

## The role of hierarchical structure in agreement interference

Julie Franck, Ulrich H. Frauenfelder (University of Geneva) & Luigi Rizzi (University of Sienna & University of Geneva)

Julie.Franck@pse.unige.ch

Experimental research on agreement production has provided compelling evidence that the interference produced by a syntactic element intervening between the subject and its verb (e.g., *\*The son of the neighbours are absent*) is sensitive to the hierarchical position of this attractor (e.g., Vigliocco & Nicol, 1998). Our research extends the construct of hierarchical structure in proposing a finer characterisation of its role in interference. This role is a function of (1) structural intervention conceived of as a necessary condition for interference, (2) the type of structural intervention (precedence versus c-command), and (3) the type of movement involved. We will present a gradient in the strength of attraction emerging from experimental research which supports this approach, and will focus in particular on the evidence suggesting that intermediate traces of movement cause interference. One of the critical experimental comparisons that support this claim involves an object relative structure (1) in which the potential attractor (*patients*) is the object of the target verb (*cures*), and a sentence complement structure (2) in which the potential attractor is the object of the main verb (*says*).

- (1) Jean parle aux patientes que le médicament guérit / \*guérissent  
John speaks to the patients-P that the medicine-S cures-S / \*cure-P
- (2) Jean dit aux patientes que le médicament guérit / \*guérissent  
John says to the patients-P that the medicine-S cures-S / \*cure-P

The results show interference in (1), with more errors in sentences in which the number of the object mismatched the number of the subject, but not in (2). It is argued that neither the base (postverbal) position of 'patients' in (1) nor its surface position (sentence initial) can account for the observed interference. Rather, agreement appears to be checked on an abstract intermediate hierarchical structure, consistent with current syntactic models in the Principles & Parameters/Minimalist framework. According to these models, the object of the relative clause transits via an intermediate position (AgrO, in Kayne, 1989, or the edge of the vP phase in Chomsky, 2001) that intervenes hierarchically on the AGREE relation, thus creating the condition for interference to arise. The report of interference in sentences like (1) provides new experimental evidence for the role of intermediate traces of movement in language production. Finally, preliminary evidence is presented which suggests similar hierarchical guidance of agreement checking in language comprehension.

### References

- Chomsky, N. (2001). Derivation by phase. In M. Kenstowicz (Ed.), *Ken Hale: A Life in Language*. Cambridge MA: The MIT Press.
- Kayne, R. (1989). Facets of Romance past participle agreement. In P. Benincà (Ed.), *Dialect Variation and the Theory of Grammar*, pp. 85–103. Dordrecht: Foris Publications
- Vigliocco, G., & Nicol, J. (1998). Separating hierarchical relations and word order in language production: Is proximity concord syntactic or linear? *Cognition*, 68(1), 13–29.

## Number agreement violation: An ERP analysis of its outcome

Nicola Molinaro (University of Padova), Albert Kim (University of Washington) & Francesco Vespignani (University of Padova)

nicola.molinaro@unipd.it

It is widely assumed that human language comprehension is robust in the face of grammatical anomalies and grammatical processing errors. However, little is known about the mechanisms of such robustness. Here we studied the processing of grammatically anomalous sentences like "*\*The hostess were dressing herself/themselves...*", which contains two anomalies, one early and one late. We investigated how processing of the later anomaly (at the pronoun 'herself' or 'themselves') was affected by the processing of the early anomaly (at 'were'). We considered two possible outcomes at the later anomaly:

- 1) The subject-verb number agreement error at the first verb is "repaired" to match the verb, rendering 'herself' anomalous;
- 2) The subject-verb agreement error is repaired to match the subject noun, rendering 'themselves' anomalous.

Our dependent measure was event-related scalp potentials (ERPs), for which numerous studies have shown a slow positive shift (P600) correlated with syntactic anomalies, including failures of number agreement (Coulson, King & Kutas, 1998; Osterhout & Mobley, 1995). We recorded EEG while 20 participants read sentences. We manipulated the number of the verb (*was/were*) and the pronoun (*herself/themselves*) to create four conditions balanced for number. Here we present only the versions with the singular subject, labeled SSS, SSP, SPS, SPP (see Examples).

SSS is a well-formed control, against which effects were measured. SSP is well-formed until the pronoun. SPP and SPS both contain violations at the verb and pronoun. For SPP, the pronoun agrees with the verb but not the first noun. For SPS, the pronoun agrees with the noun but not the verb.

As expected, SSP elicited a P600 effect at the pronoun, and SPS and SPP both elicited a P600 at the verb. The central question concerned effects at the pronoun for SPS and SPP: SPS elicited a P600-like effect at the pronoun, while SPP elicited no reliable effect.

One possible explanation of this pattern of effects is that verb knowledge dominates recovery from subject-verb agreement violations; the parser resolves the subject-verb discrepancy to match the verb. However, it is also possible that the processing outcome reflects the impact of sentence linearity on the establishment of grammatical dependencies and feature agreement: Since the feature of number is redundantly encoded throughout a sentence, the assignment of the number of the partial phrase marker can always be done using the number of the most recently analyzed number-marked word. In this case, the pronoun is perceived as ill-formed when it fails to number-agree with the recent verb rather than the more distant noun.

Our data clearly show that readers compute the meaning of sentences in the face of syntactic anomalies and processing errors that are common in language processing. We will discuss how a linearity-based and verb-dominant account can be teased apart, as well as implications of these for models of sentence processing.

