Agent-first and pivot-second constraint effects in the online sentence processing of Tagalog flexible word order

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Abstract

Multiple explanatory accounts of Tagalog word-order preferences have been proposed in the literature. We report three psycholinguistic experiments that investigate on-line comprehension patterns in Tagalog to illustrate the strength and consistency of two grammatical constraints in sentence processing (Bondoc and Schafer, 2022): a tendency for the agent to be placed in the first argument position (agent-first), and for the syntactically prominent argument (the pivot) to be placed in the second argument position (pivot-second). Our results show significant effects of these two constraints in the moment-by-moment reading of sentences, and also that their effects shift across measures and tasks. These outcomes contribute to the evidence of agent-first and pivot-second constraints influencing Tagalog word-order preferences and highlight their critical role in cognition and in Tagalog sentence processing.

Keywords: *sentence comprehension, Philippine-type voice, psycholinguistics, reading, word order*
ISO 639-2 language code: tgl

1.0 Background

A good number of the world's languages exhibit word-order flexibility, particularly in the ordering of the major sentential constituents subject (S) and object (O) relative to the verb (V) in basic declarative sentences.* Such flexibility has been documented in many languages exhibiting the Philippine-type voice, a system of verbal morphology that can select elements of various thematic roles as syntactically prominent, which we call the *pivot* in this paper (e.g., Chen & McDonnell, 2019). Most of the Formosan and Philippine languages associated with the Philippine-type voice system have been described with word-order flexibility (e.g., Reid & Liao, 2004).

One of the Philippine-type languages extensively described in terms of word-order flexibility is Tagalog, a major language spoken in the Philippines (Eberhard et al., 2023). Despite the

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flexibility of word order in Tagalog, speakers nevertheless demonstrate preferences. How are these preferences best captured in the grammar? Explanations for what drives word-order preferences in Tagalog have not reached a consensus, perhaps in part because of the somewhat limited empirical evidence that has been available to distinguish among different characterizations. Some scholars argue for a preference for patterns in which agents occupy the first argument position in the sentence (e.g., Schachter, 2015), while some argue for a tendency for the syntactically prominent argument to occupy the last argument position in the sentence (e.g., Himmelmann, 2005). Other accounts argue for an interaction between these tendencies, resulting in a ranking of preferences across possible permutations of word order and voice (e.g., Kroeger, 1993).

In this paper, we bring empirical evidence to bear on this question and argue for an explanation based on a grammar comprised of multiple gradient constraints. We experimentally examine two grammatical constraints proposed to influence Tagalog word-order preferences: agent-first and pivot-second (described further below). In three reading experiments, we show that both grammatical constraints account for aspects of online comprehension patterns, and remain evident even in cognitively constrained contexts, offering support as explanations for Tagalog word order. We also demonstrate how the strength of these two grammatical constraints emerges differently across our three experiments. These empirical findings from online comprehension illustrate how using psycholinguistic methods can support the examination of grammatical phenomena such as Tagalog word order, and set the stage for further investigation of the nature of cognitive and linguistic factors that underlie these constraints.

This paper is organized as follows. We begin with a review of the Tagalog voice system and the theoretical explanations used to account for the word-order patterns. We then turn to the three experiments, to examine how the online comprehension patterns support the agent-first and pivot-second constraints. We end with a Discussion section, in which we highlight the implications of the experimental findings for explanations of Tagalog word-order preferences, discuss the nature of these grammatical constraints, and outline future research directions that can be pursued to further our understanding of the nature of these constraints.

1.1 The Tagalog Voice System

Tagalog is a major language in the Philippines spoken by approximately 83 million people worldwide as both first and second languages (Eberhard et al., 2023). It employs the Philippine-type voice system, characterized by the presence of voice morphology on the verb that identifies the *pivot*, the element accessible to many syntactic phenomena. In Philippine-type languages, various thematic roles (e.g., agent, patient, locative, benefactive, instrument, etc.) can be marked as the pivot (Foley, 1998; Himmelmann, 2005; Latrouite, 2011; McDonnell, 2016; Riesberg, 2014; Schachter & Otanes, 1972). In Tagalog the element marked as pivot receives the nominal marking *ang* [ʔaŋ], while the non-pivot argument has the marking *ng* [naŋ].

Example sentences (1) and (2) illustrate this voice system, using the verb stem *hanap* 'to search'. Both sentences contain an agent and a patient argument. In sentence (1), the verb is marked with the agent voice affix <-um->. In the agent voice, the agent argument *pamilya* 'family' is identified as the pivot or the syntactically privileged argument, and is thereby marked by *ang*. The non-pivot patient argument *doktor* 'doctor' is marked with *ng*. In contrast, the verb in sentence (2), which is in the patient voice, receives the patient voice affix <-in->. In the patient voice, the patient argument *doktor* 'doctor' is identified as the pivot, marked with *ang*, while agent *pamilya* 'family' is identified as the non-pivot agent, marked with *ng*.

Agent Voice, Agent-Initial Order

(1)	H<**um**>anap	**ang**	**pamilya**	ng	doktor.
	<AV.PRF>search	PVT	family	NPVT	doctor

'The family looked for a/the doctor.'

Patient Voice, Agent-Initial Order

(2)	H<**in**>anap	ng	pamilya	**ang**	**doktor**.
	<PV.PRF>search	NPVT	family	PVT	doctor

'A/The family looked for the doctor.'

What adds to the intricacy of Tagalog syntax is the flexibility of word order (Kroeger, 1993; Schachter & Otanes, 1972). Sentences (1) and (2) have agent-initial word order; these two voice alternations also allow patient-initial word order, as illustrated in (3) and (4). In these sentences, only the position of the noun phrases is switched; nominal marking remains the same relative to voice morphology. The agent and patient voice patterns are the two most common patterns in the language, with the patient voice occurring more frequently than the agent voice (Cooreman et al., 1984).

Agent Voice, Patient-Initial Order

(3)	H<**um**>anap	ng	doktor	**ang**	**pamilya**.
	<AV.PRF>search	NPVT	doctor	PVT	family

'The family looked for a/the doctor.'

Patient Voice, Patient-Initial Order

(4)	H<**in**>anap	**ang**	**doktor**	ng	pamilya.
	<PV.PRF>search	PVT	doctor	NPVT	family

'A/The family looked for the doctor.'

1.2 Previous Work on Tagalog Word-order Flexibility

There are multiple proposals on the preferred word-order pattern(s) in Tagalog. Some scholars suggested a preference for the agent to occupy the first argument position (which we refer to as the agent-first tendency; Chen, 2017; Manueli, 2010; Schachter, 2015), while some suggested a preference for the pivot to occupy the last argument position (referred to here as the pivot-last tendency; Himmelmann, 2005)[2]. Other scholars posit the application of both principles. Riesberg et al. (2019) suggest that the agent-first tendency applies to non-agent voice patterns, while the pivot-last tendency applies to agent voice patterns. In contrast, Kroeger (1993) described the application of both agent-first and pivot-last principles in Tagalog. Assuming a declarative sentence that contains both an agent and patient, the influence of both of these principles produces the strongest preference for Patient Voice with Agent–Patient word order as it satisfies both principles; an equal preference for the two Agent Voice patterns (Agent–Patient and Patient–Agent orders) as each pattern only satisfies one of the two principles; and a strong dispreference for Patient Voice with Patient–Agent order as it does not satisfy either of the two principles. Other

[2] In his work, pivots are referred to as subjects, hence the principle is subject-last. We refrain from using the term 'subject' due to disagreements in the field regarding the subject in Philippine-type voice languages (e.g., Schachter, 1976; Kroeger, 1993). In constructions with just two arguments following the verb, a "pivot-last" constraint and a "pivot-second" constraint would make the same prediction; however, the two formulations can differ in other cases.

scholars have taken a similar view with Kroeger on the influences of both principles on Tagalog (Hsieh, 2016; Kaufman, 2009).

