This is a contribution from *Pragmatics and Autolexical Grammar*.
In honor of Jerry Sadock.
Edited by Etsuyo Yuasa, Tista Bagchi and Katharine Beals.

Autolexical Grammar in interdisciplinary research

Constraining mismatch in grammar and in sentence comprehension

The role of default correspondences

Elaine J. Francis

This chapter presents psycholinguistic evidence for "default correspondences" – canonical mappings between semantic roles and constituent ordering – in the comprehension of two types of noun phrase mismatch: possessive free relatives and quantificational nouns. Experiments showed that possessive free relatives were processed more slowly and comprehended less accurately than normal possessive relatives, whereas quantificational nouns were processed more quickly and understood more accurately than normal binominal noun phrases. Following Townsend & Bever (2001), possessive free relatives cause processing difficulty because the position of the head violates the default, leading to confusion in semantic role assignment. Quantificational nouns do not violate the default in this way. One implication is that default correspondences may help limit mismatch in languages through their role in sentence comprehension.

1. Introduction[1]

An appealing aspect of Sadock's Automodular Grammar (Sadock 1991; to appear; Yuasa 2005) is that syntax-semantics mismatches are treated in a straightforward way. According to this approach, the competence grammar is divided into several distinct autonomous components, each of which has its own categories and combinatoric rules. Because there is a direct mapping between parallel representations in syntax and semantics, there is no need for movement, deletion, or insertion in the syntax. Instead, complex grammatical phenomena typically involve *mismatches* or

1. I am grateful to Yanhong Zhang for help with data collection, two anonymous referees for insightful comments, Etsuyo Yuasa for extensive help with revisions, and audience members at Jerry's conference. I especially want to thank Jerry Sadock for his helpful comments on this work and for the great personal and intellectual inspiration he has given me throughout my career. Funding for this research was provided by Purdue University, College of Liberal Arts and Department of English.

deviations from the canonical mappings between different components of grammar.[2] Lacking any movement rules, Automodular Grammar constrains the set of possible mismatches by means of lexical information and default correspondence principles – interface principles that specify canonical mappings between syntax and semantics or between other levels of linguistic structure.[3] Default correspondences define canonical phrase and sentence types and may be overridden by more specific information, resulting in mismatch between levels. Two relevant principles (shortened and simplified somewhat) are shown here.

(1) *Geometrical Correspondence Conditions* (Sadock 2007): In the default case, relations of dominance, c-command, and linear ordering should be preserved between any two components of grammar.[4]

(2) *Generalized Interface Principle* (Sadock & Schiller 1993: 393): When lexical requirements or combinatoric rules prohibit perfect alignment between any two components, representations should correspond as closely as possible while still characterizing a grammatical expression in each component.

These principles ensure that within a given language, constituency relations and linear ordering map as closely as possible between the different components of grammar. Mismatch is therefore limited to the extent that there must be an existing lexical item, morpheme, or construction available in the language to override the default (e.g. Raising verb, passive construction).[5] A challenge for this approach, then, is to determine what constrains the *possibility* for lexicalized or grammaticalized mismatch in language. In this paper, I will argue that the default correspondences themselves (in particular linear order defaults) play an important role in constraining mismatch through their use in online sentence comprehension.

Townsend & Bever (2001) and Ferreira (2003) present evidence that certain types of mismatched sentence structures, though permitted by the grammar, are difficult to

2. This modular approach to the syntax-semantics interface is closely shared with Jackendoff's Parallel Architecture (Culicover & Jackendoff 2005; Jackendoff 2007).

3. Note that Culicover & Jackendoff (2005) similarly propose both linear order defaults and constituent structure defaults.

4. In Sadock's most recent version of the theory (Sadock to appear), the linear order default has been replaced with a separate linear order component of grammar which interfaces with structural hierarchies in syntax and semantics. For ease of exposition, I am using a simpler formulation from an earlier manuscript (Sadock 2007), which is similar to the Linearity and Constructional Integrity constraints from Sadock (1991: 163).

5. The notion of construction figures prominently in Construction Grammar (Goldberg 2006) and some versions of Automodular Grammar (Yuasa 2005). In this context, default correspondences can be understood as highly general constructions which may be overridden by information associated with lexical items or more specific constructions.

process because they violate a type of linear order default correspondence. Specifically, they propose that "canonical sentence templates," representing the canonical ordering of arguments within a clause (e.g. NP-V-NP = Agent-Action-Patient) are used early in sentence comprehension to derive a preliminary interpretation before a full parse is completed. Sentences which match these templates (e.g. active sentences, subject clefts) are understood more quickly and accurately than sentences which deviate from the templates (e.g. passive sentences, object clefts).

Building on these previous studies of the comprehension of non-canonical clauses, the current study reports on two psycholinguistic experiments which examined the processing of two types of non-canonical NP structures in English: quantificational nouns (3a) and possessive free relative clauses (3b):

(3) a. A lot of ideas are floating around. (quantificational noun)
b. Whoever's ideas those were is a fool. (poss. free relative)

Although both types of NP involve a non-canonical head noun (cf. Section 3), the results show that possessive free relatives were processed more slowly and comprehended less accurately than normally-headed possessive relatives, whereas quantificational nouns were processed more quickly and understood more accurately than canonically headed binominal NPs. The difference, I argue, is related to the type of mismatch involved. Possessive free relatives are difficult to process because the non-canonical positioning of the semantic head violates the default ordering of arguments and leads to potential confusion in the role assignment of different referents. However, quantificational nouns are relatively easy to process because the normal quantifier-head ordering is preserved and there is only one possible referent for the NP. Based on these findings, I argue that the use of linear order defaults in processing may help shape grammars by making certain types of linear order mismatches especially costly for language users – namely, those that violate the expected ordering of arguments within a NP or clause.

