The role of event knowledge in semantic interpretation

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INTRODUCTION

What can semantic ambiguity reveal about underlying language processing mechanisms?

__Heuristic__ vs. __algorithmic__ processing (Simon, 1956; Caramazza & Zurif, 1976; Fodor, 1982)

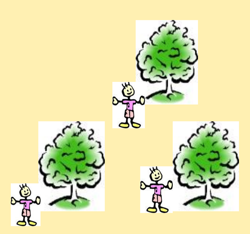
- •Examine Quantifier Scope Ambiguity
- •*Every N1 Verbed a N2*

Two possible meanings:

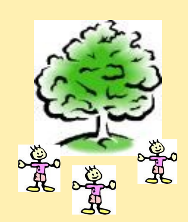
Meaning determined by the order of interpretation of quantifiers (i.e. scope interpretation)

__Every__ kid climbed __a__ tree

Surface scope interpretation:
•Consistent with linear order
i)(∀x) (x is a kid)→(∃y) (y is a tree & x climbed y)



Inverse scope interpretation:
•Consistent with inverse order
ii) (∃y) (y is a tree) & (∀x) (x is a kid → x climbed y)



Disambiguation of QSA sentences
•*Relies on number interpretation*
•Previous work, starting with Kurtzman and MacDonald (1993) showed that the plural interpretation was preferred.

PREVIOUS FINDINGS

		Context: Ambiguous	Context: Control
Continuation	Singular	Every kid climbed a tree. The tree __was__ in the park.	Every kid climbed the same tree. The tree __was__ in the park.
Continuation	Plural	Every kid climbed a tree. The trees __were__ in the park.	Every kid climbed a different tree. The trees __were__ in the park.

•A recent ERP study by Dwivedi et al. (2010) showed no preference for singular vs. plural interpretation

•See midline ERP recordings at Verb in Continuation sentence

•Underspecification of QSA sentences, i.e., algorithmic computation did not apply immediately

•In addition, an off-line norming experiment was included where 32 participants circled the most appropriate continuation sentence following QSA contexts.

•Questionnaire consisted of 160 ambiguous sentences, 80 unambiguous sentences, & 80 fillers

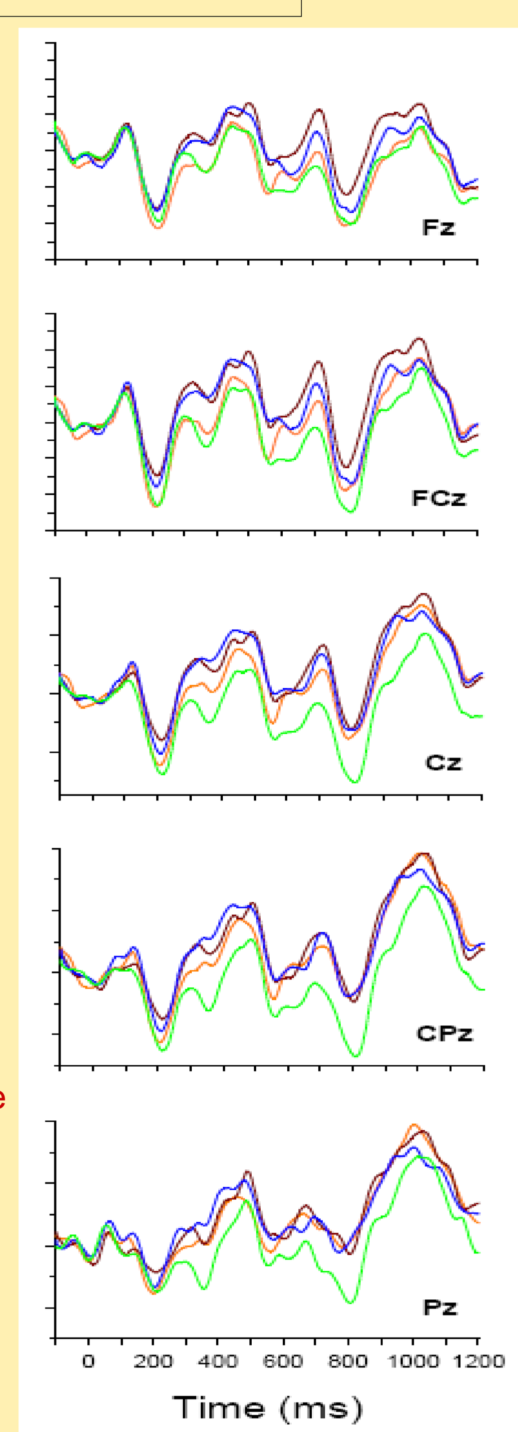
Every schoolgirl crossed a road.
The roads were flat and paved.
The road was flat and paved.