A recent production study by Bondoc and Schafer (2022) examined how voice morphology relates to word order, by testing two probabilistic grammatical constraints across various voice patterns, including understudied voices such as the benefactive and instrument voice. The two gradient constraints they proposed interact with each other and drive the distribution of the various sentence patterns and the probabilities in which they occur. These probabilities correlate with their frequencies, and impact processing difficulty, such that more frequent patterns are processed more easily, and less frequent ones are processed with more difficulty. These two probabilistic constraints were the agent-first constraint, which states that agents preferentially occupy the first argument position, and the pivot-second constraint, which states that pivots preferentially occupy the second argument position. Results showed that native Tagalog adults demonstrated word-order preferences that aligned with these constraints. These results entail a strong preference for the agent-initial word order in patient voice, and two equally preferred word-order patterns (Agent–Patient and Patient–Agent orders) in the agent voice. These results are congruent with other recent experimental work (e.g., Garcia et al., 2018), as well as more recent corpus work. In this latter work Garcia and colleagues (2021) extracted sentences containing two arguments (either pronominals or lexical noun phrases) from a Tagalog corpus of child-directed speech. In sentences containing pronominals, agent-first patterns dominated regardless of voice. However, in sentences containing two lexical noun phrases, agent-first patterns only dominated in the patient voice; an equal preference for agent-first and patient-first sentences was attested in the agent voice.

Previous work on the comprehension of Tagalog declarative sentences also shows evidence of the agent-first constraint. Questionnaire studies have shown better accuracy for sentences with Agent–Patient word order than those with the opposite pattern, with higher accuracy in the more frequent patient voice than in the agent voice (Bondoc et al., 2018; Garcia et al., 2020). A visual world eyetracking study by Sauppe (2016), which examined the real-time anticipation of elements in the unfolding signal using verb and voice information, found that regardless of the voice, comprehenders showed online anticipatory effects for the agent (but not the pivot) upon hearing the verb and its voice morphology.

While previous work has shown the effects of the agent-first constraint in online processing, the effects of pivot-second have been less apparent, potentially due to the methodologies used in earlier work. For example, participants may employ strategies in comprehension questions when completing experiments to get high accuracy scores (e.g., identifying the agent in the sentence instead of fully comprehending the sentence). The visual presentation of the stimuli in the visual world eyetracking paradigm (e.g., presenting agents/animate entities at the top of the and patients/inanimates at the bottom of the screen) may also increase the saliency of certain entities over others (Bondoc & Schafer, 2022), thereby directing listeners' attention to the more salient elements rather than generating morphosyntactic effects in response to processing arguments at their specific positions in the sentence.

In this study, we employ a reading methodology to demonstrate the effects of agent-first and pivot-second in online (i.e., moment-by-moment) comprehension. Through three reading experiments we show the manifestation of agent-first and pivot-second in real-time comprehension, supporting the validity of the proposed grammatical constraints and their underlying influence in driving Tagalog word-order preferences. Two of our experiments also include the addition of a cognitive load while reading (e.g., an additional time or memory constraint) to shed light on how the effects of the agent-first and pivot-second constraints might differ in strength across situations. Lastly, we discuss the important implications of these findings in the context of the Tagalog word-order phenomenon, the nature of these constraints, and the future directions that can be pursued.

2.0 Experiment 1: Self-Paced Reading

In Experiment 1 we used self-paced reading to probe agent-first and pivot-second effects as Tagalog speakers read through sentences that varied in terms of Voice and Word Order. More specifically, we used a non-cumulative moving window self-paced reading task. In such tasks, sentence fragments are presented in increments on a computer. Participants are asked to press a button to read the next sentence fragment and hide the previous fragment. The computer records the online (moment-by-moment) response time in reading and processing each sentence fragment.

We manipulated whether the verb was marked with agent voice or patient voice and whether the arguments were ordered as Agent–Patient (AgPat) or Patient–Agent (PatAg). In this experiment, critical sentential regions—the verb, first noun phrase, and second noun phrase—were presented in increments to measure response times in real time as each fragment was encountered (Table 1). Each critical sentence consisted of a warm-up adjunct (Region 1), the main verb (Region 2), the initial half of the first NP (Region 3), the latter half of the first NP (Region 4), the initial half of the second NP (Region 5), the latter half of the second NP (Region 6), and a concluding adjunct (Region 7).

A long line of research has established the highly incremental nature of typical sentence comprehension by native speakers, in which moment-by-moment effects are generated as the linguistic material unfolds. In our particular task of self-paced reading, the timing of the effects appears to be sensitive to how the material is partitioned into regions, as well as other aspects of the task. In some studies, effects can be observed at the earliest opportunity, that is, at the sentence region that presents the critical material (e.g., Garnsey et al., 1997; Pizarro-Guevara & Dillon, 2022). In other studies, the effects can be displaced to the following region (or regions), a phenomenon known as "spill-over" effects (e.g., Wagers et al., 2009). Although we are unaware of controlled studies of spillover effects, we can expect that they are more likely when the critical region presents short, high frequency material (as in Wagers et al., 2009) and the participants are generally exhibiting shorter reading times (across the board), while immediate effects are more likely with lower frequency lexical items and a less rapid pace of reading (Pizarro-Guevara & Dillon, 2022).

In our study, the lexical content of the regions led us to anticipate that the effects of the grammatical constraints should be observed at and/or immediately following the sentence regions associated with them. Assuming immediate effects, at Region 2, we should expect an advantage for the highly preferred Patient Voice, resulting in shorter reaction times for verbs in the PV compared to the AV. Morphosyntactic effects in response to pivot-second, or positioning the pivot in the second position, should be observed in the nominal marker regions, i.e., Regions 3 and 5. Assuming a verb that takes two nominal arguments, a tendency for pivot-second should be demonstrated with Tagalog speakers preferring the non-pivot argument (the *ng*-phrase) to be placed in the first position, and the pivot argument (the *ang*-phrase) to be placed in the second position. Hence, at the first nominal marker, Region 3, the earliest effect of pivot-second could be observed with shorter reaction times for the nominal marker *ng* compared to *ang*. At the second nominal marker, at Region 5, RTs for phrases containing the pivot marker *ang* should result in shorter reading times compared to the non-pivot marker *ng* in the second noun phrase. Lastly, effects of agent-first should be observed after speakers have encountered a nominal marker for a non-pivot (*ng*) and then encounter a noun that is appropriate for an agent role in the first noun phrase (Region 4); such effects should result in shorter reading times (RTs) for nouns marked as agent versus patient. Unlike pivot-second effects which demonstrate comprehenders' expected syntactic ordering of the arguments, agent-first effects illustrate the semantic identification of the likely agent relevant when extracting the sentential meaning. Hence, we would expect to find agent-first effects at the first noun. Finding these effects in these regions would illustrate the speakers' preferences for the agents and pivots to occur in the first and second argument positions, respectively.