### Examples

The hostess was dressing herself ...	SSS (singular, singular, singular)
*The hostess was dressing <u>themselves</u> ...	SSP
*The hostess <u>were</u> dressing <u>herself</u> ...	SPS
*The hostess <u>were</u> dressing <u>themselves</u> ...	SPP

### References

- Coulson, S., King, J., & Kutas, M. (1998). Expect the unexpected: Event-related brain response to morphosyntactic violations. *Language and Cognitive Processes*, 13, 21–58.
- Osterhout, L., & Mobley, L. A. (1995). Event-related brain potentials elicited by failure to agree. *Journal of Memory and Language*, 34, 739–773.

## The construction of subject-verb agreement in sentence production by bilinguals

Anna Hatzidaki, Martin J. Pickering & Holly P. Branigan (University of Edinburgh)

annh\_22@yahoo.com

What is the impact of the syntax of the non-target language when bilinguals produce utterances in the target language? So far, there has been an abundance of evidence that bilingual speakers consider the non-target language with respect to lexical processing, (e.g., Hermans, Bongaerts, De Bot, & Schreuder, 1998; Colomé, 2001; Van Hell & Dijkstra, 2002), but few studies have investigated syntactic processing (Loebell & Bock, 2003; Hartsuiker, Pickering, & Veltkamp, 2004). A related question is whether any such influence of the non-target language on syntactic processing might be affected by the "mode" (monolingual vs. bilingual) of a speaker when performing on a language production task. Our focus is on the factors affecting number agreement, which has been central to work on monolingual production (Bock & Miller, 1991), in particular, on the influence that relates to the characteristics of the subject: Whereas it might initially appear that agreement is governed by the morphosyntactic form of the head noun (singular vs. plural), (Bock, Nicol, & Cutting, 1999), it is in fact also affected by the numerosity of the subject (whether it refers to one vs. many entities), (Vigliocco, Butterworth, & Semenza; 1995). How can we use the evidence from monolingual subject-verb agreement to develop an account of bilingual subject-verb agreement? In many cases, a word and its translation will have the same number. For example, the English *tree* and the Greek *dendro* both refer to the same entity and are both singular. But in other cases, a word may be singular in one language but be plural in the other language. For example, the English *cash* is singular but the Greek translation, *psila*, is plural. It is possible that this conflict in number will lead to interference between the languages in bilingual speakers, so that they produce a plural rather than a singular verb, or vice versa. An exploration of the conditions under which such interference occurs should prove highly informative about the construction of agreement and hence the representation of syntactic information in bilinguals. We address these questions by investigating bilinguals' construction of subject-verb agreement, both when they produce utterances in one language (monolingual mode) and when they produce mixed-language utterances (i.e., involving code-switching; bilingual mode). We report five experiments in which fluent Greek and English bilinguals performed on a sentence-completion task by producing verbs to singular or plural subjects when the number of the translation was either the same or different, and when their completion either did or did not switch languages. For single-language utterances, completions were affected by the subject's number in the non-response language, particularly when participants used both languages in the course of the experiment and when the non-response language was their native language. Comparable but enhanced effects occurred for mixed-language utterances, with agreement appearing to depend on morphological and notional salience. The results demonstrate that the grammar of both languages can be activated when participants produce both single-language and mixed-language utterances. We interpret our results in terms of a model of bilingual sentence production.

## The use of thematic role information during pronoun resolution: A visual-world eye-movement study

Juhani Järvikivi (University of Turku & University of Dundee), Roger P. G. van Gompel (University of Dundee) & Jukka Hyönä (University of Turku)

j.jarvikivi@dundee.ac.uk

A very controversial issue is whether pronoun resolution is immediately affected by semantic factors such as verb bias (e.g., Garnham et al., 1996; Greene & McKoon, 1995; McDonald & MacWhinney, 1995; Stewart et al., 2000). To investigate the time course of semantic information associated with thematic roles, we conducted two experiments that used the visual-world eye-movement method. This method is highly sensitive to the time course of different effects on pronoun resolution (Järvikivi et al., 2005), so it is ideally suited to answer this question. In addition, Experiment 2 investigated whether semantic effects interact with the type of pronoun.

In Experiment 1, participants listened to Finnish sentences such as in (1), which contained a personal pronoun *hän* and two potential antecedent characters (*Räikkönen* and *Schumacher*). At the same time, they saw pictures of these characters. In half the conditions, the subject was the stimulus and the object the experiencer (when the verb was *pelotti* in (1)); in the other half, this was reversed (*pelkäsi* in (1)). Finnish has flexible word order, which enabled us to contrast the time course of the thematic role effect with the subjecthood preference (Crawley et al., 1990) and first-mention preference (Gernsbacher & Hargreaves, 1988): The sentences had either subject-verb-object (1a) or object-verb-subject order (1b).

The results showed effects of order-of-mention and thematic role: Participants looked more often at pictures of first-mentioned than second-mentioned characters, and more often at the stimulus than the experiencer. There was no effect of grammatical role (subject vs. object). Most importantly, the thematic role effect occurred slightly earlier than the order-of-mention effect.

Interpretation preferences for anaphors are strongly affected by the type of anaphor. For example, personal pronouns are easier to process when they refer to structurally salient antecedents, whereas the reverse is true for names (Gordon et al., 1993). Experiment 2 investigated personal pronouns (*hän*, 2a) and demonstrative pronouns (*tämä*, 2b) and contrasted two types of saliency: Thematic saliency (stimulus vs. experiencer) and saliency due to order-of-mention. The question is whether *hän* refers to antecedents that are both thematically salient and salient due to order-of-mention, while *tämä* refers to antecedents that are non-salient on both dimensions.

