets

Experiments 1 and 2 showed a clearly different pattern of results that indicate priming in Tagalog is voice-dependent. However, the design of the experiments was not typical in that we manipulated target voice and held prime voice constant.[8] In our pre-registered Experiment 3, we tested the opposite relation, holding target voice constant (agent voice) and manipulating prime voice. We chose to use agent over patient voice targets because of the absence of abstract priming in Experiment 2. If we once again find that priming is voice-dependent using this slightly altered design, it would suggest that there are multiple independent transitive structures in Tagalog. Based on results of Experiments 1 and 2, we predicted word order priming effects

[8] We thank an anonymous reviewer for making this point.

when the prime sentence was in agent voice and thus matching the voice of the target, but not for mismatching prime sentences in the patient voice.

4.1 Method

4.1.1 Participants

We recruited a total of 96 participants (68 females, 28 males) from Greater Manila Area. Our sample had a median age of 25 years (SD = 5.32, range: 18, 36). None reported having been previously diagnosed with any speech or language impairments, or a psychological or neurological illness. As in Experiments 1 and 2, we excluded participants who contributed less than 20 trials (n = 12), had done the experiment previously (n = 8), failed to follow the instructions (n = 9) or showed a sentence-picture match accuracy lower than 60% (n = 3). We replaced rejected participants so that the final data set included 4 participants per experimental list; i.e. a total of 64 participants for analysis.

4.1.2 Design, Materials, and Procedure

In a 2 x 2 x 2 design, we crossed prime order (i.e., thematic role order of the prime sentence: agent-initial, patient-initial), prime voice (i.e., voice-marking of the prime verb: agent voice, patient voice), and lexical overlap between prime and target verbs (verb overlap, no verb overlap; see Table 4 for a full item and https://osf.io/wc2xz for a complete list of the items). The target prompts were always in the agent voice. The rest of the design, materials, and procedure were the same as those used in Experiments 1 and 2. The experiment was pre-registered on OSF: https://osf.io/57g4u.

Table 4. Sample item for the target verb "tickling" given a target picture of a monkey tickling a dog, and prime pictures involving a bear and a frog in Experiment 3. The prime sentence in the lexical overlap condition translates to "The/A bear is tickling the/a frog", while the prime sentence in the no overlap condition translates to "The/A bear is kicking the/a frog". All target prompts were "tickling" in the agent voice, i.e., "kumikiliti."

Lexical overlap	Prime word order	Prime voice	Prime sentence
overlap	agent-initial	agent voice	Kumikiliti ang oso ng palaka.
		patient voice	Kinikiliti ng oso ang palaka.
	patient-initial	agent voice	Kumikiliti ng palaka ang oso.
		patient voice	Kinikiliti ang palaka ng oso.
no overlap	agent-initial	agent voice	Sumisipa ang oso ng palaka.
		patient voice	Sinisipa ng oso ang palaka.
	patient-initial	agent voice	Sumisipa ng palaka ang oso.
		patient voice	Sinisipa ang palaka ng oso.

4.2 Results

Data analysis followed the same methods as in Experiments 1 and 2. We removed trials with missing recordings or incorrect voice (76 trials, 4%), and trials where participants responded incorrectly to the sentence-picture match task (219 trials, 11%) suggesting insufficient engagement with the prime sentence.

Table 5 summarises the results of the Bayesian mixed-effects model on the probability of using patient-initial sentences. There was strong evidence for a main effect of prime voice, showing that patient-initial productions were more frequent for agent voice primes than for patient voice primes. As might be expected, and similar to Experiments 1 and 2, there was strong support for a main effect of prime order, showing more patient-initial sentences for patient-initial primes. While there was no evidence for a main effect of lexical overlap, we found support for two-way interactions for prime order by prime voice and by lexical overlap. Evidence for the prime voice by lexical overlap interaction was negligible. Finally, there was converging evidence for the three-way interaction of prime voice, prime order, and lexical overlap.