Table 1

Stimulus items for each condition in Experiment 1

	Voice	Word Order	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7
			Adjunct	V + TimeExp	NM + Num	Adj + N	NM + Num	Adj + N	Adjunct
			Because of the accident	*looked for earlier*	*the two*	*poor families*	*the three*	*wise doctors*	*in the province*
(5)	AV	AgPat (A1-P1)	Dahil sa aksidente	h**um**anap kanina	ang dalawang	dukhang pamilya	ng tatlong	matalinong doktor	sa probinsya.
(6)	PV	AgPat (A1-P2)	Dahil sa aksidente	h**in**anap kanina	ng dalawang	dukhang pamilya	ang tatlong	matalinong doktor	sa probinsya.
			Because of the accident	*looked for earlier*	*the three*	*wise doctors*	*the two*	*poor families*	*in the province*
(7)	AV	PatAg (A2-P2)	Dahil sa aksidente	h**um**anap kanina	ng tatlong	matalinong doktor	ang dalawang	dukhang pamilya	sa probinsya.
(8)	PV	PatAg (A2-P1)	Dahil sa aksidente	h**in**anap kanina	ang tatlong	matalinong doktor	ng dalawang	dukhang pamilya	sa probinsya.

2.1 Participants

Seventy-one native Tagalog speakers (age range 18-48, mean 25.89; 41 female, 30 male by self-report) from Metropolitan Manila in the Philippines participated in the experiment. All participants identified themselves as Tagalog-dominant in a language background questionnaire. All participants also spoke English as a second language, in varying degrees of proficiency. Some participants also identified themselves as speaking a third or fourth language, but of lower proficiency compared to Tagalog and English.

2.2 Norming and materials

Fifty-two verbs for a pretest norming study were drawn from McFarland's (1989) frequency count of Tagalog lemmas. The verbs were controlled in terms of their ability to take AV/PV affixes and the elements that they take as pivots, i.e., all 52 verbs took animate agent and patient elements as pivots.

Complete sentences containing an agent and a patient animate argument were created from these 52 verbs. Highly frequent nominal elements based on the McFarland frequency count were used for the sentences. To ensure the grammatical soundness and naturalness of the sentences for the experiment, a grammaticality judgment task was implemented, in which a different set of 39 native Tagalog participants were asked to rate the naturalness of the sentences for the experiment using a 10-point Likert scale. The 52 verbs were crossed with two voice alternations and the two word-order patterns in a Latin-square design, distributed to four lists. An additional 48 filler sentences were also interspersed among these critical items. These filler sentences included 18 grammatically acceptable sentences of other sentence types and 30 grammatically unacceptable sentences (incorrect word-order patterns, incorrect voice morphology, or missing nominal marking). All sentences within each list were pseudo-randomized.

The judgment ratings were aggregated by verb, voice, and word order, such that there was a rating for each verb for each condition. These ratings were transformed to z-scores, and verbs that had z-scores lower than -0.5 in at least one condition were excluded. A total of 36 verbs were selected for the main study on the basis of the norming study.

The main experiment consisted of 36 critical item verbs, crossed with the two voice alternations and the two word-order patterns in a Latin-square design, distributed to four lists. An additional 72 filler items were used, consisting of intransitives or other sentential patterns (e.g., benefactive/instrumental voice and complex sentences). Sentences in each list were pseudo-randomized to ensure that no two critical items of the same condition occurred consecutively.[3]

Post-stimulus yes/no comprehension questions were administered to test participant comprehension. A sample post-stimulus question for sentence (5) was: "*Humanap ba ang mga pamilya ng mga doktor?* (Did the families look for doctors?)." The syntactic structure of the questions was controlled so that both the sentence stimulus and the question were in the same voice and word order. The full set of items for all experiments is available in the first author's OSF account.

2.3 Procedure

The self-paced reading experiment was implemented using the program E-Prime (Schneider et al., 2002) on a laptop. Participants were assigned in a rotating fashion to one of the lists. They were asked to press a key to read the next sentence fragment, in such a way that the program recorded the online response time in reading and processing each sentence fragment. Participants responded to the post-stimulus task (yes/no comprehension question) by pressing specific letters on the keyboard.

2.4 Analyses

Accuracy in the post-stimulus task was analyzed using a maximal mixed effects logistic regression model in R (R Core Team, 2013) using the *lme4* and *lmerTest* packages (Bates et al., 2015; Kuznetsova et al., 2017). The analysis began with the maximal model justified by the design (Barr et al., 2013), with the binary comprehension responses as the dependent variable. To directly test the effects of grammatical constraints in terms of main effects, we coded our four Voice x WordOrder conditions in our model with the fixed effects Voice (AV/PV), WordOrder (agent-first [A1]/agent-second [A2]), and the interaction of Voice and WordOrder, which corresponds to pivot-second; and with participants and items as random effects. All fixed effects were deviation-coded, such that AV and A1 were mapped to the negative coefficients, and PV and A2 were mapped to the positive coefficients.

[3] All experimental materials and R scripts for analysis are uploaded in OSF and can be accessed with this link: https://osf.io/p37f2/.

For the online task, the reaction times (in ms) for each region were extracted for every condition. Critical items with incorrect responses in the post-stimulus task were excluded. The reaction times for the remaining data were log-transformed, and reaction times that had values greater than 3 standard deviations from the means, separated by region, were excluded. The log-transformed reaction time values for every sentence region were statistically treated using a maximal mixed effects linear regression model in R (Barr et al., 2013; R Core Team, 2013) using the *lme4* and *lmerTest* packages (Bates et al., 2015; Kuznetsova et al., 2017), with the log-transformed RTs as the dependent variable. Similarly, we coded our four Voice x Word Order conditions in our model as Voice (AV/PV), WordOrder (A1/A2), and their interaction as the fixed effects, and with participants and items as random effects. As in the analysis of accuracy, all fixed effects were deviation-coded, such that AV and A1 were mapped to the negative coefficients, and PV and A2 were mapped to the positive coefficients.

2.5 Results and Discussion

Three participants were excluded due to low post-stimulus task accuracy scores (<65%). Only data from 68 participants were included in the analysis (Figure 1).

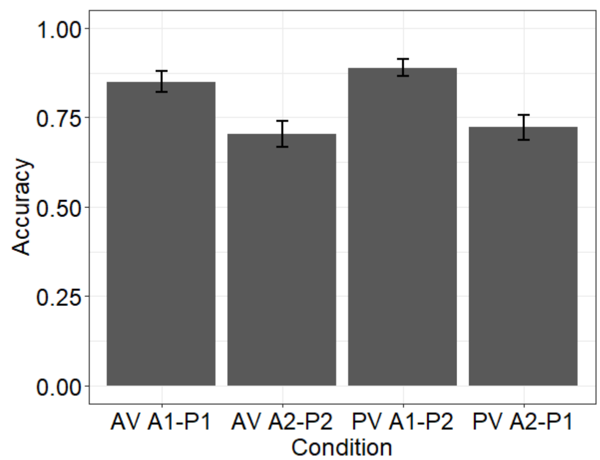

Figure 1. Comprehension accuracy rates in the post-stimulus task. Error bars reflect 95% CI.