The paper is organized as follows. Section 2 describes previous research by Ferreira (2003) and Townsend & Bever (2001) on canonical templates in the processing of non-canonical verb-argument structures. Sections 3 and 4 discuss the current experiments on the processing of non-canonical NPs. Finally, Section 5 explores some of the implications of these results for understanding how the potential for mismatch in languages is constrained.

2. Canonical sentence templates in sentence processing

The term "canonical form" usually refers to the most frequently occurring orderings of arguments within a simple clause in a language. Experimental evidence shows that canonical sentence forms are processed more quickly and more accurately than non-canonical forms (Love & Swinney 1998; Menn 2000; Townsend & Bever 2001). To account for this, Townsend & Bever (2001) propose that listeners/readers use "canonical sentence templates" for a rough and ready interpretation of sentences before full syntactic and semantic processing is complete. For example, the NVN template for English, shown in (4) below, specifies a canonical mapping between constituent order and semantic roles for a transitive clause.

(4)	Constituent order:	NP	V	NP
	Semantic role:	Agent	Action	Patient
		The dogs	destroyed	the garden.

Sentences which follow the templates are understood quickly and easily while those that violate the templates require additional processing to identify which NP is associated with which semantic role.

Ferreira's (2003) study provides compelling evidence for this view. Three experiments showed that sentences violating the NVN template were not only processed more slowly than canonical sentences but also *misunderstood* significantly more often. This was true even for simple, unambiguous, semantically plausible sentences. For example, in one experiment, participants listened to a series of semantically plausible and unambiguous active and passive sentences and had to identify either the doer (agent) or undergoer (patient) of the action. Agent decisions were only 88% correct for passive sentences as compared with 99% for active sentences (Ferreira 2003: 176). This effect was even more dramatic for cleft sentences. Agent decisions were only 80% correct for object clefts, as compared with 98% correct for subject clefts (Ferreira 2003: 186). This result is interesting because both subject and object clefts involve a non-canonical mapping of semantic roles to constituent structure, but only object clefts change the ordering of the arguments, making the assignment of roles to referents more difficult.

In Automodular Grammar, canonical templates are equivalent to default correspondences, and can be considered special cases of Sadock's Geometrical Correspondence Condition on linear order. Alternatively, canonical templates can be understood as default constructions (Francis 2007) or prototype constructions (Yuasa 2005) which specify highly general form-meaning correspondences. Although specific lexical items and constructions may contain the relevant information to override the defaults, Ferreira's (2003) study showed that this information is not always accessed in online processing in time to ensure a correct interpretation. Thus, in the framework assumed here, linear order defaults are both part of the grammar, helping to constrain mismatch within a language, and a part of the comprehension system, providing an efficient but imperfect mechanism for understanding sentences quickly.

3. Canonical templates and two types of NP mismatch

Previous research suggests that linear order defaults are important for the comprehension of verb-argument structure of clauses. The experiments reported here extend this line of research to NP structure, examining two types of mismatch in English NPs. The first case, possessive free relative clauses, involves non-canonical ordering of semantic elements within the NP such that the semantic roles of two referents become potentially confusable, while the second case, quantificational nouns, involves only one referent and the same ordering of semantic elements as in a normal quantified NP, but a mismatch in the mapping between semantic structure and syntactic constituent structure. The main questions addressed in this study are: (1) Do linear order defaults play a role in NP comprehension? (2) Do mismatches involving a non-canonical ordering of two semantic arguments create more problems for processing than other types of NP mismatch involving only constituent structure? If the answer to these questions is "yes", it is predicted that possessive free relatives should be processed less accurately and more slowly than normal possessive relative clauses, whereas quantificational nouns should be processed at about the same level of speed and accuracy as normal quantified NPs. In the following sections (3.1–3.2), I make these predictions explicit by further examining these two types of NP mismatch.

3.1 Possessive free relatives

Free relative clauses in English contrast with normally headed relative clauses in that they do not seem to have any external head. In (5a), the restrictive relative clause *who said that* modifies the noun *person*. However, in (5b) there appears to be no overt head preceding the relative clause.

(5) a. The person who said that is a fool. (restrictive relative)
b. Whoever said that is a fool. (free relative)

Thus, free relative clauses as in (5b) have the distribution of NPs but the internal structure of wh-clauses (cf. Grosu & Landman 1998).

The most important feature for comprehending free relatives is the semantic content of the free relative pronoun, which includes the referential index of the NP as part of its meaning. For example, the pronoun *whoever* in (5b) is understood as "the person who." Possessive free relative clauses are unique in that the possessive relative pronoun *whoever's* in (6a) is interpreted as possessor of the following noun within the relative clause (similar to *whose* in (6b)), but also as the semantic head (i.e. the word that contributes a referential index) of the matrix clause NP. Thus, *whoever's* is interpreted as "the person whose", and it is the girlfriend (not the boyfriend) who is described as a lucky girl in (6a).

(6) a. Whoever's boyfriend did this is a lucky girl.
b. The girl whose boyfriend did this is a lucky girl.

Although possessive free relatives are interpretable in an appropriate context, they are, at least intuitively, somewhat difficult to parse, especially when both nouns refer to persons as in (6a). To capture this intuition, I hypothesize that there exist language-specific canonical templates for NP which pair a certain linear ordering of constituents with a certain semantic role. In English, the templates for clause-modified NPs order the determiner before the semantic head, as shown in (7).

(7)	Constituent Order:	Det	N	S
	Semantic Role:	Specifier	Head	Modifier
		[The	dogs	that got loose] are in trouble.

Ordinary possessive relative clauses are syntactically and semantically complex, but still conform to the canonical template, as shown in (8):

(8)	Constituent Order:	Det	N	S
	Semantic Role:	Specifier	Head	Modifier
		[The	guy	whose dogs got loose] is in trouble.