From the posterior, we obtained the priming effects—the difference between patient-initial and agent-initial prime conditions—to evaluate the three-way interaction. The results can also be seen in Figure 4. Word order priming was found for agent voice primes (which match the voice of the target verb) in the lexical-overlap condition (Estimate = 3.50, PI = [2.65, 4.44]), with a substantially smaller effect in the no-overlap condition (Estimate = 0.61, PI = [-0.03, 1.30]). As predicted, we observed no word order priming effects for the patient voice primes (mismatching the voice of the target), neither in the lexical overlap condition (Estimate = -0.26, PI = [-1.21, 0.70]) nor in the no-overlap condition (Estimate = -0.16, PI = [-0.98, 0.69]).

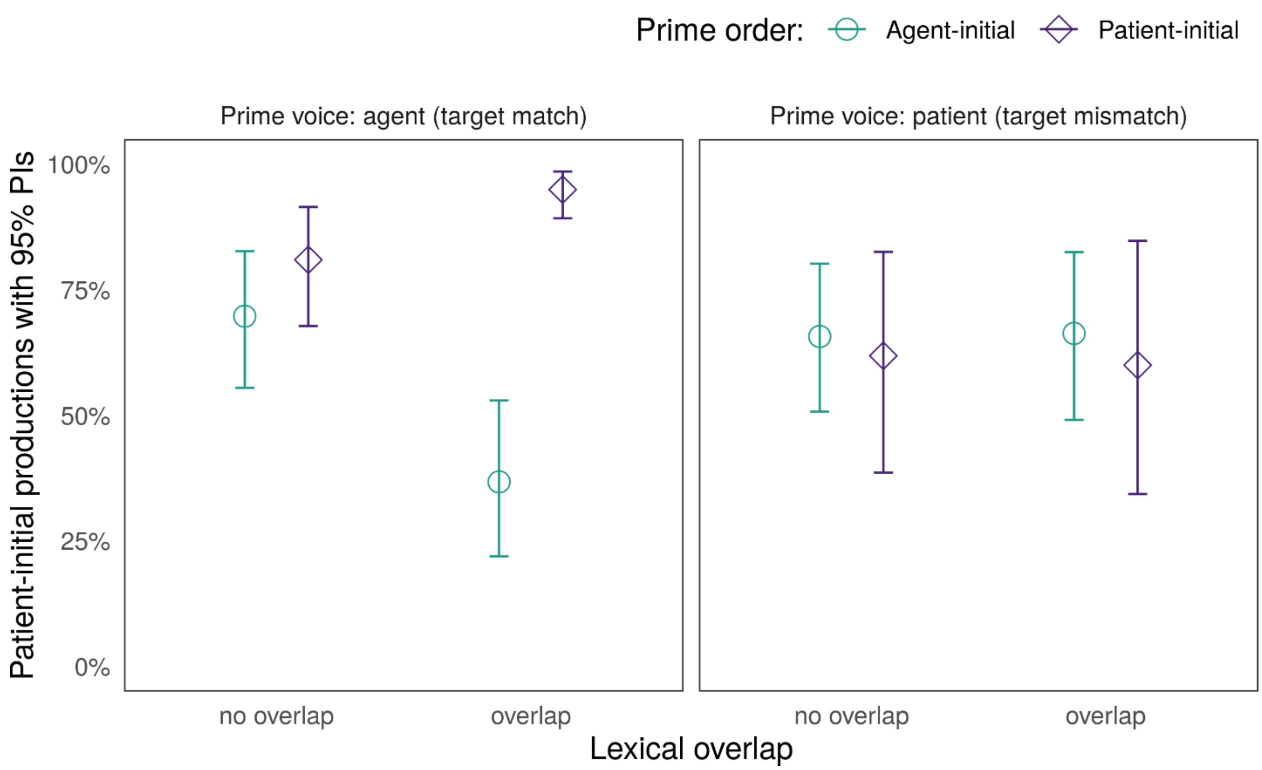

Figure 4. Inferred population means with 95% probability intervals (PIs) in Experiment 3.