2.5.1 Comprehension Accuracy. In terms of voice, accuracy rates were numerically higher in the patient voice condition ($\bar{x}$ = 80.56%, *sd* = 0.40) compared to the agent voice condition ($\bar{x}$ = 77.70%, *sd* = 0.42), but the difference between these two conditions was not significant ($z = 0.99$, $p = 0.32$). As for word order, participants had better performance in the Agent–Patient order ($\bar{x}$ = 86.93%, *sd* = 0.34) compared to the Patient–Agent pattern ($\bar{x}$ = 71.32%, *sd* = 0.45). The difference between these two word-order patterns was observed as a significant WordOrder effect ($z = -5.32$, $p < 0.001$). Further, participants had comparable performance between the Nonpivot–Pivot (P2) order ($\bar{x}$ = 79.66%, *sd* = 0.40) and to the Pivot–Nonpivot (P1) pattern ($\bar{x}$ = 78.59%, *sd* = 0.41), in alignment with the lack of a significant interaction effect of Voice and WordOrder ($z = -1.10$, $p = 0.27$). These results suggest that the offline comprehension patterns were influenced by the agent-first constraint, but not the pivot-second constraint. Table 2 summarizes the results of the mixed-effects logistic regression model.

Table 2

Results of the mixed effects logistic regression models for comprehension accuracy

	β	*SE*	*z*	*p*
Intercept	**1.65**	**0.12**	**13.70**	**< 0.001**
Voice (AV vs PV)	0.20	0.20	0.99	0.32
WordOrder (A1 vs A2)	**-1.12**	**0.21**	**-5.32**	**< 0.001**
Voice:WordOrder	-0.38	0.35	-1.10	0.27

2.5.2 Reaction Times. The reaction times were analyzed for every sentence region (Figure 2). The data will be discussed only for the regions of greatest interest (Table 3), in parallel with the results of the mixed effects linear regression models that examined the main effects of Voice, WordOrder, and their interaction, representing pivot-second effects.[4]

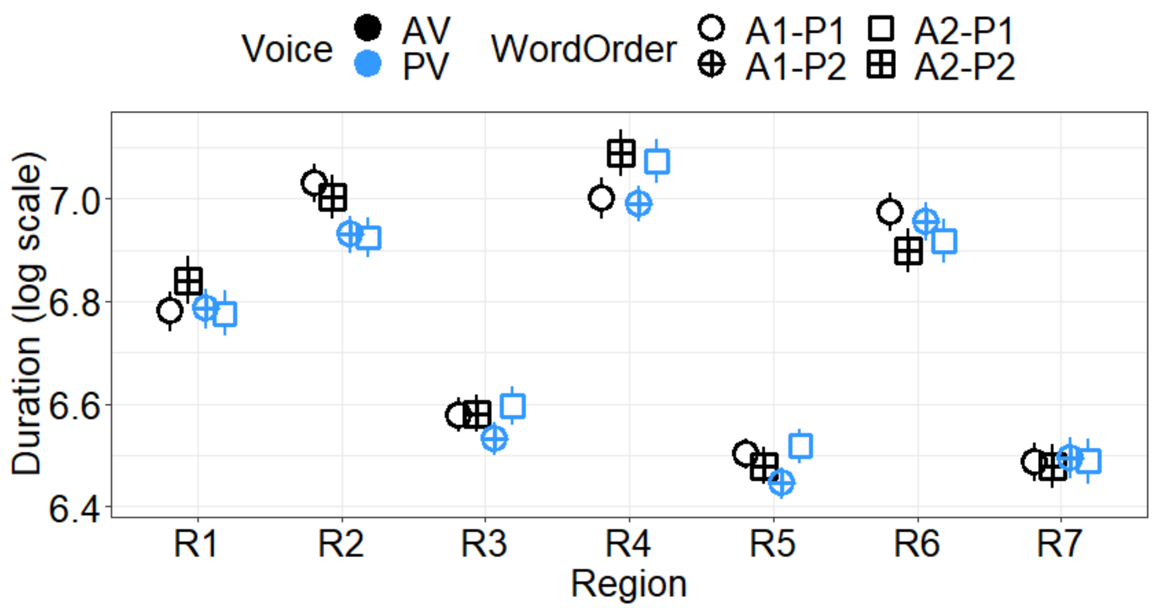

Figure 2. Reaction times (in log scale) in the four conditions across the sentence regions. Error bars reflect 95% confidence intervals.

In Region 2 (verb + adverb), we found observably shorter mean reaction times for the two conditions in the patient voice (blue symbols in Figure 2) compared to the two in the agent voice (black symbols in Figure 2). There was a significant main effect of Voice (t = -2.44, $p < 0.05$), but not of WordOrder (t = -0.16, p = 0.88) nor their interaction (t = 0.04, p = 0.97). The significant Voice effect verified that native Tagalog speakers have a strong preference for patient voice, congruent with the results reported in previous descriptive (Cena, 1977; Cooreman et al., 1984) and experimental work (Garcia et al., 2020; Tanaka et al., 2022).

[4]Results of the statistical models for all sentence regions are uploaded in OSF and can be accessed with this link: https://osf.io/p37f2/.

Table 3

Results of the mixed effects linear regression models that tested the reaction time differences between the conditions reflecting the relevant constraint effects.

	β	***SE***	***t***	***p***	***β***	***SE***	***t***	***p***
	Region 2				**Region 3**			
Intercept	**6.97**	**0.03**	**220.06**	**<0.001**	**6.57**	**0.02**	**279.45**	**<0.001**
Voice (AV vs PV)	**-0.09**	**0.04**	**-2.44**	**<0.05**	-0.01	0.02	-0.64	0.52
WordOrder (A1 vs A2)	-0.005	0.03	-0.16	0.88	0.03	0.02	1.65	0.11
Voice:WordOrder	0.002	0.06	0.04	0.97	0.07	0.04	1.75	0.09
	Region 4				**Region 5**			
Intercept	**7.04**	**0.03**	**204.90**	**<0.001**	**6.49**	**0.02**	**314.92**	**<0.001**
Voice (AV vs PV)	0.001	0.04	0.02	0.98	-0.005	0.02	-0.26	0.80
WordOrder (A1 vs A2)	**0.10**	**0.03**	**3.21**	**<0.01**	0.02	0.02	1.44	0.15
Voice:WordOrder	-0.02	0.06	-0.31	0.75	**0.09**	**0.03**	**-2.57**	**0.01**

In Region 3 (nominal marker + numeral of NP1), numerically shorter mean reaction times were observed for the non-pivot marker *ng* (756.56 ms) compared to the pivot marker *ang* (784.72 ms). However, this small difference did not emerge as a significant interaction effect of Voice and WordOrder representing the pivot-second effect ($t = 1.75$, $p = 0.09$), nor of Voice ($t = -0.64$, $p = 0.52$) nor of WordOrder ($t = 1.65$, $p = 0.11$).