Non-possessive free relative clauses as in (9) also conform to the canonical template, despite the (apparent) absence of a clause-external head noun in the syntax. For identifying the referential index of NP, *whichever dogs* in (9) functions similarly to *the dogs* in (7) above.

(9)	Constituent Order:	Det	N	S
	Semantic Role:	Specifier	Head	Modifier
		[Whichever	dogs	got loose] are in trouble.

Superficially, possessive free relatives look similar to *whichever*-phrases as in (9). However, they have an interpretation more similar to that of possessive relative clauses as in (8). In the possessive free relative in (10), *whoever's dogs got loose* is interpreted as "the person whose dogs got loose", deviating from the expected interpretation specified by the template.

(10)	Constituent Order:	Possessor	N	S
	Expected Role:	Specifier	Head	Modifier
	Actual Role:	Head	Modifier	
		[Whoever's	dogs	got loose] is in trouble.

Thus, possessive free relatives instantiate a kind of linear order mismatch within the NP which can cause referent roles to be confused. First, the semantic head comes earlier than expected and in a morphological form normally reserved for possessor NPs. In addition, the phrase *whoever's dogs* is the subject NP within the relative clause even though *dogs* does not provide the referential index for the matrix clause subject. Therefore, in comprehending a sentence like (10), there is a potential confusion between two referents (the dogs and the owner), only one of which can function as an argument of the matrix clause predicate. It should be noted that this is not quite the same kind of mismatch as found in passive sentences. Passive sentences involve a reversal of the expected ordering of arguments within the clause (e.g. agent and patient), whereas possessive free relatives involve a shifting of the semantic head to the left edge of the phrase. However, since both cases involve a non-canonical ordering of semantic elements that leads to potential confusion between two referents, I hypothesize that the effect of the mismatch should be similar.

3.2 Quantificational nouns

While possessive free relatives involve a linear order mismatch in which two persons or entities are potentially confusable, English quantificational nouns such as *lot* and *bunch* involve a mismatch only in constituent structure. In syntax, they are complement-taking nouns, while in semantics they are quantifiers similar to *several* or *many* (Yuasa & Francis 2003).

Quantificational nouns combine properties of normal quantified NPs and normal binominal NPs. A normal quantified NP has a simple structure and can be represented by the template in (11).

(11)	Constituent Order:	Det	N	
	Semantic Role:	Quant	Head	
		some	coins	are in the drawer.

Ordinary binominal NPs which are headed by complement-taking nouns, such as container nouns, follow a different template, which I will call the binominal NP template. As shown in (12), the binominal NP template is similar to the clause-modified NP template described in (7) above except that the head noun takes a PP modifier rather than a clause.

(12)	Constituent Order:	Det	N	PP	
	Semantic Role:	Specifier	Head	Modifier	
		a	box	of coins	is in the drawer.

Quantificational noun constructions as in (13) fit the template for ordinary quantified NPs as in (11) in terms of semantic role ordering, but share the syntactic constituent ordering of binominal NPs as in (12).

(13)	Constituent Order:	Det	N	PP
	Semantic Role:	----	Quant	Head
		a	lot	of coins are in the drawer.

Although quantificational nouns are morphologically marked as count nouns, the number marking has no semantic content and does not control subject-verb agreement. In (13), the semantic head of the subject NP is *coins,* and *coins* controls agreement with the verb *are*. For similar reasons, the singular determiner *a* has no semantic content even though it agrees in (morphological) number with the singular-marked noun *lot*.

When compared to the binominal NP construction as in (12), the mismatch involved in the quantificational noun construction in (13) appears to be similar to the mismatch in possessive free relative clauses.[6] The semantic head of a quantificational noun construction comes later than might be expected, in a position within what would normally be a modifying PP. Similarly, in possessive free relatives as in (10) above, the semantic head comes earlier than might be expected, in the position where a specifier would normally occur. Thus, both constructions involve a kind of mismatch in which the head noun is in an unexpected position. However, there is an important difference. In a quantificational noun construction, the ordering of semantic elements is the same as in an ordinary quantified NP: quantifier before head. In addition, quantificational nouns have no independent reference. Thus, there is no potential for confusion between referents because there is only one referent for the NP. In contrast, possessive free relatives have the potential for confusion between referents denoted by the relative pronoun *whoever's* and by the following noun.

Since quantificational nouns share the syntactic properties of container nouns, it is possible that readers/listeners might initially interpret them as binominal NPs as in (12) and thus incur additional processing costs. In particular, the semantically empty determiner and number marking on the quantificational noun could be deceptive. However, the results of Ferreira's (2003) experiment on subject and object clefts suggest that extra syntactic constituents with minimal semantic content (expletive subject, copular verb, relative pronoun) have no discernable effect on the processing time and comprehension of subject cleft sentences in English (e.g., *It was the dog that chased the cat*). If this is true for NP structure as well, quantificational nouns should be processed similarly to normal quantified NPs.

4. Experiments

Based on the templates proposed above in Section 3 within the framework of Townsend & Bever (2001), it is predicted that: (1) possessive free relatives should be

6. I am grateful to an anonymous referee for pointing out this similarity and helping me clarify the important distinction between these two types of mismatch.

processed less accurately and more slowly than normal possessive relative clauses, and (2) quantificational nouns should be processed at about the same level of speed and accuracy as normal quantified NPs. As reported in the following sections, Experiment 1 tested prediction (1) and Experiment 2 tested prediction (2).