Table 5. Main effects and interactions of the patient-initial productions in Experiment 3 (agent, patient voice primes) with coefficients shown on the logit scale.

Predictor	Estimate	Lower	Upper	BF
Main effects				
Prime voice	2.22	0.94	3.49	63.02
Prime order	-2.88	-4.45	-1.33	> 100
Lexical overlap	0.41	-0.92	1.71	0.4
Interactions				
Prime voice × Prime order	-3.81	-5.36	-2.23	> 100
Prime voice × Lexical overlap	0.14	-1.08	1.37	0.31
Prime order × Lexical overlap	2.42	1.17	3.64	> 100
Prime voice × Prime order × Lexical overlap	2.52	1.14	3.87	72.36

Note. Upper and lower indicate the bounds of 95% probability intervals (PIs). Bayes Factors (BFs) indicate the evidence in favor of the alternative hypothesis.

4.3 Discussion

Our hypothesis of voice-specific priming was confirmed. Like in Experiment 1, we found that agent voice primes only led to word order priming in agent voice targets. This occurred both in the presence and absence of verb overlap (but was stronger in the former) and is once again consistent with the suggestion that the agent and patient voice structures are representationally distinct (Chen & McDonnell, 2019; Himmelmann, 2002, 2005; Foley, 2008; Riesberg, 2014), which we have argued logically follows from Chang et al. (2006)'s Dual-path model of sentence production.

5. General Discussion

In the current paper, we have presented three structural priming studies focusing on Tagalog's symmetrical voice system, a typologically unique feature of Philippine-type Austronesian languages whereby the transitive alternation is syntactically 'balanced' (i.e., symmetrical) in the agent and patient voice. Studying Tagalog enabled us to test the effect of voice morphology on priming. Word order priming was conditional on the voice of the target sentence, and the priming strength differed across voice. Priming effects were stronger in agent voice sentences (Experiment 1) than in the patient voice (Experiment 2), which showed an overwhelming preference for agent-initial sentences, barely allowing for any priming at all. Notably, we observed that priming effects disappeared when the voice of the target verb mismatched the voice of the prime sentence. In our pre-registered Experiment 3, we confirmed that word order priming effects disappeared when the voice of the prime did not match the voice of the target.

The current results are inconsistent with the residual activation account of priming, as there was priming only when the prime and target verbs had the same voice (i.e., both prime and target verbs were inflected with the infix -*um*-). In other words, word order priming effects were subject to changes in verb morphology, which is not predicted by the residual activation account (Pickering & Branigan, 1998). Our experiments, to the best of our knowledge, constitute the first time that this account was tested in a language with a voice-marking system where a change in verbal morphology results in changes in the mapping of thematic and syntactic roles. We demonstrated convincingly that word order priming effects disappear when verbal voice morphology in the prime and target verbs differ, and therefore the mapping between syntactic and thematic roles.

We note that our interpretation of the residual activation account presumes that verbs inflected in agent or patient voice have the same lemma-level representation. We assumed that voice is not represented at the lemma level (similar to tense), which is not implausible because both voices have the same root morpheme. However, it might be that verbs in agent voice and patient voice have different lemma-level representations in Tagalog. If this were the case, the residual activation account would predict a different pattern of priming, but one that may still be inconsistent with our results. On this account, a Tagalog agent voice *kick-ng-ang* (patient-initial) prime sentence would result in residual activation in agent voice-KICK, in the *ng-ang* node, and in the link between agent voice-KICK and the *ng-ang* node. The most straightforward prediction from this account would be to observe abstract priming and lexical boost for agent voice KICK targets. In this case, the current results would not be inconsistent with Pickering and Branigan's (1998) model. However, activation of the *ng-ang* node may also lead to the prediction of an abstract priming effect but no lexical boost for patient voice KICK targets, which we did not observe.[9] In any case, this would require the additional assumption that voice morphology is representationally different from other verb inflections such as tense and number, which is not originally specified in the account. Whether or not voice is represented at the lemma level is an empirical question for future research.