In Region 4 (adjective + nominal of NP1), there were shorter reaction times for the agent-initial word-order patterns (circle symbols in Figure 2) compared to the opposite order (square symbols). The difference between these two word-order patterns was shown through a significant main effect of WordOrder ($t = 3.21$, $p < 0.01$). There was neither a significant main effect of Voice ($t = 0.02$, $p = 0.98$) nor of the interaction in this region ($t = -0.31$, $p = 0.75$). Contrastingly, in Region 5, there were shorter reaction times for phrases containing the pivot marker *ang* (plus-filled symbols in Figure 2) versus the non-pivot marker *ng* (open symbols in Figure 2). Notably, a significant interaction effect of Voice and WordOrder was attested in this region ($t = -2.57$, $p = 0.01$)[5], but not of Voice ($t = -0.26$, $p = 0.80$) nor of WordOrder ($t = 1.44$, $p = 0.15$). The two effects found in Regions 4 and 5 illustrate the influence of the grammatical constraints agent-first and pivot-second in the on-line processing of Tagalog declarative sentences. The constraints proposed by Bondoc & Schafer (2022) hold not only for production tasks such as sentence continuation but are also observable in real-time sentence comprehension.

It is noteworthy that the effects of agent-first and pivot-second vary between the two dependent measures. Agent-first effects were observable with both comprehension accuracy and real-time processing, while pivot-second was evident only in the latter. The pivot-second effect was also observable only at the second nominal marker, i.e., Region 5, but not at the first nominal marker, i.e., Region 3. We return to the discussion of these points below. First, though, we present a pair of experiments in which cognitive constraints were applied, to allow evaluation of the consistency and strength of the agent-first and pivot-second constraints across varying cognitive contexts.

[5]A separate maximal mixed effects model in Region 5, with deviation-coded Voice and WordOrder set in terms of pivot-first/pivot-second also captured a significant WordOrder effect ($t = -2.38$, $p < 0.05$), consistent with our pivot-second interpretation of the interaction in the model reported in the text.

3.0 Experiment 2: Rapid Serial Visual Presentation

In Experiment 2 we examined whether agent-first and pivot-second effects would be demonstrated in a cognitively constrained task. One example of a cognitively constrained context is one in which language is comprehended under time pressure, as in rapid serial visual presentation (RSVP). RSVP tasks are similar to self-paced reading ones, except that the timing of the sentential regions is constrained to a short duration. Cognitively constrained conditions often reflect language processes that can occur in everyday situations, given that people often engage in language activities while also engaging in some other activity or task. Because time pressure can limit the cognitive resources to fully process the sentence, speakers may adapt by focusing on the most informative parts of the signal (Wilkinson et al., 2012). Conditions with time pressure permit us to observe whether speakers continue to observe tendencies such as agent-first or pivot-second despite the cognitive constraint. Continuing to find agent-first and/or pivot-second effects even under time pressure would support the strength of the constraints within the cognitive system.

Experiment 2 was a parallel study done in conjunction with Experiment 1. The same stimuli used in Experiment 1 were presented at two presentation rates for Experiment 2. One version of the experiment (Experiment 2a) presented each sentence region for 500ms, while another version (Experiment 2b) presented each sentence region for 750ms.

3.1 Participants

Participants in Experiment 2 included 114 Tagalog speakers from the Metropolitan Manila region in the Philippines (age range 18-60, mean 25.85; 75 female, 39 male by self-report). All participants identified themselves as Tagalog-dominant, and spoke English as a second language, in varying degrees of proficiency. Some participants also identified themselves as speaking a third or fourth language, but of lower proficiency compared to Tagalog and English.

3.2 Materials

To allow for a direct comparison with the self-paced reading task, the experimental items and lists were identical to Experiment 1, except that the stimulus onset asynchronies (SOAs) of the sentence regions were manipulated. Experiment 2a presented each sentence region for 500ms SOA, while Experiment 2b presented the sentence regions at a 750ms SOA. An identical post-stimulus task (yes/no questions) to that of Experiment 1 appeared after the sentence presentation.

3.3 Procedure

This study was conducted using rapid serial visual presentation (RSVP), using the program E-Prime (Schneider et al., 2002) on a laptop. Participants were assigned in a rotating fashion to one of the lists. They were asked to press a button to begin the trial. Then each region of the sentence was presented for the relevant SOA, in a non-cumulative moving window display, to provide a minimal difference in procedure from Experiment 1. Afterward, participants responded to the post-stimulus task (yes/no comprehension question) using keyboard buttons.

3.4 Analyses

Because of the similarity of the results between Experiments 2a and 2b, they were combined in the statistical analyses. The coding of conditions and structure of the model was the same as in Experiment 1.

3.5 Results and Discussion

In both Experiments 2a and 2b, the highest accuracy was found for Patient Voice with Agent–Patient word order (Figure 3), the strongly preferred pattern that satisfies both agent-first and pivot-second constraints (Bondoc & Schafer, 2022; Garcia et al., 2018; Kroeger, 1993). However, the statistical model (Table 4) revealed a significant effect of WordOrder ($z = 2.78$, $p < 0.01$), but not of Voice ($z = 1.45$, $p = 0.15$), nor their interaction ($z = -0.84$, $p = 0.39$), confirming the influence of the agent-first constraint in this task.

While Experiment 2 demonstrated the strength of the agent-first constraint under time pressure, we did not find a significant pivot-second effect in Experiment 2. We further probe the strength of pivot-second effects through a different type of cognitively constrained task in Experiment 3.

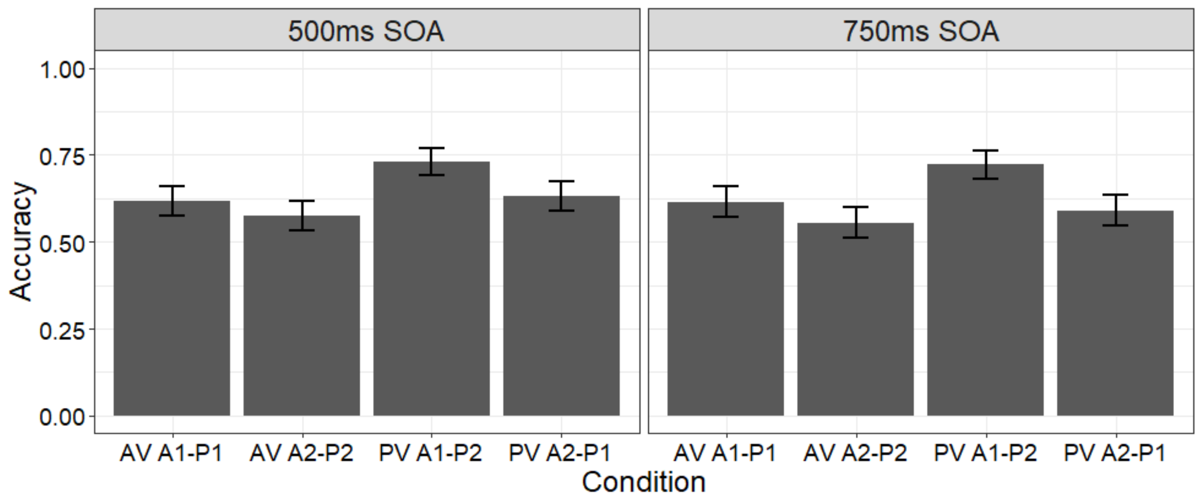

Figure 3. Accuracy rates in the two voice and word-order conditions in Experiments 2a (500ms) and 2b (750ms). Error bars reflect 95% confidence intervals.