We observed an early thematic role effect: Between 500–900 ms after pronoun onset, participants looked more often at the stimulus than the experiencer, regardless of the type of pronoun. There was an interaction between order-of-mention saliency and pronoun from 700 ms after pronoun onset: For *hän*, participants looked more often at the first character than the second character, whereas this pattern was reversed for *tämä* (see also Kaiser & Trueswell, in press). The interaction with thematic saliency occurred much later: From 1100 ms after pronoun onset, there was a stimulus preference for *tämä*, but no thematic role effect for *hän*. Crucially however, *tämä* was not interpreted as referring to the less salient experiencer role.

We conclude that semantic information associated with thematic roles has an early effect on pronoun resolution. However, in contrast to order-of-mention saliency, thematic saliency does not interact with type of pronoun.

### Examples, Experiment 1

- (1) a. Kimi Räikkönen pelotti / pelkäsi Michael Schumacheria ennen osakilpailun starttia, koska hän oli varsin vakuuttavasti osoittanut tallin uuden auton olevan todella kilpailukykyinen.  
Kimi Räikkönen [SUBJECT] frightened / feared Michael Schumacher [OBJECT] before the start of the race, because he had quite convincingly shown that the new team car was really competitive.
- b. Kimi Räikköstä pelotti / pelkäsi Michael Schumacher ennen osakilpailun starttia, koska hän oli varsin vakuuttavasti osoittanut tallin uuden auton olevan todella kilpailukykyinen.  
Kimi Räikkönen [OBJECT] frightened / feared Michael Schumacher [SUBJECT] before the start of the race, because he had quite convincingly shown that the new team car was really competitive.

### Examples, Experiment 2

- (2) a. Kimi Räikkönen pelotti / pelkäsi Michael Schumacheria ennen osakilpailun starttia, koska hän oli varsin vakuuttavasti osoittanut tallin uuden auton olevan todella kilpailukykyinen  
Kimi Räikkönen [SUBJECT] frightened / feared Michael Schumacher [OBJECT] before the start of the race, because he [personal pronoun] had quite convincingly shown that the new team car was really competitive.
- b. Kimi Räikköstä pelotti/pelkäsi Michael Schumacher ennen osakilpailun starttia, koska tämä oli varsin vakuuttavasti osoittanut tallin uuden auton olevan todella kilpailukykyinen  
Kimi Räikkönen [SUBJECT] frightened / feared Michael Schumacher [OBJECT] before the start of the race, because he [DEMONSTRATIVE PRONOUN] had quite convincingly shown that the new team car was really competitive.

## Interpreting ambiguous pronouns: Sometimes it's easier

Peter C. Gordon, Randall Hendrick & J. Scott Hajek (University of North Carolina)

pcg@email.unc.edu

A recent series of experiments using eye tracking to study grammatical attachment in reading has supported the striking claim that sentences with ambiguous attachment are understood more quickly than sentences with unambiguous attachment (e.g., van Gompel, Pickering & Traxler, 2001). The results support a variable-choice reanalysis model where an interpretive choice is made on a probabilistic basis for an ambiguous input and that choice is only revisited if it is proven wrong because it leads to an implausible or ungrammatical interpretation further down the path. The model predicts that a globally ambiguous sentence will be easier (or at least no harder) to understand than an unambiguous sentence because whatever choice is made at the point of ambiguity will be consistent with the input that follows. Eye tracking on VP-NP attachment ambiguities confirms this prediction.

The current research extends the variable-choice reanalysis model to the coreferential interpretation of pronouns, expressions that in principle are highly ambiguous. Subjects read three-sentence passages, such as the one shown below, in which two named characters were mentioned in the first sentence and the third sentence contained a third-person singular pronoun. In the ambiguous condition, the two named characters were the same gender. Therefore, the features of the pronoun itself could not be used to uniquely identify its referent. In the unambiguous condition, the two named characters were different genders, meaning that the features of the pronoun could be used to uniquely identify its referent. (Two versions of each unambiguous sentence were used, one referring to the first named character and the other referring to the second named character.) If the variable-choice reanalysis model accurately characterizes pronoun interpretation in passages like this, then comprehension should proceed more rapidly when the pronoun is ambiguous than when it is unambiguous. This prediction was confirmed by the regression-path durations on a region of text consisting of the pronoun and the preceding word. Times were slower when the pronoun was unambiguous than when it was ambiguous (584 versus 476 ms;  $F_1(1,39)=7.28, p=.01$ ;  $F_2(1,19)=6.20, p=.02$ ).

Our finding that ambiguous pronouns are understood more readily than unambiguous ones contrasts with recent findings showing that understanding pronominal reference is more difficult when more than one antecedent matches the gender and number features of a pronoun (Badecker & Straub, 2002; Kennison, 2003). We believe that these studies explored sentence or discourse configurations in which pronouns are biased to a preferred antecedent even though the lexical features of the pronoun match more than one antecedent. In such cases, the sentences are not globally ambiguous; therefore the variable-choice reanalysis model does not predict an advantage of ambiguity. When taken together with previous results on grammatical attachment, the present findings on pronoun interpretation suggest that common principles govern the processing of ambiguity at different levels of linguistic analysis.

### Example

The tennis club brought George together with Jacob/Claire. Matches were held Tuesday nights.  
He must have lost every game.

### References

- Badecker, W., & Straub, K. (2002). The processing role of structural constraints on the interpretation of pronouns and anaphors. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 28, 748–769.
- Kennison, S. M. (2003). Comprehending the pronouns her, him, and his: Implications for theories of referential processing. *Journal of Memory and Language*, 49, 335–352.
- van Gompel, R. P. G., Pickering, M. J., & Traxler, M. J. (2001). Reanalysis in sentence processing: Evidence against current constraint-based and two-stage models. *Journal of Memory and Language*, 45, 225–258.