The current results are consistent with Chang et al.'s (2006) Dual-path model. This model claims that syntactic generalisations are acquired across the course of language development and

[9] We thank an anonymous reviewer for alerting us to this point.

are language-specific. Notably, because the model acquires syntactic knowledge in an initially lexicalized, non-decomposed manner, it predicts that priming should be specific to each voice because each voice will have a separate structural representation (e.g., see Chang, 2009; Chang et al., 2015), which is consistent with symmetrical voice analyses of Austronesian voice (Chen & McDonnell, 2019; Himmelmann, 2002, 2005; Foley, 2008; Riesberg, 2014). The current findings are partly consistent with Chang et al.'s (2015) results, who found that the magnitude of structural priming in German varied depending on tense/aspect-induced word order variation. Notably, they reported that priming was strongest when prime and target shared word order overlap (i.e., verb-final structures primed verb-final targets more than verb-medial targets and vice-versa), a finding they suggested was consistent with a model whereby German speakers acquire distinct but connected transitive structures (i.e., a past tense, where the verb occurs in the second position, and a past participle, where the inflected lexical part of the verb is clause final). In contrast to Chang et al., we found no evidence of priming across voices in Tagalog. We interpret this to mean that the agent and patient voice are, in fact, separate structures.

There is some evidence to support the claim–that agent and patient voice are separate structures–from both language acquisition and online processing. In acquisition, young Tagalog-speaking children follow the distributional patterns present in child-directed language, whereby they have an overall preference to use the more frequent patient voice, and when using the agent voice, they prefer to use it in the intransitive (Garcia & Kidd, 2022). This early preference to use the patient voice seems to result in the earlier acquisition of patient voice argument mappings compared to agent voice mappings for the transitive (Garcia et al., 2018, 2019; Garcia & Kidd, 2020). Data from studies with adults also suggest differences between the two voices. In production, evidence from pupillometry suggests that the two voices do not differ in terms of their planning processes, but that the use of the patient voice involves slightly more cognitive effort (which was taken to suggest an anti-patient-as-subject bias, Sauppe, 2017). The differences across the two structures are more evident in comprehension. In a visual world eye-tracking study, Garcia et al. (2021) found that adult speakers could rapidly predict the identity of the upcoming referent in patient voice but not in agent voice. The same qualitative pattern was observed in 5- to 9-year-old Tagalog-speaking children. They interpreted the results to reflect a representational difference between the two voice types; that is, that there exist distinct transitive structures for each voice type. The data from the current study are consistent with this interpretation.

5.1. Variability of priming between voices

Not only was there no priming across voice in our data, but the pattern of priming within voice was considerably different. Notably, priming in the agent voice resembled priming effects in more commonly-studied languages (see Mahowald et al., 2016): we found a robust word order priming effect and a larger lexical boost effect. This was not the case in the patient voice, where we only observed priming when the same verb was used in the prime and target.

This pattern of results is consistent with the grammatical preferences on word order in the language. Specifically, the agent voice allows greater flexibility in argument order because of the countervailing forces of the agent-first and *ang*-last preferences (Guilfoyle et al., 1992; Kroeger, 1993b; Riesberg et al., 2019): an agent-initial order in the agent voice satisfies the first but not the second preference, while a patient-initial order in the agent voice satisfies the second but not the first preference. In instances where other cues to word order are neutralised (e.g., animacy cues, discourse cues), as was in the case in our study, this results in no overwhelming preference for one word order over the other. The end result is that there is greater priming in the agent voice. In contrast, for the patient voice the constraints on word order converge to strongly prefer one word order—agent-initial *ang*-last—which reduces the chance to observe priming effects in patient voice sentences. In fact, data from the sentence-picture matching task component of our prime trials revealed a lower accuracy for patient voice sentences that were patient-initial compared to agent-initial sentences (Experiments 2 and 3)[10]. This finding suggests that participants had more difficulty interpreting patient-initial sentences in the patient voice compared to agent-initial sentences.