•Participants chose the plural interpretation 74% of the time (c.f., Kurtzman & MacDonald, 1993)

•By items analysis revealed that some sentences were heavily biased for the plural interpretation
•Eg, *Every kid climbed a tree* was interpreted as plural 100% of the time

•And some sentences were not biased for either interpretation
•Eg, *Every jeweller appraised a diamond* was interpreted as plural 50% of the time.

•Dwivedi (2013) proposed sentences are processed using **Heuristic first, algorithmic second** strategies.



THE PRESENT STUDY

"Heuristic interpretation of number associated with events"
Investigate lexical-pragmatic biases of number

•Chwilla & Kolk (2005) conducted an ERP priming study using word triplets
•Eg, DIRECTOR BRIBE __DISMISSAL__ VS. VACATION TRIAL __DISMISSAL__

•Evidence of N400 indicated that word triplets (in absence of grammatical information) can yield event interpretation

THE PRESENT STUDY cont'd

•To date, properties of events have been defined by types of participants, temporal and causal properties (Johnson-Laird, 1983; Altmann & Kamide, 1999; Madden & Zwaan, 2003). However, the ***number*** of participants per event has yet to be investigated.

__Hypothesis__:
•SG vs. PL judgments for sentences *Every kid climbed a tree, Every jeweller appraised a diamond* should serve as good predictors for judgments for word triplets KID CLIMB TREE, JEWELLER APPRAISE DIAMOND

METHODS

EXPERIMENTAL CONDITION	FORMAT	EXAMPLE
Ambiguous (AX)	N_1–V–N_2	KID CLIMB TREE
Control Singular (CS)	N_1–V–"ONE"–N_2	KID CLIMB ONE TREE
Control Plural (CP)	N_1–V–"SEVERAL"–N_2	KID CLIMB SEVERAL TREE

Table 1. Conditions, format and examples of critical stimuli.

FILLER CONDITION	FORMAT	EXAMPLE
Filler Determiner Singular THE, THIS, THAT	Det-N_1-V-N_2 Or N_1-V-Det-N_2	THIS LUMBERJACK CHOP LOG; NANNY MAKE THAT BREAKFAST
Filler Quantifier Plural ALL, MANY, TWO, FOUR, SIX	Q-N_1-V-N_2 Or N_1-V-Q-N_2	MANY BEAVER BUILD DAM; BANDIT ROB ALL TRAIN
Filler Content, Left Visual Field	N_1–V–N_2	FIREMAN EXAMINE LADDER
Filler Number, Central Visual Field	Q(numeral)-N-V	TEN FAX ARRIVE

Table 2. Conditions, format and examples of filler stimuli.

__Participants__
- 45 right-handed, native English speakers from Brock University

__Materials__
- 159 ambiguous sentences (Dwivedi et al., 2010) altered to make word-strings (Chwilla & Kolk, 2005)
- Stimuli separated into 3 lists so that each list contained every scenario in only one of the experimental conditions via Latin Square Design
- Experimental stimuli were pseudo-randomly mixed with 231 fillers, creating a total of 390 items per list
- Right visual field in experimental stimuli was controlled for using content fillers that required left visual field or central visual field judgments
- Word-triplets were followed by 2 pictures representing different interpretations of the scenario