Table 4

Results of the mixed effects logistic regression models that examined comprehension accuracy in the two RSVP conditions

	β	***SE***	***z***	***p***
Intercept	**0.71**	**0.13**	**5.61**	**< 0.001**
Voice (AV vs PV)	0.30	0.20	1.45	0.15
WordOrder (A1 vs A2)	**-0.59**	**0.21**	**-2.78**	**< 0.01**
Voice:WordOrder	-0.30	0.36	-0.84	0.39

4.0 Experiment 3: Self-Paced Reading with Memory Load

The lack of pivot-second effects in Experiment 2 raises the question as to why such effects were not observed. Is it the case that agent-first effects are more robust than pivot-second? It is possible that the measures we used in Experiment 2 were not sensitive enough to capture pivot-second effects, and that pivot-second effects are more readily demonstrated in online comprehension measures such as reading times. As observed in Experiment 1, pivot-second effects were observed in the moment-by-moment reading measure, but not in the comprehension accuracy measure.

Hence, it is likely that pivot-second effects are more observable with an online measure. In Experiment 3, we retain the use of a cognitive constraint to test the strength and influence of word-order constraints, but turn to one that allows us to collect a more sensitive dependent measure.

In Experiment 3, we implemented the same self-paced reading task of Experiment 1, except that it was coupled with the cognitive constraint of a memory load. We asked how strongly the agent-first and pivot-second constraint effects would be observed in the online reading measures (i.e., parsing of the linguistic signal) when another cognitive operation was taking place in parallel. To accomplish this, participants were tasked with actively retaining a series of letters in working memory while they read each sentence. We also examined whether the same agent-first effects would be observed in the comprehension accuracy measure when a different type of cognitive constraint was applied. As in Experiment 1, we anticipated patient voice effects to emerge in Region 2, pivot-second effects to show up in Regions 3 (first nominal marker) and 5 (second nominal marker), and agent-first effects to manifest in Region 4 (first nominal).

4.1 Participants

Ninety-seven native Tagalog speakers from the Philippines (age range 18-52, mean age 27.38; 77 female, 20 male by self-report) were recruited online for Experiment 3. All participants identified themselves as Tagalog-dominant, and as second language English speakers with varying degrees of proficiency. Some participants also identified themselves as speaking a third or fourth language, but of lower proficiency compared to Tagalog and English.

4.2 Materials

To allow for direct comparison between experiments, all sentence stimuli, comprehension questions, and experimental lists were identical to Experiments 1 and 2, with the exception of three filler items that were modified for each list with sentences involving exclamatives in Region 1, as a counter-check for unusually long reading times from participants. For the memory load task, a series of three letters was pseudo-randomly generated for every trial. Each series of letters in the memory load only contained consonants, to prevent them from being encoded as pronounceable syllables. No two consecutive trials had a similar letter in the memory load.

4.3 Procedure

The self-paced reading task from Experiment 1 was implemented using IbexFarm ver 0.3.9 (Drummond, 2013). Participants were assigned in a rotating fashion to one of the lists. To induce a memory load, participants were asked to remember a series of three letters (such as Z M X) that were flashed for one second prior to sentence presentation, while reading the sentences. Participants pressed a key to read each sentence fragment. Afterwards, participants responded to the post-stimulus task (yes/no question) by either clicking on the Yes/No options on the screen or by pressing a key. The trial ended with the participants asked to recall and type in a textbox the series of letters flashed prior to sentence presentation.

4.4 Analyses

We analyzed comprehension accuracy and on-line reading measures using the same fixed and random effects structures used in Experiment 1.

4.5 Results and Discussion

Nine participants were removed from the analysis due to a low comprehension accuracy score and/or a low memory task score (<60%), and two participants were removed as they had participated in Experiments 1 and 2, leaving data from 86 participants for further analysis.

4.5.1 Comprehension Accuracy. As shown in Figure 4, the overall accuracy for questions involving the patient voice ($\bar{x}$ = 76.49%, *sd* = 0.42) and the agent voice ($\bar{x}$ = 75.26%, *sd* = 0.43) was similar; the difference between these two Voice conditions was not significant ($z = 0.48$, $p = 0.63$). There was an observable word-order effect for both voices. Participants had significantly better performance in the Agent–Patient patterns ($\bar{x}$ = 84.56%, *sd* = 0.36) compared to the Patient–Agent patterns ($\bar{x}$ = 67.18%, *sd* = 0.47), illustrating an effect of agent-first through the main effect of WordOrder ($z = -8.12$, $p < 0.001$). When analyzed in terms of pivot and nonpivot orders, there was comparable accuracy for the Nonpivot–Pivot order ($\bar{x}$ = 76.23%, *sd* = 0.43) versus the Pivot–Nonpivot order ($\bar{x}$ = 75.52%, *sd* = 0.43). This was supported by a lack of a significant interaction effect between Voice and WordOrder ($z = -0.89$, $p = 0.38$). Thus the comprehension accuracy results were consistent with those from Experiment 1. Table 6 summarizes the results of the mixed-effects logistic regression model.

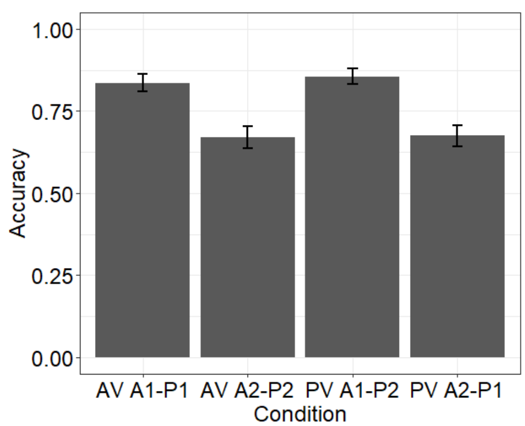

Figure 4. Comprehension accuracy rates in the different voice and word-order conditions in Experiment 3. Error bars reflect 95% CI.

Table 6

Results of the mixed effects logistic regression models for comprehension accuracy

	β	*SE*	*z*	*p*
Intercept	**1.70**	**0.22**	**7.68**	**< 0.001**
Voice (AV vs PV)	0.06	0.13	0.48	0.63
WordOrder (A1 vs A2)	**-1.39**	**0.17**	**-8.12**	**< 0.001**
Voice:WordOrder	-0.19	0.21	-0.89	0.38

4.5.2 Reaction Times. The data only included the trials where participants had a correct response for the corresponding comprehension question (exclusion of 24.13% trials). Table 7 summarizes the results of the mixed effects linear regression models.