Indeed, priming in the patient voice was limited to the verb overlap condition, which we suggested may indicate a qualitatively different form of priming. Specifically, we suggested that this may be driven by explicit memory, following arguments that the lexical boost arises from explicit memory traces for structure cued by the repetition of the verb (Chang et al., 2003; Bernolet et al., 2016; Hartsuiker et al., 2008; Mahowald et al., 2016). Thus, in Experiment 2, the verb “kick” marked with the patient voice inflection in the target sentence acted as a memory cue to the wording of a prime sentence with a patient voice inflected “kick” and to this prime’s word order. The key finding here is not that priming was found in instances of lexical overlap, but that abstract priming was absent. The patient voice is particularly resistant to word order priming, which is not the case for the agent voice.

This provides interesting individual-level data bearing upon arguments regarding diachronic change in Austronesian symmetrical voice systems. In particular, Riesberg et al. (2019) argued that, based on the Universal Agent Principle, symmetrical voice languages follow a diachronic change pattern in which strict subject-last (i.e., *ang*-last in Tagalog) ordering

[10] The analysis of participants’ accuracy scores in the sentence-picture matching task can be found in the full results released on OSF: https://osf.io/39rdw.

changes across time to become strictly agent-initial (i.e., *ang*-first in Tagalog agent voice), via an intermediate stage in which both orders are possible, a stage that Tagalog currently appears to be in. That the agent voice transitive is capable of greater priming than the patient voice may suggest that priming (or indeed, *implicit learning*, see Dell & Chang, 2014) could be one mechanism that drives this diachronic change. This is consistent with arguments made by Jäger and Rosenbach's (2008), who outlined a model of how priming at the individual level leads to unidirectional language change across time. The suggestion is that a universal preference to place agents in early sentence positions (Bickel et al., 2015; Bornkessel & Schlesewsky, 2006; Sauppe et al., 2021) primes the use of agent-initial sentences, gradually changing speaker preferences across time, with different Austronesian languages that contain Philippine-style symmetrical voice systems being at different points in this process.[11]

5.2 Locus of priming

Past research suggests that structural priming may occur at the syntactic level (Bock & Loebell, 1990; Pickering & Ferreira, 2008), or the semantic (thematic) level (Cai et al., 2012; Chang et al., 2003; Köhne et al., 2014; Salamoura & Williams, 2007; see Ziegler et al., 2019 for a review). For Tagalog, the differing pattern of priming depending on voice suggests that priming occurred at the level of syntactic roles *in concert with* their voice-specific thematic role mappings. That is, priming occurred in the case of (9a) and (9b; in instances of lexical overlap, where A = agent, and P = patient), but was not observed in the case of (10a) and (10b).

[11] Evidence in favor of priming as a driver of diachronic change is not overly extensive, but has been linked to contact-induced language change in bilingual communities (e.g., Kootstra & Sahin, 2018), where contact with one language can influence variable preferences in another, and in instances of language change in the absence of multilingualism (Torres Cacoullos, 2015; see also Pickering & Garrod, 2017).

(9a) V<A> *ng*<N_P> *ang*<N_A>   (9b) V<P> *ng*<N_A> *ang*<N_P>

↓ ↓   ↓ ↓

V<A> *ng*<N_P> *ang*<N_A>   V<P> *ng*<N_A> *ang*<N_P>

(10a) V<A> *ng*<N_P> *ang*<N_A>   (10b) V<P> *ng*<N_A> *ang*<N_P>

———   ———

V<P> *ng*<N_A> *ang*<N_P>   V<A> *ng*<N_P> *ang*<N_A>

That priming did not occur across voice, despite the use of the same syntactic noun markers, was taken by us to indicate that the agent and patient voice structures are representationally distinct. One alternative possibility is that they are not distinct, but that the valency change induced by voice cancelled two opposing sources of priming—structural and thematic role priming. Since the Tagalog symmetrical voice system allows a flexible mapping between thematic and syntactic roles, word order priming can only be associated with either syntactic or thematic roles, not with both. Thus, if the prime is patient / "non-subject"-initial but the voice of the target sentence mismatches the prime, as in (10a), the target sentence can only be either patient-initial or "non-subject"-initial. Therefore, Tagalog allows us to test what happens if priming on a syntactic and a thematic level is predicting opposite word order configurations.