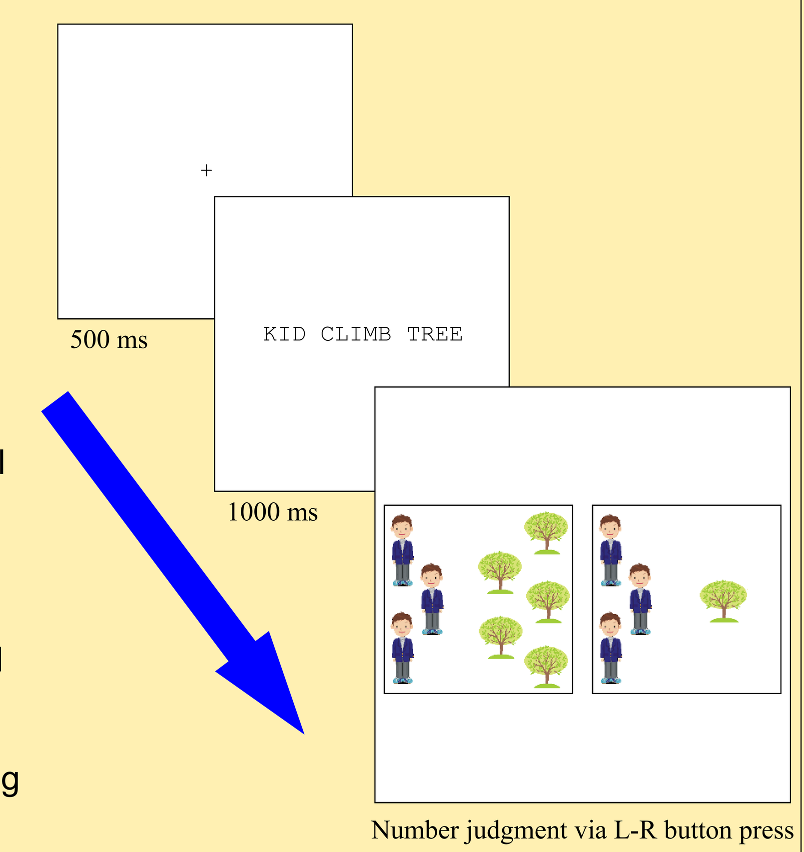


Figure 1. Example of stimuli, KID CLIMB TREE

__Procedure__
- Participants were instructed to read triplets for interpretive purposes; as if these were telegrams
- Each word-triplet was presented to participant on computer screen for 1000 ms; participants were required to press either "L" or "R" on E-prime button box indicating which picture they felt best matched the telegram.

RESULTS

- A binary logistic regression analysis of the full model against a constant only model, using SPSS, indicated that *proportion of plural judgments for full sentences in Dwivedi et al. (2010) significantly predicted binary plural judgments for word triplets in the present work (chi square = 5.43, p=0.020, with df=1)*; confirmed by Wald criterion, *p=0.022*).
- EXP(B) indicated that when proportion of plural judgment for full sentences increased by one unit, binary judgment for corresponding word triplets is 4.1 times more likely to be plural (see Fig. 2).

Data (see Table 3) were analyzed using a 2 (control/filler) x 2 (singular/plural) ANOVA for response time and accuracy data separately.

RT analyses: Significant main effect of Condition (control/filler) [F_1 (1,44)=125.0, *MSE*=22309.0; $p<.001$, $\eta_p^2=0.74$]
- Number was not significant ($F<1$).
- Condition X Number interaction was significant [F_1 (1,44)=28.0, *MSE*=14884.9; $p<.001$, $\eta_p^2=0.39$].
- Participants were significantly faster for control compared with filler stimuli. Regarding number, whereas they took more time at CP vs. CS, interestingly, FDS took longer than FQP. This probably has to do with the status of referential determiners THIS and THAT.

Accuracy data analyses: both main effects of Condition [F_1 (1,44)=4.79, *MSE* = 0.003; $p = .034$; $\eta_p^2=0.098$] and Number [F_1 (1,44)=55.24, *MSE*=0.005; $p<.001$; $\eta_p^2=0.56$] were significant.
- However, the Condition x Number interaction was not significant.
- Participants were slightly more accurate for Control compared with Filler conditions(2%) as well as more accurate for Singular compared to Plural conditions (8%)