4.1 Experiment 1: Possessive free relatives

It is predicted that possessive free relatives should be more frequently misunderstood and more slowly processed than normal possessive relative clauses. As previously reported in Francis (2007), this hypothesis was tested using two different experimental tasks. For ease of exposition, a detailed summary is given here for the first experiment, a verb decision task, since this experiment is directly comparable to the new experiment in Section 4.2. The reader is referred to the earlier paper (Francis 2007) for details of the second experiment, a true-false decision task, which corroborated the results of the verb-decision experiment. The analyses of noun number in the verb decision experiment presented here are new and were not included in the previous paper.

4.1.1 *Methods*

Ten sets of sentences containing the four sentence types in Table 1 were constructed by combining each of two levels of two factors (possessive/non-possessive and free/normal). Non-possessive sentences were included as control conditions to ensure that effects of the possessive free relative structure could be separated from any effects of free relative structures in general. Each set included ten sentences: four for the normal possessive sentence type (with number varied on the two nouns) and two for each of the other sentence types (with number varied on the only noun). In all, 100 test sentences and 100 filler sentences were included.

Table 1. Stimulus materials for Experiment 1

Sentence Types	Example Sentence
Normal possessive	The guy whose dogs got loose is in trouble.
Free possessive	Whoever's dogs got loose is in trouble.
Normal non-possessive	The dogs that got loose are in trouble.
Free non-possessive	Whichever dogs got loose are in trouble.

Following a brief background questionnaire, readers were presented with a series of sentences in which main verb was missing, as in (14):

(14) Whoever's dogs got loose __ in trouble.

Upon reading each sentence on the computer screen, participants pressed a button on a response box choosing either "is" or "are" to complete the sentence. Participants had to identify the head noun in the subject of the matrix clause to make a correct response. A correct response for sentence (14) above, for example, would be "is", since it is the owner (not the dogs) who is in trouble. Accuracy and response time data were recorded automatically. Forty-two Purdue University students who were native speakers of English participated in the experiment.

4.1.2 *Results and discussion*

Results for both accuracy and response time are summarized in Table 2.

Table 2. Accuracy and response time for sentence types in Experiment 1

	Normal possessive	Free possessive	Normal non-possessive	Free non-possessive
Percent Correct	94.29%	78.45%	96.90%	94.29%
Response Time (ms)	3310.33	4036.31	2412.36	3155.90

4.1.2.1 Accuracy Mean proportion of correct responses for each condition was calculated and analyzed using repeated measures analyses of variance with two factors of two levels each (possessive/non-possessive and free/normal). As shown in Table 2, participants' responses were less accurate overall for possessive free relatives (78% correct) than for the other three sentence types (94–97% correct), resulting in significant main effects of the factors possessive ($F (1, 41) = 33.27, p < 0.01$), and free ($F (1, 41) = 60.29, p < 0.01$) and a significant interaction between possessive and free ($F (1,41) = 26.40, p < 0.01$).

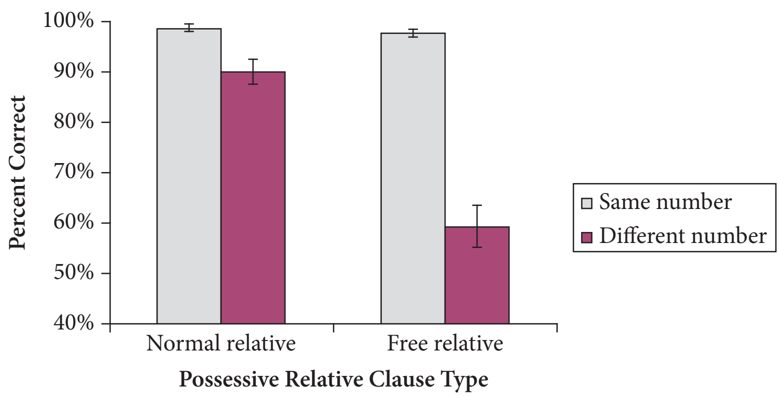

Figure 1. Percent correct for same vs. different noun number in possessive relative clauses.[7]

7. Error bars on all figures indicate standard error of the mean and are based on by-participant analyses.

Considering the same data but looking only at possessive relative clauses, we can consider the additional factor of same vs. different number on the two nouns. As shown in Figure 1, responses on items with different number on the two nouns were less accurate than responses on items with the same number, resulting in a significant main effect of noun number ($F(1, 41) = 90.42$, $p < 0.01$). Responses to regular possessive relatives dropped from 99% correct in the same number condition to 90% correct in the different number condition. This effect was much greater for possessive free relatives, which dropped from 98% to 59% correct, resulting in a significant interaction between noun number and clause type ($F(1, 41) = 53.65$, $p < 0.01$).

4.1.2.2 Response time Mean response times were calculated and analyzed using the same methods as for accuracy (above). Inaccurate responses were excluded from the analysis of response time. Similar to the accuracy results, response times for possessive free relatives were slower than for normal possessive relatives (Table 2). However, unlike with the accuracy results, response times for non-possessive free relatives were significantly slower than for normal non-possessive relatives. Thus, there were main effects for both possessive ($F (1, 41) = 105.83$, $p < 0.01$) and free ($F (1, 41) = 44.95$, $p < 0.01$), but there was no significant interaction between possessive and free ($F (1,41) = 0.01$, $p = 0.91$).

As shown in Figure 2, the effects of noun number on response times were similar to the effects of noun number on accuracy. Response times on items with different number on the two nouns were significantly slower than for items with the same number, as shown by the main effect of number ($F(1, 40) = 63.4$, $p < 0.01$). Similar to the results for accuracy, the effect of noun number was greater for possessive free relatives than for normal possessive relatives, resulting in a significant interaction between noun number and clause type ($F(1, 41) = 13.37$, $p < 0.01$).