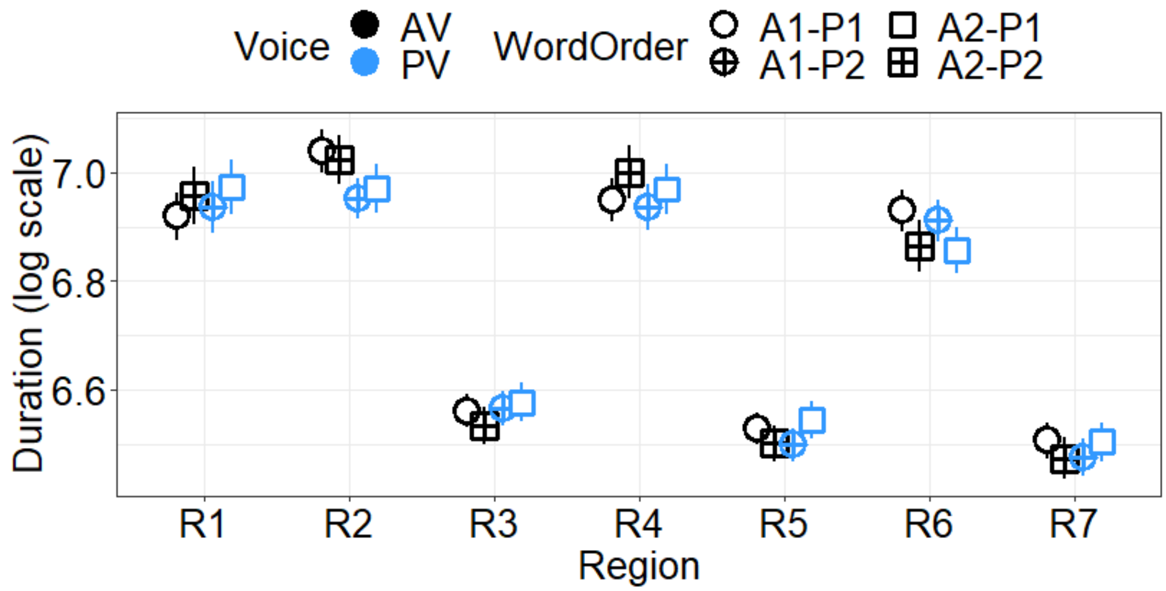

Figure 5. Reading times (in log scale) in the four conditions in Experiment 3 across the sentence regions. Error bars reflect 95% confidence intervals.

As in Experiment 1, an asymmetry between the two voice conditions was observed in Region 2 (verb + adverb), as the RTs for patient voice (blue symbols in Figure 5) were shorter than for agent voice (black symbols in Figure 5). The mixed effects model for this region showed a significant main effect of Voice (t = -2.55, $p < 0.05$), suggesting a strong patient voice advantage that remained in the memory load task. There was no significant main effect of WordOrder (t = 0.19, p = 0.85) nor of the Voice and WordOrder interaction (t = 1.42, p = 0.16) in this region, as expected.

In Region 3, we found numerically shorter reaction times for the non-pivot marker *ng* (740.70 ms) compared to the pivot marker *ang* (756.03 ms), but as in Experiment 1, this did not emerge as a significant Voice and WordOrder effect; i.e., there was not a significant pivot-second effect (t = -1.72, p = 0.09). Further echoing Experiment 1, neither Voice (t = 1.44, p = 0.16) nor WordOrder (t = -0.48, p = 0.63) produced a significant effect in this region.

Region 4, which showed an agent-first advantage in Experiment 1, no longer demonstrated a significant main effect of WordOrder (t = 0.82, p = 0.42) in Experiment 3, suggesting the weakening of the agent-first effect in this cognitively constrained task. Neither Voice (t = -0.68, p = 0.50) nor the interaction of Voice and WordOrder (t = -0.72, p = 0.47) produced a significant effect in this region.

Region 5, which showed a pivot-second advantage in Experiment 3, continued to demonstrate pivot-second effects (plus-filled symbols versus open symbols in Figure 5) through a significant interaction effect of Voice and WordOrder (t = 2.73, $p < 0.01$)[6], suggesting the robustness of this grammatical constraint in online sentence processing. Region 5 did not show significant Voice (t = 0.65, p = 0.52) or WordOrder effects (t = 0.17, p = 0.87).

[6]A separate maximal mixed effects model with deviation-coded Voice and WordOrder coded in terms of pivot-first/pivot-second showed a significant effect of WordOrder (t = -2.17, $p < 0.05$), supporting our interpretation of pivot-second in this region.

The use of a self-paced reading task with memory load illustrated the strength of the patient voice advantage and of pivot-second (at least at the second nominal marker) in the moment-by-moment reading of sentences. Meanwhile, while agent-first was not observed in the reading time measure, its effects remained in the offline comprehension accuracy measure, consistent with the comprehension accuracy measures in Experiments 1 and 2. The presence of agent-first and pivot-second effects under a cognitively constraining task supports their general influence in shaping Tagalog word-order preferences. We discuss the implications of these findings in the General Discussion section.

Table 7

Results of the mixed effects linear regression models that tested the reaction time differences between conditions per sentence region in Experiment 3

	β	***SE***	***t***	***p***	***β***	***SE***	***t***	***p***
	Region 2				**Region 3**			
Intercept	**7.02**	**0.03**	**203.59**	**<0.001**	**6.57**	**0.02**	**294.57**	**<0.001**
Voice (AV vs PV)	**-0.07**	**0.03**	**-2.55**	**<0.05**	0.03	0.02	1.44	0.16
WordOrder (A1 vs A2)	0.004	0.02	0.19	0.85	-0.01	0.02	-0.48	0.63
Voice:WordOrder	0.05	0.03	1.42	0.16	-0.05	0.03	-1.72	0.09
	Region 4				**Region 5**			
Intercept	**6.99**	**0.03**	**220.82**	**<0.001**	**6.53**	**0.02**	**346.03**	**<0.001**
Voice (AV vs PV)	-0.01	0.02	-0.68	0.50	0.01	0.02	0.65	0.52
WordOrder (A1 vs A2)	0.03	0.04	0.82	0.42	0.003	0.02	0.17	0.87
Voice:WordOrder	-0.03	0.04	-0.72	0.47	**0.08**	**0.03**	**2.73**	**<0.01**

5.0 General Discussion

In this study, we experimentally examined the influence of the proposed agent-first and pivot-second grammatical constraints on Tagalog word-order preferences using three sentence processing experiments. In Experiment 1, we used self-paced reading to determine the moment-by-moment effects of agent-first and pivot-second in online sentence reading. To determine how strongly the grammatical constraints continued to influence preferences and processing for the Tagalog word-order patterns, we added a cognitive constraint in each of the other two experiments. In Experiment 2, we added time pressure using rapid serial visual presentation (RSVP), and in Experiment 3, we induced additional memory load to the self-paced reading task from Experiment 1.