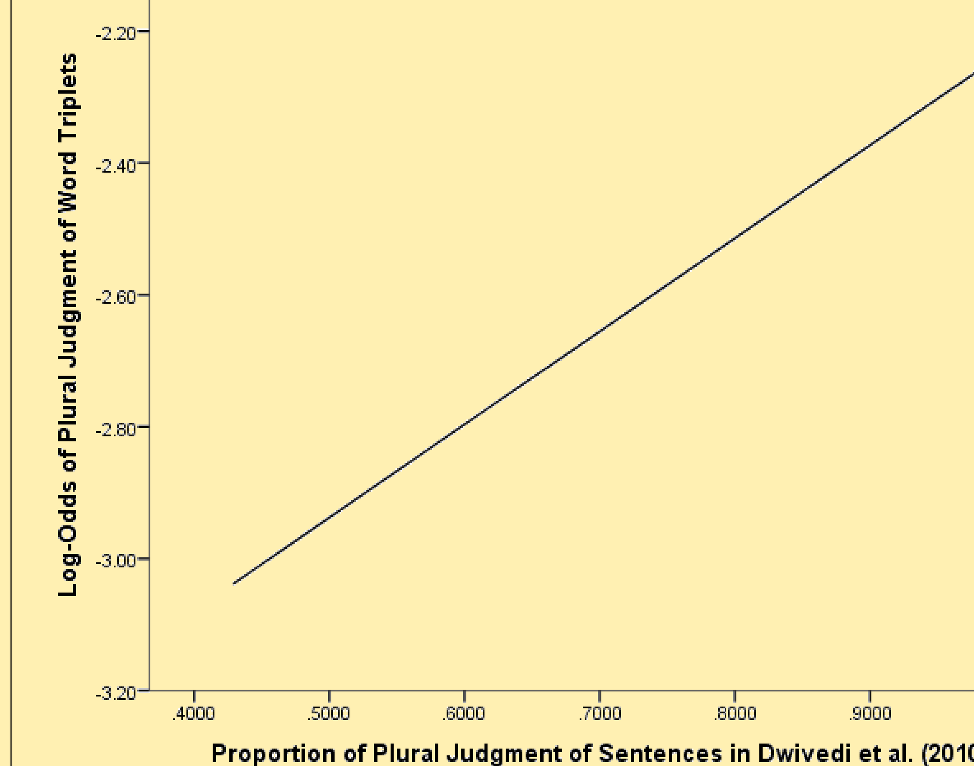


Figure 2. Binary Logistic Regression Analysis of probability of plural number judgment for word triplet stimuli with number judgments for full sentences as predictor.

Table 3. Mean comprehension response times (RT) and accuracy (%), by condition.

Condition	*RT (ms)* Mean (MSE)	*Accuracy (% Correct)* Mean (MSE)
Ambiguous (AX)	1595.6 (69.5)	---
Control Singular (CS)	1149.4 (47.6)	97.3 (0.4)
Control Plural (CP)	1261.1 (52.8)	89 (1.4)
Filler Determiner Singular	1494.5 (59.8)	95 (0.7)
Filler Quantifier Plural	1413.8 (54.4)	87.6 (1.4)
Filler Content, Left Visual Field	1383.1 (45.1)	97.1 (0.4)
Filler Number, Central Visual Field	912.4 (41)	97.6 (0.4)

DISCUSSION

- **Quantifier scope ambiguous sentences can be interpreted using heuristic only strategies using number interpretation wrt events.**
- That is, binary logistic regression revealed that plural judgments for QSA sentences did predict judgments for word triplets.
- **Thus, like Chwilla & Kolk (2005), we have shown that word triplets evoke event interpretations.**
- **Further, these triplets reveal that people's conceptual knowledge about events includes not just participants as per thematic relations, but also the stereotypical NUMBER of participants in an event.**
- **Finally, this information is available immediately for on-line interpretation.**
- *Activation of event knowledge is modulated by non-linguistic factors of lexical frequency and complexity of picture task.*
- Eg, results indicated overwhelming preference of singular!
- SG preference likely due to higher frequency of SG words and simpler SG pictures (measured via comparing compressed bitmap images, as correlated with subjective image complexity, cf. Donderi 2006).
- In addition, perhaps absence of inflection led participants to interpret words as SG
- This could explain less accurate performance at Control Plural and Filler (quantifier) Plural stimuli.
- *Preliminary discussion re: language-number interface*
- RTs for (baseline) Filler Number were fastest, even compared to (other baseline) Filler Content, suggesting participants are faster at estimating amounts vs. identifying nominal objects.
- Other preliminary results suggest that quantifier ALL was most difficult and took most time as compared to MANY and NUMERALS.
- Need to further investigate semantic link between representation of quantity as indicated by numerals vs. quantifiers.

FUTURE STUDIES

- Add more linguistic context to force participants to more deeply interpret event (overcome SG bias due to lack of inflection?) and/or include a plausibility judgment task to force event interpretation.
- E.g., *KID CLIMB TREE in the __park__ / __ocean__; JEWELLER APPRAISE DIAMOND at the __store__ / __zoo__*
- Investigate the complexity effect which results in pictures with several vs. fewer items.
- Compare numeral quantification vs. context dependent quantification
- Compare interpretation of different weak (eg MANY, SOME, NUMERALS) vs. strong quantifiers (ALL, EVERY)
- The results also indicate that numerical cognition and quantification of objects are intricately linked; this rich area requires further investigation.
- Examine interpretation of number in quantifier sentences/events in special populations (ie individuals with dyscalculia)

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