Accordingly, there are two possible explanations for why we observed no word order priming for mismatching voices. Firstly, priming could be conditional on an identical mapping between syntactic and thematic roles in prime and target. If the prime requires a different mapping, priming does not occur. Secondly, word order priming could occur at both levels, syntactic and thematic roles, but because they do not converge in one surface structure, the output sentence may be generated probabilistically, either following a syntactic or a thematic preference. In other words, for voice mismatching target verbs, participants could produce a sentence that is congruent with a syntactic priming effect for some trials, and a sentence that is congruent with a thematic priming effect for other trials, making a priming effect difficult to observe. While possible, we suggest that this explanation is less likely than our claim that the knowledge of the transitive is voice-specific. There are several reasons for this. Firstly, we note that thematic role order priming is typically weaker than syntactic role priming (Chang et al., 2003), so it is unclear whether it could cancel out syntactic role priming.[12] Secondly, if thematic role priming and syntactic role priming work antagonistically in related structures, we should see a similar pattern of variance in both across-voice priming conditions. However, this was not the case: the variability instead reflected the general flexibility of the voice inflection in the target—more flexible in the agent voice and distinctly inflexible in the patient voice. That is, it reflected the usage patterns of the two voice types unaffected by the prime (Garcia et al., 2018).

5. Conclusion

In the current paper, we present data that demonstrate syntactic priming in Tagalog is voice-specific in two key ways: first, there were no word order priming effects if the verbs of the prime and the target sentence were marked by different voice inflections; second, when the verb of the prime and the target sentence were inflected with the same voice morpheme, the magnitude of word order priming effect was conditional on the voice morpheme, with priming

[12] Interestingly, Garcia and Kidd (2020) found some evidence for a weak thematic role priming effect for agent voice primes in children (ages 3 – 7 years), but not adults. It is conceivable that thematic role ordering is prioritised in development as children acquire abstract knowledge of the noun markers. Regardless, the authors found no evidence of the effect in their adult participants.

effects being larger for the voice type that was associated with a more flexible word order. This voice-dependency of word order priming is best explained by models of language that acquire language-specific grammatical representations (Chang et al., 2006).

Overall, these results emphasise the importance of casting the widest possible linguistic net to challenge the predictions of psycholinguistic theories. Psycholinguistics has largely ignored typological diversity, and this is reflected in many potentially erroneous assumptions made by theories. For example, at the broad level, many approaches have assumed that grammatical relations in all languages can be described in the same representational format, using hierarchical structure. Even when that assumption is tested, the languages brought to bear upon the issue typically belong to the class of languages from which the original ideas came (i.e., Indo-European languages like Dutch, e.g., see Coopmans et al., 2022). The 7,000 or so languages of the world show remarkable diversity that provide important tests of these ideas (e.g., in contrast to Indo-European and Austronesian, Australian languages are famous for their distinct lack of constituent structure, for psycholinguistic implications see Nordlinger et al., 2022). A point that we have argued here is that, consistent with Chang et al.'s (2006) learning-based model of language production, grammatical generalisations can be language-specific (see also Chang, 2009; Chang et al., 2015). This is not to say that we should not expect commonality and similarity across languages; typological diversity is not completely unconstrained and involves 'soft' universals (e.g., Keenan & Comrie, 1977) and functional constraints such as how the agent-first principle exerts an influence on word order preferences (Bickel et al., 2015; Bornkessel & Schlesewsky, 2006). Taking typological diversity seriously challenges our psycholinguistic models in exactly the right manner, bringing us closer to explanatory adequate models of language.

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