## The time course of lexical vs. stereotypical gender processing in reference resolution: Evidence from eye-movement

Hamutal Kreiner (University of Glasgow), Patrick Sturt (University of Edinburgh) & Simon Garrod (University of Glasgow)

hamutal@psy.gla.ac.uk

Previous research has shown that readers immediately slow down when an anaphor refers to an antecedent that mismatches in stereotypical gender [1, 3] (e.g., "the minister reminded herself about the letter"). One interpretation is that elaborative inferences are made when a stereotypical noun is processed, leading to processing difficulty downstream when the anaphor mismatches the inferred gender [1]. However, an alternative account is that stereotypical gender is marked as a lexical feature, as suggested by [3], leading to a feature clash in the case of mismatch. Current results do not distinguish between these two accounts, because all published studies used anaphora, where the referring expression follows the critical noun. This allows time for inferences to occur between the critical noun and the referring expression, so that any mismatch cost at the referring expression could equally be due to inference or lexical clash. The two eyetracking experiments reported here attempted to resolve this issue.

The experiments compared stereotypical nouns like "minister" with true lexically gender marked nouns, e.g., "king", where gender is part of the meaning of the word. To increase the likelihood of early effects, both experiments used materials where the dependency between referring expression and critical noun phrase was forced grammatically (see also [2]), in our case using binding and control (see [a, b]). Experiment 1 used cataphora [5], where the referring expression precedes the stereotypical noun, as in [a]. Crucially, the two accounts make different predictions here. According to the lexical account, there should be an early gender mismatch cost for both noun types at "the king/minister", due to the feature clash. In contrast, the inference account predicts an early mismatch cost for the lexically marked nouns, while effects for the stereotype nouns, if any, should be weak and delayed, because any inference can only begin after the relevant noun has been processed. The mismatching effect for lexically marked nouns was significant at "king" in early and late EM measures. However, for the stereotype nouns, only a delayed marginal effect was found (regression-path in prefinal region), with no second-pass effects.

Experiment 2 was a control experiment using almost identical materials, but with the order of clauses reversed, so that the referring expression occurred after the critical noun [b]. Here, both accounts predict an early mismatch cost for both types of noun, as has been found in previous studies. In a variety of EM measures a gender-mismatching effect was found both for lexically marked and stereotypical nouns. Although the effect emerged slightly earlier for lexically marked nouns (first fixation on "himself") than for stereotypical nouns (first pass on following word), overall, the stereotypical nouns exhibited an earlier and much more persistent gender mismatch cost in Experiment 2 compared with Experiment 1.

The results therefore support a model in which stereotypical gender effects emerge from inference, rather than lexical specification. This finding converges with recent evidence that stereotype effects can be modulated with context [4].

### Examples

- [a] After reminding himself (herself) about the letter, the king (minister) immediately went to the meeting at the office.  
 [b] Yesterday the king (minister) left London after reminding himself (herself) about the letter.

### References

- [1] Carreiras, M., Garnham, A., Oakhill, J., & Cain, K. (1996). The use of stereotypical gender information in constructing a mental model: Evidence from English and Spanish. *The Quarterly Journal of Experimental Psychology*, 49A(3), 639–663.  
 [2] Osterhout, L., Bersick, M., & McLaughlin, J (1997). Brain potentials reflect violations of gender stereotypes. *Memory and Cognition*, 25, 273–285.  
 [3] Sturt, P. (2003). The time-course of the application of binding constraints in reference resolution. *Journal of Memory and Language*, 48, 3, 542–562.  
 [4] Duffy, S. A., & Keir, J. A. (2004). Violating stereotypes: Eye-movements and comprehension processes when text conflicts with world knowledge. *Memory and Cognition*, 32, 551–559.  
 [5] Van Gompel, R. P. G., & Liversedge, S. P. (2003). The influence of morphological information on cataphoric pronoun assignment. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 29, 128–139.

## Perspective matters during on-line production and interpretation of questions and replies in unscripted conversation

Sarah Brown-Schmidt, Christine Gunlogson, Duane Watson, Carol Faden & Michael Tanenhaus (University of Rochester)  
brownsch@uiuc.edu

Cooperative speakers ask questions when they don't know the answer, but believe their addressee might. They assert things they know but believe their addressee might not know. While the presuppositions tied to construction types suggest the distinction between private and shared knowledge is basic to language processing, addressees often fail to distinguish shared from private information (1, 2), and when they do, the egocentric perspective can interfere with reference interpretation (3). However, most on-line work on perspective uses imperatives, which may encourage egocentrism due to authority-induced suspension of skepticism and the addressee's aim not to appear confused. We examined four semantic/syntactic forms (a–d) that differ in discourse function (requesting / imparting / confirming information) in goal-directed interactive conversation. Examining utterance forms which presuppose a distinction between speaker and hearer knowledge (e.g., questions and replies) should provide insights into whether this information is used on-line.

Speech and eye-movements were recorded as naive participants completed a referential communication task (4). Each of 36 cubbyholes had a game-piece visible to one partner (private), or both (shared). Both sides of each game-piece had an identical image of a cow, horse or pig wearing a hat, glasses or shoes. Participants rearranged game-pieces such that no adjacent game-pieces matched for animal or attribute type. We analyzed the eye-tracked participant's interpretation of *wh*-questions and statements, and her production of question-responses and acknowledgments. Utterances referring to a game-piece and following the form of (a)–(d) were analyzed. Critical NPs were always ambiguous between multiple potential referents distinguished only by cubbyhole type (shared / private / partner's private) and discourse history.

Conversations from nine pairs were transcribed. Eye-tracking analyses for six pairs are presented here. All reported effects are significant at  $p < .05$ . Consistent with predictions, *wh*-questions primarily inquired about addressee-private game-pieces, whereas statements were about shared or speaker-private game-pieces. Question-responses predominately referred to a speaker-private game-piece; acknowledgments were significantly more likely to be about an addressee-private game-piece.