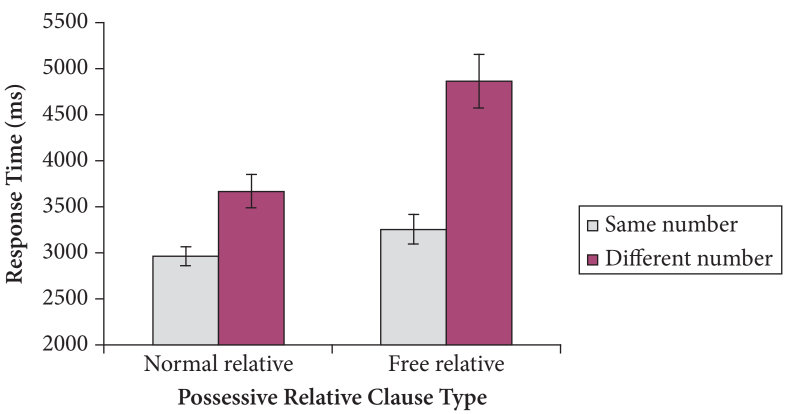

Figure 2. Response time for same vs. different noun number in possessive relative clauses

4.1.2.3 Discussion As predicted, participants were least accurate and had the slowest response times for possessive free relatives, and the effect of different noun number on accuracy was greater for possessive free relatives than for normal possessive relatives. Thus, the results for accuracy appear to confirm the hypothesis that non-canonical structure contributes to more frequent miscomprehension. Results for response time were similar, though somewhat less conclusive. The effect of noun number on response time was greater for possessive free relatives than for normal possessive relatives, as expected. However, responses for free relatives were slower than for normal relatives to about the same degree, regardless of whether the sentences were possessive or not. Since non-possessive free relatives conform to the canonical template for NP (Table 1), the response time data cannot be fully explained by the non-canonical position of the head noun.[8]

4.2 Experiment 2: Quantificational nouns

As discussed above, it was predicted that unlike possessive free relatives, which should be processed more slowly than normal possessive relatives, binominal NPs headed by a quantificational noun should be processed similarly to normal quantified NPs. The same kind of verb decision task as in Experiment 1 was used to test this hypothesis.

4.2.1 *Methods*

4.2.1.1 Materials Ten sets of stimuli like the set in Table 3 below were constructed by varying the number on N1 and N2 (singular, plural) for three noun phrase types: normal quantified NP, container noun (normal binominal NP), and quantificational noun. This resulted in four versions each for quantificational nouns and container nouns and two versions for the normal quantified NPs (since those contain only one noun). Pairs of semantically similar plural count and singular mass nouns (e.g. *coins, money*) were used to vary the number of N2, since varying the number on the count noun would result in unacceptable combinations (e.g. **a box of coin*). To avoid a collective or measure noun interpretation, which is possible with most quantificational nouns (e.g. *bunch, couple, heap, load*), the noun *lot* was used in all ten sets of sentences.

8. A possible explanation for this could be the morphological similarity between non-possessive *whichever* and possessive *whoever's*, which may have resulted in slower response times for both types of free relatives. An anonymous referee suggests that another possible explanation could lie in the discourse-linking function of free relative pronouns such as *whichever*, since discourse linking has been shown to increase processing difficulty in pronoun interpretation (Piñango et al. 2001).

Table 3. Sample stimulus set for Experiment 2

Sentence Types	Example Sentence
Normal quantifier, plural subject	Some coins are in the drawer.
Normal quantifier, singular subject	Some money is in the drawer.
Quantificational noun, plural N2	A lot of coins/lots of coins are in the drawer.
Quantificational noun, singular N2	A lot of money/lots of money is in the drawer.
Container noun, plural N2	A box of coins/boxes of coins is/are in the drawer.
Container noun, singular N2	A box of money/boxes of money is/are in the drawer

4.2.1.2 Procedure Following a brief background questionnaire, readers were presented with a series of sentences in which the main verb was missing, as in (15):

(15) A lot of coins __ in the drawer.

After reading each sentence on the computer screen, participants pressed a button on a response box choosing either "is" or "are" to complete the sentence. Participants had to identify the head noun in the subject NP to make a correct response. A correct response for sentence (15) above, for example, would be "are", since agreement is with the semantic head, "coins".

Stimuli were presented in five blocks of 40 sentences each (20 test sentences including two tokens from each of the ten stimulus sets, 20 fillers in each block), with random ordering of sentences within each block and random ordering of blocks. Accuracy and response time data were recorded automatically by the E-Prime program used to present the sentences.

4.2.1.3 Participants Forty Purdue University students, ranging in age from 19 to 28 (average age 20), participated. Of these, 8 were men and 32 were women. All were native speakers of a North American variety of English. Participants gave informed consent and were compensated with a choice of either $3 or course credit, for a 15–20 minute session. One participant's data were excluded for failure to attend to the task.

4.2.2 *Results and discussion*

4.2.2.1 Accuracy Mean proportion of correct responses for each condition was calculated and analyzed using repeated measures analyses of variance with one factor of three levels (NP type). In addition, t-tests were used to make some pairwise comparisons between conditions.

Overall accuracy for each of the three NP types is shown in Figure 3 below. Normal quantified NPs showed the highest accuracy at 99% correct, followed by quantificational nouns at 93% and container nouns at 87%. These differences were reflected in a main effect of NP type ($F(2, 37) = 27.44$, $p < 0.01$). Pairwise t-tests confirmed that all pairs of NP types were significantly different from each other (quantificational noun vs. container noun: $t = 3.42$, $p < 0.01$; quantificational noun vs. normal quantified NP: $t = 4.33$, $p < 0.01$; normal quantified NP vs. container noun: $t = 7.09$, $p < 0.01$).