Our results showed repeated significant influences of agent-first and pivot-second constraints on Tagalog word-order comprehension, and also revealed differences across the three experiments. Speakers demonstrated a preference for the agent to appear in the first noun region and for the pivot marker to appear in the second nominal marker region in the online measures of Experiment 1, demonstrating the influence of agent-first and pivot-second grammatical constraints. This major finding supports the proposal by Bondoc & Schafer (2022) of the critical role of these constraints in Tagalog word-order preferences. It also extends the current Tagalog psycholinguistic literature, as previous work has shown only agent-first, and not pivot-second effects, in declarative sentence processing (Garcia et al., 2020; Sauppe, 2016). In the current work, we demonstrated that morphosyntactic pivot-second effects could emerge in online comprehension as well, through the use of psycholinguistic reading methodologies. Further, despite the spill-over patterns that sometimes occur with self-paced reading, the effects we find in our experiments can be localized to the regions where we expect them to be observed, i.e., an agent-first effect at the nominal in the first noun phrase, and a pivot-second effect at the second nominal marker in the second noun phrase, consistent with other studies that also show localized effects (e.g., Garnsey et al., 1999; Pizarro-Guevara & Dillon, 2022).

However, the effects of these two constraints differed somewhat across measures and tasks. The findings are summarized in Table 8. Agent-first effects, but not pivot-second effects, were strongly and consistently evident in comprehension accuracy measures, regardless of the cognitive constraint imposed on the tasks. The impact of agent-first might be more evident than pivot-second in comprehension accuracy because the thematic roles in the linguistic message have a greater lasting relevance to understanding and recalling the event than the morphosyntactic information associated with a pivot-second configuration, and early information about the agent role is especially beneficial to a range of cognitive tasks (Cohn & Paczynski, 2013; Isasi-Isasmendi et al., 2023).

Table 8

Summary of grammatical constraint findings from post-sentential comprehension accuracy and moment-by-moment sentence reading measures

Experiments	**Comprehension Accuracy**		**Reading Times**	
	Agent-first	**Pivot-second**	**Agent-first**	**Pivot-second**
Exp 1 Self-Paced Reading	**sig.**	n.s.	**sig.**	**sig.**
Exp 2 Rapid Serial Visual Presentation	**sig.**	n.s.	(n.a.)	(n.a.)
Exp 3 Self-Paced Reading with Memory Load	**sig.**	n.s.	n.s.	**sig.**

The agent-first advantage is deeply rooted in language and cognition. Extensive work in the literature has identified agents as less marked and more highly ranked in thematic role hierarchies than other thematic roles (Aissen, 1999; Croft, 1991; Langacker, 1995). In speaking, there is a production advantage when producing sentences where the agent is the sentential subject, at least for heavily studied subject-initial languages (Ferreira, 1994; Kemmerer, 2012); in comprehension, classic work has documented the parser's tendency to identify the first noun as the agent, resulting in an agent-first advantage (Ferreira, 2003; Townsend & Bever, 2001). Agent prominence in the processing of events has also been observed in other work on Tagalog (Sauppe, 2016; Sauppe et al., 2013) and in other populations, such as typically developing children (Bautista, 1983; Garcia et al., 2020; Garcia, Roeser, et al., 2018; Segalowitz & Galang, 1978; Tanaka, 2016) and adults with agrammatic aphasia (Bondoc et al., 2018).

In contrast, pivot-second effects were more strongly observable in the online reading measures than in the offline ones, even when a cognitive load was imposed. One likely reason is the manifestation of speakers' purely syntactic preferences as sentences unfold in real time. As Tagalog speakers read through a sentence, they unconsciously anticipate and respond to the location where they expect the pivot argument to be positioned in the sentence, particularly at the second nominal argument position. Additionally, the presence of significant pivot-second effects might indicate how speakers use such morphosyntactic information together with agent-first information in decoding the thematic roles in the sentence and in developing the gist of the message. However, structural information is more forgettable compared to sentence meaning (e.g., Gibson & Thomas, 1999). Hence, it is not surprising for pivot-second effects to be observed more in online compared to offline reading comprehension measures.

Pivot-second effects can be explained from a cognitive standpoint. The tendency of pivots to be positioned in the second argument position can be explained in terms of a preference to position the syntactically prominent argument in close proximity to the verb, modulo a greater preference for early positioning of the agent. The pivot argument is accessible to many syntactic phenomena (e.g., Chen & McDonnell, 2019; Himmelmann, 2005; Kroeger, 1993; Riesberg, 2014), thereby making it syntactically prominent, with some researchers also suggesting its important role in information structure (Latrouite, 2011; Latrouite & Riester, 2018). The prominent role of pivots may lead the cognitive system to track it in syntactic computation and preferentially place it near the verb, as there is a cognitive tendency to place dependents (e.g., the pivot) closer to the head (e.g., the verb) (Hawkins, 2004; Jaeger & Tily, 2011). However, given the saliency of the agents, which preferentially occupy the first argument position, the closest position to the verb where the pivot could be placed is at the second nominal argument, following the agent. The online comprehension experiments in the present study thus reinforce the cognitively driven account of the agent-first and pivot-second constraints proposed in Bondoc and Schafer (2022).

One interesting finding in our experiments is the lack of significant Pivot-Second effects at the first nominal marker compared to the second nominal marker. A possible explanation offered by an anonymous reviewer on an earlier manuscript is the division of the sentences into phrase-by-phrase regions, rendering a somewhat unnatural prosodic and syntactic division of the sentence, as the phrasal regions are not prosodic/syntactic constituents. An ongoing follow-up study is currently addressing this concern.[7]

Beyond the effect for agent-first and pivot-second, we also observed robust effects of a preference for patient voice over agent voice in the reading times at the verb in Experiments 1 and 3. Such a pattern of results is consistent with previous literature on Tagalog (Cena, 1977; Cooreman et al., 1984; Tanaka et al., 2022), and reinforces our interpretation of morphosyntactic effects being more transient than the agent-first preference that tracks early identification of the sentential agent.

6.0 Concluding Remarks

Through three reading experiments we investigated and demonstrated the influence of the grammatical agent-first and pivot-second constraints on Tagalog word-order preferences. Agent-

[7]We also conducted a meta-analysis by combining both Experiments 1 and 3 to determine if pivot-second effects (through the interaction of Voice and WordOrder) would emerge with greater power, particularly in Region 3. We found a significant effect of WordOrder at the first nominal region in that analysis ($t = 2.52$, $p = 0.012$). Thus, the weaker effects of pivot-second at that region seem to emerge with greater power. We include the results of our meta-analysis in our online repository for reference.

first and pivot-second effects were strongly observed in the moment-by-moment comprehension of Tagalog sentences. We also probed the strength and consistency of these two constraint effects through the addition of cognitive constraints in our experiments, and found that their influences persisted overall, although they varied somewhat depending on the task and on the measures. Agent-first effects were more evident with offline comprehension, while pivot-second effects were more strongly observed in online comprehension. These experimental findings highlight the critical role of agent-first and pivot-second in shaping Tagalog word-order preferences, and open doors for investigating their influences in other syntactic phenomena involving Philippine languages.

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Abbreviations

A1	agent-first	P2	pivot-second
A2	agent-second	PatAg	Patient-Agent order
AgPat	Agent-Patient order	PRF	perfective
AV	agent voice	PV	patient voice
NPVT	non-pivot	PVT	pivot
P1	pivot-first	RT	reaction/reading times