When interpreting statements, fixations to targets rose ( $p = .08$ ) following reference onset. Most of the fixations were to shared cubbyholes; fixations to addressee-private cubbyholes dropped following reference onset. When interpreting *wh*-questions, target fixations rose later, in the region preceding mention of the 'anchor' (defined below). Unlike statements, fixations to addressee-private and shared cubbyholes were initially equivalent. Addressee-private fixations rose following reference to the anchor.

Speakers acknowledging their partner's statements directed only 20% of fixations to the target; immediately before speech onset, shared cubbyhole fixations dropped and speaker-private fixations increased. The speech-gaze link was stronger for question-responses. One second before speech onset, target fixations rose to 70%, then dropped to 40% following speech onset. Dovetailing with *wh*-interpretation results, speaker-private cubbyhole fixations were initially high, then dropped immediately before response onset. When participants failed to respond to *wh*-questions (e.g., *Huh?*), target fixations were delayed.

In sum, the distinction between shared and private game-pieces was reflected in referent- type differences across utterance forms, and on-line interpretation of utterances with different discourse functions. During goal-directed conversation, interlocutors clearly take into account each other's perspective when producing and comprehending utterances for which perspective is relevant.

**Examples** ('referent' = 1st underlined; 'anchor' = 2nd underlined)

- a) *Wh*-Question            What's next to the pig with the hat?  
 b) Statement              There's a cow with shoes next to the pig with the hat.  
 c) Question response    (What's next to the pig with the hat?)... A cow with shoes.  
 d) Acknowledgment      (There's a cow with shoes.)... A cow with shoes.

Type of 'referent'	Shared	Speaker-Private	Addressee-Private
Wh-Question	1.2%	1.9%	96.9%
Statement	35.9%	59.9%	4.2%
Question Response	5.6%	92.3%	2.1%
Acknowledgment	28.2%	15.0%	57.0%

### References

- (1) Keysar, Lin & Barr (2003)
- (2) Barr & Keysar (2002)
- (3) Hanna, Tanenhaus & Trueswell (2003)
- (4) Krauss & Weinheimer (1966)

## Investigating reference frame categorisation using dialogue

Matthew E. Watson, Martin J. Pickering & Holly P. Branigan (University of Edinburgh)

s0129081@sms.ed.ac.uk

We report three experiments which used a confederate priming paradigm (Branigan, Pickering & Cleland, 2000) to investigate the mental representation of reference frames. Reference frames are an axial, co-ordinate system that are imposed upon a scene and allow the description of the location of a figure object in relation to a reference object (Logan & Sadler, 1996). Reference frames can be roughly categorised as either based upon directional features of the environment (e.g., gravity), directional features of an object, or directional features of a viewer; a speaker has to select one of these reference frame types when describing the location of an object. Although researchers have agreed about the existence of reference frames, they have disagreed about their taxonomy. Levinson (1996, 2003) has partitioned reference frames into *absolute* (based upon salient directional features of the environment), *intrinsic* (a binary argument based upon the directional axes of the reference object), and *relative* (a ternary argument based upon the viewpoint of an observer and their directional axes). In contrast, researchers in psycholinguistics (e.g., Carlson-Radvansky & Irwin, 1993; Miller & Johnson-Laird, 1976) have traditionally categorised reference frames as *absolute* (essentially the same as Levinson's absolute), *intrinsic* (based upon the intrinsic sides of a non-egocentric reference object), and *deictic* (an egocentric reference frame). The essential difference between the two taxonomies is that Levinson's taxonomy argues that descriptions like *The ball is in front of the car* (at the car's headlights) and *The ball is in front of me* use an intrinsic reference frame, because both descriptions involve a binary relation between a figure and a reference object, whereas the Traditional taxonomy argues that *The ball is in front of me* uses a deictic reference frame, the same reference frame as *The ball is to the left of the car* (from my perspective) because both are egocentric reference frames. Note that under Levinson's account, the latter uses a relative reference frame, because it is a ternary argument between a figure object, a reference object and a viewpoint. Our experiments exploited the tendency for interlocutors to re-use a reference frame that they have just heard their partner use, in preference to an alternative reference frame (*reference-frame alignment*; Watson, Pickering & Branigan, 2004), to investigate these alternative accounts. Participants alternately described the location of objects to their partner and chose pictures that matched descriptions of object locations. The results support the Traditional taxonomy over Levinson's taxonomy: Participants were more likely to use a sentence of the form *The ball is to the left of the car* than *the ball is in front of the car* after hearing the confederate use a sentence of the form *The ball is in front of us*. This suggests that participants represented *the ball is in front of us* in the same manner as *the ball is to the left of the car* as predicted by the Traditional taxonomy. Additionally, we found reduced alignment of reference frames when the reference object was in different positions in prime and target. This suggests that different aspects of reference frames contribute independently towards alignment between interlocutors.

### References

- Branigan, H. P., Pickering, M. J., & Cleland, A. A. (2000). Syntactic co-ordination in dialogue. *Cognition*, 75, B13–B25.
- Carlson-Radvansky, L. A., & Irwin, D. E. (1993). Frames of reference in vision and language: Where is above? *Cognition*, 46, 223–244.
- Levinson, S. C. (1996). Frames of reference and Molyneux's questions: Cross linguistic evidence. In P. Bloom, M. A. Peterson, L. Nadel & M. F. Garrett (Eds.), *Language and Space*, pp. 109–169. Cambridge MA: The MIT Press.
- Levinson, S. C. (2003). *Space in Language and Cognition: Explorations in Cognitive Diversity*. Cambridge: Cambridge University Press.
- Logan, G. D., & Sadler, D. D. (1996). A computational analysis of the apprehension of spatial relations. In P. Bloom, M. A. Peterson, L. Nadel, & M. F. Garrett (Eds.), *Language and Space*, pp. 493–529. Cambridge MA: The MIT Press.
- Miller, G. A., & Johnson-Laird, P. N. (1976). *Language and Perception*. Cambridge MA: The MIT Press.
- Watson, M. E., Pickering, M. J., & Branigan, H. P. (2004). Alignment of reference frames in dialogue. *Proceedings of the 26th Cognitive Science Meeting*.