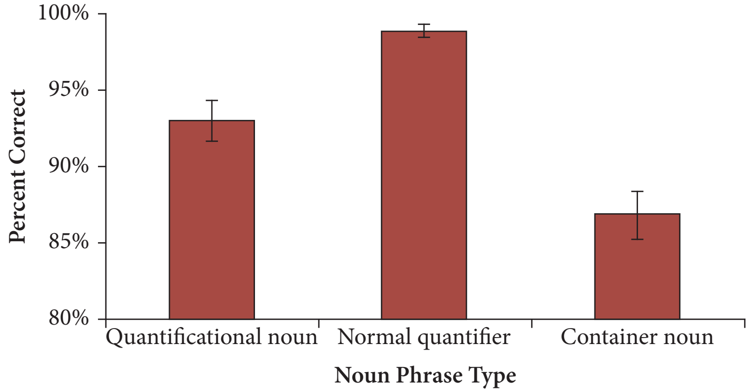

Figure 3. Percent correct for NP Types

Considering only the two types of binominal NPs (container nouns and quantificational nouns), it is possible to include the additional factor of same vs. different number on the two nouns. As shown in Figure 4 below, accuracy of responses differed by both number and NP type. As expected, responses on items with different number on the two nouns were significantly less accurate than responses on items with the same number, as shown by the main effect of noun number ($F(1, 38) = 55.04$, $p < 0.01$). Responses for container nouns went from 97% accurate in the same number condition to 77% in the different number condition. This effect was not as strong for quantificational nouns, which dropped from 98% to 88% correct, as shown by the significant interaction between noun number and NP type ($F(1,38) = 4.77$, $p = 0.035$).

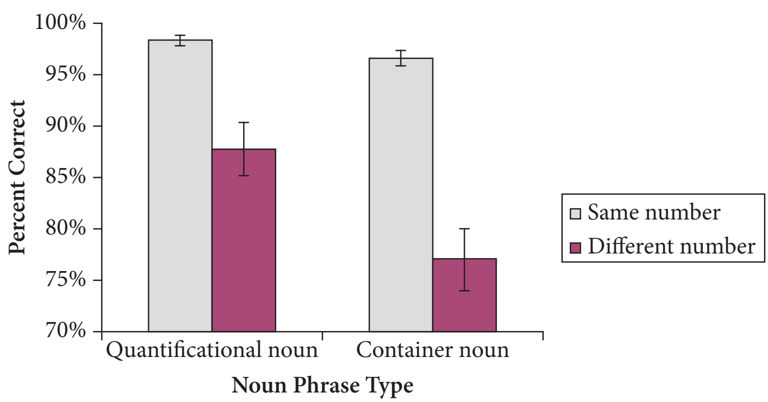

Figure 4. Percent correct for same vs. different noun number

4.2.2.2 Response time Results for response time patterned very similarly to the accuracy results. As shown in Figure 5 below, response times were fastest for normal quantified NPs at 1852ms, followed by quantificational nouns at 2131ms and container nouns at 2278ms. The main effect of NP type was highly significant ($F(2, 37) = 17.3$, $p < 0.01$), and pairwise t-tests reveal that there were significant differences among response times for all three pairs of NP types (quantificational noun vs. container noun: $t = 2.81$, $p < 0.01$; quantificational noun vs. normal quantified NP: $t = 4.5$, $p < 0.01$; normal quantified NP vs. container noun: $t = 5.93$, $p < 0.01$). As in Experiment 1, inaccurate responses were excluded from the analysis of response time.

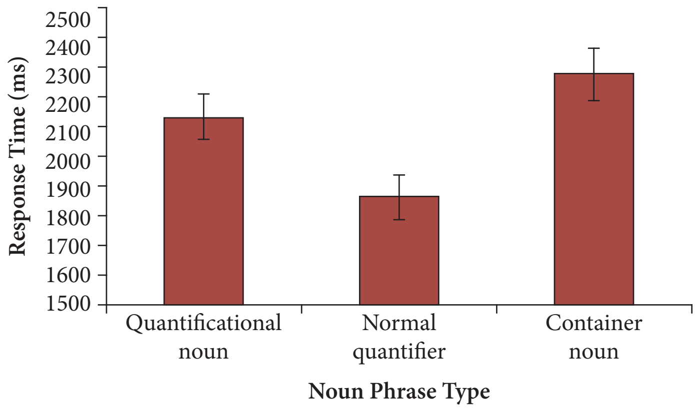

Figure 5. Response time for NP types

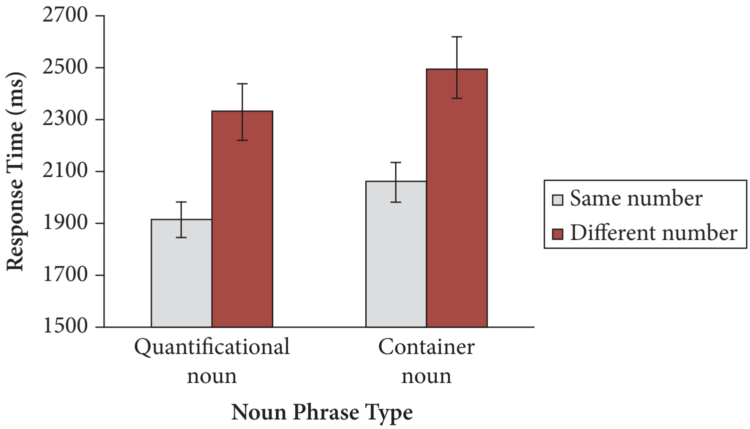

Figure 6. Response time for same vs. different noun number

For the container noun and quantificational noun stimuli, speed of responses differed by both noun number and NP type. As shown in Figure 6, responses on items with different number on the two nouns were significantly slower than responses on items with the same number, as confirmed by the main effect of number

($F(1, 38) = 36.38$, $p < 0.01$). There was also a main effect of NP type, confirming that responses for container nouns were significantly slower than for quantificational nouns ($F(1, 38) = 8.26$, $p < 0.01$). However, unlike with the accuracy results, there was no significant interaction between number and NP type ($F(1,38) = 0.03$, $p = 0.86$). Although quantificational nouns were faster overall than container nouns, noun number had approximately the same effect on both NP types.