## Effects of picture perception on the expression of abstract concepts in sentence production

Manami Sato, Amy J. Schafer & Benjamin K. Bergen (University of Hawai'i, Manoa)

manamis@hawaii.edu

Lakoff (1987) argues that abstract concepts are not only described in terms of concrete concepts like physical objects, but that these abstract *target domains* are also conceived in terms of concrete *source domains*. For example, an abstract concept like "time" can be conceived of and described in terms of the concrete source domain of possession ("have time", "spend time", etc.). If correct, this view suggests that language about abstract concepts should be influenced by the activation of related concrete concepts (e.g., Boroditsky 2001). This study used picture perception to prime two concrete source domains, containment and possession, and found associated increases in the use of metaphorical language specific to those domains in sentence production.

In each trial of a production experiment, subjects saw two consecutive pictures depicting containment, possession, or neither relation (hereafter, "neutral" relations), as in (1). Norming with a picture description task ensured that each picture clearly conveyed containment, possession, or neutral relations. The pair of pictures was followed by a linguistic prompt — a person's name and an abstract word (e.g., "Sally, trouble"). A large corpus analysis using the British National Corpus verified that each of the abstract words was used in both containment-related metaphorical expressions (e.g., "be in trouble") or possession-related ones (e.g., "have trouble") with similar frequency. Based on each linguistic prompt, subjects produced a simple sentence. The resulting productions were categorized as containment, possession, or neutral expressions (following Lakoff's 1987 criteria, also used for the corpus analysis). Results from 30 subjects demonstrated that perceiving containment or possession pictures significantly increased the production of associated metaphorical sentences compared to responses in the neutral condition.

The observed priming effect could have resulted from two processes other than an effect of the concrete source domain on the metaphorical language chosen: (i) lexical priming (if specific words activated by the image were subsequently used in the sentence production, such as "in" for containment or "have" for possession) and (ii) syntactic priming (if specific syntactic structures were associated with containment versus possession depictions). Control analyses suggested that neither lexical nor syntactic priming was sufficient to explain the results. First, a significant effect of picture type remained after the exclusion of sentences with words likely to have been lexically primed (based on picture descriptions collected in the norming study). Second, no consistent syntactic pattern was found in descriptions of the containment or possession pictures in the norming study. Third, control materials with active- versus passive-biased pictures (see (1)) did not show significant effects of picture type on syntactic form.

This study shows that activation of a concrete concept such as containment or possession can influence sentence form in language production. It is well known that activating particular lexical items or syntactic structures can affect sentence production (e.g., Bock & Griffin 2000). These results indicate that activating a particular source domain makes speakers more likely to think and talk about abstract concepts in terms of that concrete domain, providing partial insight to processing activity at the message level of sentence production.

### Examples of picture primes in the sentence production task

- |                 |   |
|-----------------|---|
| (1) Containment | An apple <i>in</i> a box, a bird <i>in</i> a cage                 |
| Possession      | A boy <i>holding</i> an apple, a boy <i>holding</i> a model yacht |
| Neutral         | A boy using a computer, a girl playing piano                      |
| Active          | A girl attacking a bird, a boy crushing a TV                      |
| Passive         | A boy being chased by a dog, a girl being hit by a ball           |

### References

- Bock, K., & Griffin, Z. (2000). The persistence of structural priming: Transient activation or implicit learning? *Journal of Psychology*, 129(2), 177–192
- Boroditsky, L. (2001). Does language shape thought? English and Mandarin speakers' conceptions of time. *Cognitive Psychology*, 43(1), 1–22.

## Processing Japanese relative clauses in context

Tomoko Ishizuka (University of California, Los Angeles), Kentaro Nakatani (Konan University) & Edward Gibson (Massachusetts Institute of Technology)

zukka@ucla.edu

It has been reported in the literature that subject-extractions are easier to process than object-extractions in many languages with postnominal relatives, including English (e.g., King & Just, 1991), and French (Holmes & O'Regan, 1981). One way to account for this difference is in terms of resources, either in temporary storage or integration costs (Chomsky & Miller, 1963; Lewis, 1996; Gibson 2000; Gordon et al., 2001). An alternative account is in terms of depth-of-embedding of the extracted element (O'Grady, 1997), such that more embedded extractions are more complex.

Increasing attention has been paid to SOV languages with prenominal relatives, such as Japanese and Korean, where the two accounts make different predictions. The depth-of-embedding hypothesis predicts object-extractions to be harder crosslinguistically. Conversely, the resource hypothesis predicts higher complexity of subject-extractions (2b) due to the increased intervening referents between the gap and the head (2a). Recent null-context studies in these languages have reported higher complexity of object extractions than subject extractions (e.g., Ishizuka, Nakatani & Gibson 2003, Nakamura & Miyamoto, 2003; Kwon, Polinsky & Kluender 2005). The results support the depth-of-embedding hypothesis over the resource hypothesis.

Nevertheless, in Japanese and Korean, there is a confounding temporary ambiguity in object extractions (2a), such that there is a preference for a main clause interpretation of the initial clause, initiated at the subject noun. Thus the relative difficulty of processing object-extractions could be due to extra reanalysis in these structures in a null context.

To control for this temporary ambiguity, we conducted a self-paced reading experiment in Japanese where subject-extracted and object-extracted RCs were presented as answers to a question inducing RC answers, thus removing the preference for a main clause analysis. The participants were instructed to read the passage and the question (1) followed by one of the relative clauses as an answer, either (2a) or (2b). We also conducted the same experiment in English for English speakers.

The results from the Japanese experiment show that once embedded in a RC-inducing context, subject extractions (2b) were processed significantly slower than object extractions (2a) at the embedded verb ( $F_1(1,41) = 3.78, p < .06$ ;  $F_2(1,17) = 6.37, p < .05$ ), contrary to the previous results from null-context experiments. This result is consistent with the pattern of Chinese data provided by Hsiao & Gibson (2003), which shows higher processing difficulty in subject-extractions than object-extractions for prenominal RCs. On the other hand, the results from our English experiment indicate higher complexity of object-extractions, consistent with the results of previous null-context experiments ( $F_1(1,33) = 10.75, p < .005$ ;  $F_2(1,15) = 9.94, p < .01$ ). These results support the distance-based resource account over the depth-of-embedding account. In SOV languages with prenominal RCs, O is closer to V as well as to the RC head noun than S is; thus object extractions are easier. In SVO languages with postnominal RCs, however, subject extractions are easier because subjects are closer to the RC head than objects are.

### Examples from Japanese

- (1) inu-ga kawa-de obore, syonen-ga sono-inu-o tasuketa. ippoo sono-syonen-o betu-no inu-ga tasuketa.  
'A dog was drowning in the river. A boy saved that dog. On the other hand, another dog saved that boy.'  
*Hanako* syonen-ga katte-irunowa sono-ni-hiki-nouchi-no docira-no inu?  
'Which dog among the two is the one that the boy keeps?'
- (2) a. *Taro* [syonen-ga tasuketa] inu-da  
boy-NOM saved dog-COP  
'(It) was the dog that the boy saved.'
- (2) b. *Taro* [syonen-o tasuketa] inu-da  
boy-ACC saved dog-COP  
'(It) was the dog that saved the boy.'

### Examples from English

- (1) A dog was drowning in the river.  
A boy saved the dog, and then another dog saved the boy.  
*Bill* I know that one of the dogs is the boy's pet now. Which one is it?
- (2) a. *Susan* The dog that the boy saved is the boy's pet.  
b. *Susan* The dog that saved the boy is the boy's pet.

## Chinese is no exception: Universal subject preference of relative clause processing

Chien-Jer Charles Lin & Thomas G. Bever (University of Arizona)

clin@u.arizona.edu

Relative clauses (RCs) are processed differently depending on whether they involve subject or object extractions. In head-initial languages such as English, German, and Dutch, where RCs follow the head nouns, subject-extracted RCs are easier to comprehend than object RCs. This preference was confirmed by self-paced reading tasks (King & Just, 1991; Gibson et al., 2005; Schriefers, Friederici & Kühn, 1995) and eye-movement studies (Traxler et al., 2002).

The effect of subject preference could be explained both by a locality-based account (Crain & Fodor, 1985; Frazier & Clifton, 1989; Gibson, 1998) and a structure-based account (e.g. Miyamoto & Nakamura, 2003) since the gaps in subject RCs are located both closer to the head nouns and higher up in structure for probing. It is, however, important to distinguish a locality-based theory from a structure-based theory because the former relies on functional factors such as cognitive resources and integration costs, while the latter emphasizes structural positions and implies a theory of goal-probing based on syntactic knowledge. Head-final languages, where RCs precede the head nouns, provide a chance to tease these two theories apart since the object RCs contain a local gap which is however more deeply-embedded in structure.

In head-final languages (such as Japanese, Korean, and Chinese), the effect of subject preference remains controversial. Miyamoto and Nakamura (2003) reported that subject RCs are preferred in Japanese, consistent with the subject preference in head-initial languages. Similar preferences were found in Korean (Kwon et al., 2004). However, Hsiao and Gibson (2003) reported faster RTs for Chinese object RCs, supporting a locality-based theory.

In this study, we revisited the processing of Chinese RCs by carefully examining Hsiao and Gibson's experimental materials and conducting self-paced reading tasks of our own. More than half of Hsiao and Gibson's verbs take sentential and verbal complements in addition to nominal objects. This increased the possibility of garden path. Their results were only significant at the pre-relativizer region, not at the relativizer and head noun regions. We conducted self-paced reading tasks, selecting verbs that take only nominal objects. We also contrasted between RCs modifying the subject and the object in a 2 x 2 design [Subject-/Object-RC x Subject-/Object-Modifying]. Subject RCs like (1) were read significantly faster than their object counterparts like (2); for overall reading latencies ( $F_1(1, 47)=12.87, p<.01$ ;  $F_2(1,23)=8.16, p<.01$ ), at the relativizer ( $F_1(1,47)=6.96, p<.05$ ;  $F_2(1,23)=3.41, p=.078$ ), and at the head noun ( $F_1(1,47)=9.92, p=.003$ ;  $F_2(1,23)=13.63, p=.001$ ). A main effect preferring subject-modifying RCs was found at the relativizer ( $F_1(1,47)=12.70, p<.01$ ;  $F_2(1,23)=29.21, p<.001$ ) and the head noun ( $F_1(1,47)=25.76, p<.001$ ;  $F_2(1,23)=74.66, p<.001$ ). This subject preference is consistent with another reported subject preference in processing Chinese possessor relative clauses (Lin et al., 2005). Our experimental results suggest that there is a universal preference for gaps at the subject positions, which supports the structure-based theory.