4.2.2.3 Discussion Contrary to the original predictions, responses for NPs headed by quantificational nouns were both slower and less accurate than for normal quantified NPs. Thus, it is clear that the semantically empty number marking on the quantificational noun had an effect on participants' responses. However, in comparison with normal binominal NPs headed by a container noun, responses for quantificational nouns were faster and more accurate. Despite the canonical headedness of container nouns and the headedness mismatch of quantificational nouns, quantificational nouns apparently caused *less* difficulty for identifying the appropriate controller for subject-verb agreement. It appears that participants were able to make use of the lexical properties of the quantificational noun *lot*, which prevent it from acting as an agreement controller, allowing them to calculate agreement based on the second noun.[9] However, they were not able to completely ignore the semantically empty number marking on *lot*, as shown by the reduced speed and accuracy as compared to normal quantified NPs.

5. General discussion and conclusions

Townsend & Bever (2001) and Ferreira (2003) have proposed that readers and listeners use canonical templates specifying the basic linear order of clausal arguments when processing sentences in real time. When the language input violates the relevant template, there are at least two possibilities: (1) the violation is recognized and the correct interpretation is computed, overriding the initial interpretation; or (2) the syntactic information in the sentence is not fully processed and the incorrect interpretation lingers. The results of Experiment 1 suggest that canonical templates play a role in the comprehension of NPs. Violation of the canonical linear ordering of semantic arguments within the NP appears to affect the basic understanding of NP meaning,

9. As an anonymous referee suggests, the difference between quantificational nouns and container nouns may be related to the fact that interpretation of reflexive pronouns with quantified antecedents (e.g. *everyone*) elicits a faster response time than interpretation of reflexives with non-quantified antecedents (Piñango et al. 2001).

as shown by the significant drop in accurate responses for possessive free relatives. However, the results of Experiment 2 suggest that mismatch between constituent structure and semantics does not make quantificational nouns more difficult to process than other binominal NPs. In fact, quantificational nouns were understood more quickly and more accurately than normal binominal NPs headed by a container noun, despite the mismatch.

These results are similar to the results of Ferreira's (2003) study, which found that passive sentences and object clefts, which reverse the expected ordering of argument roles, were processed more slowly and misunderstood more often than simple active clauses. In contrast, subject clefts, which conform to the default linear ordering of arguments but have a non-canonical structure, were processed just as quickly and accurately as simple active clauses. The main difference between Experiment 2 and Ferreira's experiment is that responses to quantificational nouns were slower and less accurate than responses to normal quantified NPs, whereas in Ferreira's study, subject clefts patterned very similarly to simple active clauses. It appears that participants in Experiment 2 were not able to completely ignore the semantically empty number marking on the quantificational noun when choosing the correct verb form, whereas in Ferreira's study, participants were unaffected by the semantically empty elements (expletive subject, copular verb) when deciding on the identity of the agent or patient.[10]

What implications do these results have for understanding how mismatch is constrained and expressed in languages? I suggest that the use of these linear order defaults in processing may help limit the expression of mismatch in languages by making certain kinds of linear order mismatches – namely those that involve a non-canonical ordering of two semantic arguments – especially costly for language users. For example, the grammar of English does not permit the kind of mismatch that would result in an interpretation of example (16a) below in which *the cat* is the agent of the action. Such an interpretation is at least conceivable, given the existence of alternations as in (16b–c), where a lexical difference between the verbs *like* and *please* indicates a reversed ordering of argument roles.

(16) a. The dog chased the cat.
b. The dog likes the cat.
c. The cat pleases the dog.
d. The cat was chased by the dog.

10. This is likely due to the task of Experiment 2. Overt plural marking is known to affect the calculation of subject-verb agreement in production, leading to the phenomenon of 'attraction' in which a plural marked non-head can trigger plural agreement on the verb (e.g., Bock et al. 2006).

However, lack of any kind of formal marking would result in a high degree of ambiguity, making sentences with an unexpected ordering of arguments more difficult to comprehend even in an appropriate discourse context. Hawkins (2004: 147–167) has argued that explicit grammatical marking in languages is motivated in part by processing demands. Thus, languages tend to mark a non-canonical ordering of clausal arguments in some way, such as by using different verbs (as in 16b–c), or by explicit grammatical markings (as in 16d). Thus, it is likely that possessive free relatives are especially confusing because the possessive pronoun *whoever's* is the only linguistic cue to the intended interpretation and may be confusable with the morphologically similar pronoun *whichever*. In contrast to mismatches that change the normal ordering of semantic arguments, constituent structure mismatches which do not alter the ordering of semantic arguments may be subject to fewer constraints on their expression in language since they appear to be less costly for processing and more easily ignored.

Why should a non-canonical ordering of two semantic arguments be more costly for processing than (just) constituency mismatch?[11] As Jerry Sadock (p.c., May 2008) points out, constituency is virtual, and must be constructed on the basis of word order, morphology, prosody, and possibly other cues. On the other hand, linear order is more basic and does not require constituency in order to be apprehended. Thus, it may be the salience and robustness of linear order that makes it both easy to apprehend when the expected ordering of arguments is perceived and difficult to process when an unexpected ordering is perceived. In support of this idea, Jackendoff (2007: 19–20) points out that in a variety of situations in which complex syntactic structures are unavailable or not easily accessible, such as adult second language learning, Broca's aphasia, pidgin languages, and "home sign" systems (sign systems developed by deaf children and their families in the absence of any conventional sign language), people make use of simple linear order heuristics for producing and interpreting language. For example, Piñango (2000: 347) found that individuals with Broca's aphasia use a linear-order based strategy for interpreting sentences with experiencer predicates. In one experiment, sentences with experiencer-theme order (*The boy feared the dog/The boy was frightened by the dog*) were interpreted correctly most of the time, while sentences with theme-experiencer order (*The dog frightened the boy/The dog was feared by the boy*) were interpreted only at chance. Whether the sentence was active or passive did not matter because the Broca's deficit disrupted individuals' ability to apply syntactic

11. Although the quantificational noun construction involves an unexpected position for the syntactic head, there is only one semantic argument. Therefore, I am describing this construction as involving a mismatch in syntactic vs. semantic constituency (with first noun as syntactic head and second noun as semantic head) as opposed to a non-canonical linear ordering of two arguments as in the possessive free relative construction.

linking rules, forcing them to rely on a simpler linear order-to-semantics mapping. Although normal adults without any cognitive impairment can make complex syntactic computations, Ferreira (2002: 14) points out linear order heuristics are still very helpful for sentence processing given their robustness. In daily conversation, people need to understand speech rapidly in the face of distractions such as background noise, dialect differences, speech disfluencies, and multiple speakers in the conversation. Under conditions in which full syntactic computations may not be practical, it makes sense that some mismatches involving constituency might go unnoticed while mismatches that change the normal ordering of two semantic arguments would be especially disruptive to processing.

Finally, the results discussed here have implications for models of competence grammar. Defaults similar to those proposed in Sadock (1991; to appear), Sadock & Schiller (1993), and Culicover & Jackendoff (2005) are independently needed to explain facts about sentence processing. Interestingly, Townsend & Bever (2001) themselves assume a Chomskyan generative theory of syntax. Because this type of theory does not permit default correspondences directly in the grammar, Townsend & Bever must put canonical templates into a special level of "pseudo-syntax" distinct from the grammar itself. However, a theory of grammar that uses default correspondences (or, equivalently, default constructions) to help constrain mismatch within the grammar also allows us to streamline the representation of linguistic knowledge relevant for sentence comprehension, since an extra level of pseudo-syntax is not needed.

References

Bock, J. Kathryn, Butterfield, Sally, Cutler, Anne, Cutting, J. Cooper, Eberhard, Kathleen M. & Humphreys, Karin R. 2006. Number agreement in British and American English: Disagreeing to agree collectively. *Language* 82: 64–113.

Culicover, Peter W. & Jackendoff, Ray S. 2005. *Simpler Syntax*. Oxford: OUP.

Ferreira, Fernanda. 2002. Good-enough representations in language comprehension. *Current Directions in Psychological Science* 11: 11–15.

Ferreira, Fernanda. 2003. The misinterpretation of noncanonical sentences. *Cognitive Psychology* 47: 164–203.

Francis, Elaine J. 2007. The role of default constructions in the processing of mismatch: the case of possessive free relatives. In *Proceedings of the* 14th *International Conference on Head-Driven Phrase Structure Grammar: Workshop on Constructions and Grammatical Theory,* Stefan Müller (ed), 345–363. Stanford CA: CSLI.

Goldberg, Adele E. 2006. *Constructions at Work: The Nature of Generalization in Language.* Oxford: OUP.

Grosu, Alexander & Landman, Fred. 1998. Strange relatives of the third kind. *Natural Language Semantics* 6: 125–170.

Hawkins, John A. 2004. *Efficiency and Complexity in Grammars*. Oxford: OUP.

Jackendoff, Ray S. 2007. A parallel-architecture perspective on language processing. *Brain Research* 1146: 2–22.
Love, Tracy E. & Swinney, David A. 1998. The influence of canonical word order on structural processing. *Syntax and Semantics* 31: 153–166.
Menn, Lise. 2000. It's time to face a simple question: What makes canonical form simple? *Brain and Language* 71: 157–159.
Piñango, Maria M. 2000. Canonicity in Broca's sentence comprehension: the case of psychological verbs. *Language and the Brain. Representation and Processing,* Yosef Grodzinsky, Lewis P. Shapiro & David A. Swinney (eds), 327–350. San Diego CA: Academic Press.
Piñango, Maria M., Burkhardt, Petra, Brun, Dina & Avrutin, Sergey. 2001. The psychological reality of the syntax-discourse interface: The case of pronominals. Paper presented at the workshop From Sentence Processing to Discourse Interpretation: Crossing the Borders. UIL-OTS, Utrecht University, July 2001.
Sadock, Jerrold M. 1991. *Autolexical Syntax. A Theory of Parallel Grammatical Representations*. Chicago IL: University of Chicago Press.
Sadock, Jerrold M. 2007. *Describing Verbs.* Ms, University of Chicago.
Sadock, Jerrold M. to appear. *An Introduction to Automodular Grammar with Particular Reference to English.* Cambridge: Cambridge University Press.
Sadock, Jerrold M. & Schiller, Eric. 1993. The Generalized Interface Principle. In CLS 29: *Papers from the Main Session,* Katharine Beals, Gina Cooke, David Kathman, Sotaro Kita, Karl-Erik McCullough & David Testen (eds), 391–402. Chicago: Chicago Linguistic Society.
Townsend, David J. & Bever, Thomas G. 2001. *Sentence Comprehension: The Integration of Habits and Rules.* Cambridge MA: The MIT Press.
Yuasa, Etsuyo. 2005. *Modularity in Language. Constructional and Categorial Mismatch in Syntax and Semantics*. Berlin: Mouton de Gruyter.
Yuasa, Etsuyo & Francis, Elaine J. 2003. Categorial mismatch in a multi-modular theory of grammar. In *Mismatch: Form-Function Incongruity and the Architecture of Grammar*, Elaine J. Francis & Laura A. Michaelis (eds), 179–227. Stanford CA: CSLI.