### Examples

- (1) [GAP] pengdao wo de nyuhai  
[gap] bump\_into I DE girl  
'the girl who bumped into me'
- (2) wo pengdao [GAP] de nyuhai  
I bump\_into [gap] DE girl  
'the girl who I bumped into'

### References

- Hsiao, F., & Gibson, E. (2003). Processing relative clauses in Chinese. *Cognition*, 90, 3-27.
- Lin, C.-J. C., Fong, S., & Bever, T. G. (2005). Constructing filler-gap dependencies in Chinese possessor relative clauses. *Proceedings of the 19th Pacific-Asia Conference on Language, Information, and Computation*. Taipei: Academia Sinica. (Available online at <http://www.u.arizona.edu/~clin/papers/papers.htm>.)

## Contextual and syntactic cues for head-final relative clauses in Chinese

Chun-chieh Natalie Hsu, Felicia Hurewitz (University of Delaware) & Colin Phillips (University of Maryland, College Park)

cchsu@udel.edu

Head-final relative clauses (RCs) in Chinese create potential difficulties for incremental processing because the presence of a RC usually cannot be detected prior to the clause-final RC marker '-de' (1a). A mismatching classifier-noun sequence (1b) is an unambiguous — yet indirect — cue for the start of a relative clause, and may produce a processing advantage for head-final RCs, as found in Japanese [1]. However, recent studies with different experimental methodologies (self-paced reading and eye-tracking) present mixed results in Chinese [2, 3]. Since RCs are often used to individuate items in a relevant context, this study examines the role of context in supporting the use of the unambiguous classifier-mismatch cue in Chinese RCs. Results from two off-line and one on-line study show that the classifier-mismatch cue facilitates RC processing in 2-referent contexts, but not in 1-referent contexts. This finding suggests that context can support the generation of unambiguous structures, and thus goes beyond previous demonstrations that context can guide selection among competing analyses of an ambiguous strings [4, 5].

Two sentence fragment completion studies investigated speakers' expectations. In the first study the fragments ended with a classifier (2a), and in the second study the fragments ended with a classifier + noun sequence (2b). Context was manipulated in both studies by preceding sentences that contained 1 versus 2 referents compatible with the classifier (3a, 3b). The total number of referents in the context was held constant across all conditions. Results from the first study showed that speakers generate more RC-completions in 2-referent contexts than in 1-referent contexts, and generate more simple clauses in 1-referent contexts than in 2-referent contexts. Results from the second study show that speakers are able to use the mismatching classifier+noun sequence to generate RC continuations in both 2-referent and 1-referent contexts, but that the number of ungrammatical completions was substantially reduced relative to results from null context conditions in previous studies [2]. These studies provide a basis for investigating whether context can make the classifier-mismatch cue more effective in an on-line setting.

The effectiveness of the classifier-mismatch cue was tested in an on-line self-paced reading experiment (N=20) with a 2 x 2 factorial design (context: 1 versus 2 classifier-consistent referents; classifier: matching vs. mismatching following noun). Unsurprisingly, mismatching classifier+noun sequences led to significant slowdowns independent of context ( $F_1(1,19)=19.54$ ,  $p<.01$ ,  $F_2(1,19)=36.01$ ,  $p<.05$ ). However, the classifier-mismatch led to *facilitation* of reading times at the disambiguating V+de region at the end of the RC (4) only in the 2-referent contexts. This was reflected in a significant context x classifier interaction ( $F_1(1,19)=6.62$ ,  $p<.05$ ,  $F_2(1,19)=18.61$ ,  $p<.05$ ), and was confirmed by pairwise comparisons within each level of the context factor.

The above results show that in Chinese, given appropriate contexts, the parser uses the cue of a mismatching classifier to avoid garden paths in head-final RC structures. This suggests that contexts not only help in selecting among competing parses in ambiguity resolution, but also are helpful in the generation of parses based on unambiguous yet indirect syntactic cues.

### Examples

- (1a) [laoshi feichang xihuan **de**] shu ... (1b) na-**ben** [laoshi feichang xihuan de] shu ...  
 teacher very like DE book that-CL<sub>book</sub> teacher very like DE book  
 (the/that book that the teacher likes very much...)
- (2) Zhege-xueqi-zhong, (2a) na-**liang** ... (2b) na-**liang daxuesheng** ...  
 (During this semester, that-CL<sub>car</sub> ... that-CL<sub>car</sub> college-student ...)
- (3a) **2-referent context:** The college student upstairs has two motorcycles. He doesn't maintain one of the motorcycles, but he maintains the other motorcycle very carefully.
- (3b) **1-referent context:** The college student upstairs has one motorcycle and one computer. He doesn't carefully maintain his computer but he maintains his motorcycle very carefully.
- (4) ... na-**liang / wei** daxuesheng chang-yi renzhen-de taidu **baoyang-de** motuoche ...  
 ... that-CL<sub>car</sub> / CL<sub>human</sub> college-student often-with earnest attitude maintain-DE motorcycle ...

### References

- [1] Yoshida, M., Aoshima, S., & Phillips, C. (2004). Relative clause prediction in Japanese. Paper presented at the 17th Annual CUNY Conference on Human Sentence Processing, College Park MD.
- [2] Hsu, C.-C., Phillips, C., & Yoshida, M. (2005). Cues for head-final relative clauses in Chinese. Poster presented at the 18th Annual CUNY Conference on Human Sentence Processing, Tucson AZ.
- [3] Wu, F., Haskell, T., & Andersen, E. (2005). Talk at Relative Clause Workshop, Leipzig.
- [4] Altmann, G., & Steedman, M. (1988). *Cognition*, 30, 191–238.
- [5] Tanenhaus, M., et al. (1995). *Science*, 268, 1632–1634.