



# RETHINKING SUPERIORITY EFFECTS – A PROCESSING MODEL

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**ABSTRACT** - We present evidence from two magnitude-estimation studies for a processing-based model of *wh*-dependencies (Arnon, Estigarribia, Hofmeister, Jaeger, Pettibone, Sag, & Snider, 2005). Following integrative approaches to grammar & performance (e.g. Fanselow & Frisch, 2004; Kluender, 1998; Hawkins, 2004), the model derives preferences over linear orders of *wh*-phrases (e.g., (1) vs. (2)) from the associated processing cost. The model accounts for superiority effects in terms of earlier research on (a) the processing of long-distance dependencies (e.g. Gibson, 2000) and (b) accessibility-related intervention effects (e.g. Kluender, 1992; Warren & Gibson, 2002).

## Grammar-Based Accounts of Superiority

- The acceptability difference between (1) and (2) has been attributed to a syntactic constraint, Superiority (Chomsky, 1973), requiring that a dependency between a filler and its gap may not be interrupted by a *wh*-phrase syntactically superior to the gap.

- (1) *Who*  saw what? [no Superiority violation]  
 (2) *\*What did who see* ? [Superiority violation]

## Are Superiority violations really ungrammatical?

- Superiority violations (as defined by grammar-based accounts) improve significantly, if the discourse status of the extracted *wh*-phrase is linked to the context (*which man* below), as has been acknowledged by extensions to grammar-based accounts (such as D-linking; Pesetsky, 1987; 2000):

(3) *Which man did who see* ? [Superiority violation]

- However, in Arnon et al. (2005), we argued that:
  - Many naturally occurring Superiority violations cannot be reconciled with these extended grammar-based accounts, e.g.:

A: *Did you know that there are no licensing laws or sales taxes in Andorra?*  
 B: *I did not. What did who bring back?* [http://gofree.indo.ie/~tex/log/logo46.html]

- Instead, the acceptability of different orderings of *wh*-phrases is affected by non-syntactic factors more generally (cf. Fanselow & Frisch, 2004).

- As an alternative to grammar-based accounts, we suggest that the decreased acceptability of Superiority violations is due to increased processing cost.

## Method: Magnitude Estimation

- Acceptability judgments were collected using magnitude estimation:** The judgment scale was not predetermined (participants set their own scale). The acceptability of each test item is compared with a reference sentence.
- Magnitude estimation was originally used in research on psychophysics but has been applied in numerous linguistic studies (see Bard et al, 1996 for more details).
- The experiments presented below were conducted on-line using the WebExp 2.1 software package (Keller et al. 1998).
- Participants:** all native English speakers (mean age 25.7, STDEV = 6.4). Participants were recruited via email lists and participation did *not* result in any sort of payment.
  - Experiment 1: 41 participants
  - Experiment 2: 42 participants

## Experiment 1: Does acceptability decrease when the distance between the filler and the gap is increased?

**Design** - 2 x 3

EXTRACTION (subject vs. object extraction)

ATTACHMENT (no-PP, *wh*-attachment, NP-attachment)

Manipulating the distance between the *wh*-filler and the gap in terms of intervening discourse referents.

### Materials

36 items (each in 6 conditions presented below) plus 30 fillers:

#### Subject Extraction (SE)

*Which man saw the girl?*  
*Which man saw the girl in the bar on California Avenue?*  
*Which man in the bar on California Avenue saw the girl?*

No attachment  
 NP-attachment (SE.NP)  
 Wh-attachment (SE.WH)

#### Object Extraction (OE)

*Which man did the girl see?*  
*Which man did the girl in the bar on California Avenue see?*  
*Which man in the bar on California Avenue did the girl see?*

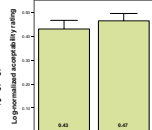
No attachment  
 NP-attachment (OE.NP)  
 Wh-attachment (OE.WH)

## RESULTS

### Are object extractions less acceptable than subject extractions? YES

Main effect of Extraction, significant by subjects ( $F(1,35) = 4.9, p < 0.05$ ), near significant by items ( $F(2,1,35) = 2.5, p = 0.12$ ), significant difference between means,  $t(40) = -2.22, p < 0.05$

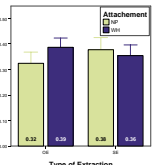
Figure 2: Overall Effect of EXTRACTION



### Does increasing the distance reduce acceptability? YES and NO

Pairs of Extraction.Attachment	Difference in number of interveners	Subject analysis	Item analysis	Practicality (me?)
OE.NP SE.NP	3	$p < 0.01$	$p < 0.05$	Yes
SE.WH OE.WH	3	$p = 0.17$	$p = 0.29$	No
OE.WH SE.WH	2	$p < 0.1$	$p < 0.05$	Yes
OE.NP SE.NP	1	$p = 0.52$	$p = 0.97$	OK
SE.WH OE.WH	1	$p = 0.38$	$p = 0.14$	OK
SE.WH SE.NP	0	$p = 0.15$	$p = 0.18$	OK

Figure 3: EXTRACTION x ATTACHMENT



- YES:** OE.NP has more interveners than OE.WH and SE.NP and is judged significantly less acceptable (see Table 1 for t-tests).
- NO:** OE.NP has more interveners than SE.WH but is not judged less acceptable.
- OK:** The difference in distance between the remaining pairs was minimal (Table 1). No effect was observed.
- No unpredicted effects were observed.

## Conclusions

- Our processing model accounts for acceptability judgments of different arrangements of *wh*-phrases (recall that there were no unpredicted effects and all but one of the predicted effects were actually observed). More specifically:
  - Superiority effects are seen as the result of interacting processing preferences – the perception of ungrammaticality results from resource limitations on memory and complexity in real-time language processing.
  - This reinforces the conclusions of Arnon et al. (2005) by proving that superiority violations are not categorically ungrammatical.

## A Processing Model of WH-dependencies

In Arnon et al. (2005), we proposed that the ease of processing *wh*-questions is determined by the interaction of four principles. Below we summarize the predictions of the three principles that were tested by two experiments presented here:

### I. Prefer gaps that are closer to fillers

- Previous support: subject relatives easier than object relatives (e.g. Hakes et al., 1976; King & Just, 1991)
- Predictions: (1)  $\geq$  'at least as acceptable as' (2), since the filler in (1) is not separated from the associated gap

### II. Prefer fillers that have more accessible referents

- Predictions: (3)  $\geq$  (4), since the filler in (3), *which man*, marks higher accessibility than the bare *wh*-word, *what*, in (4):

(3) *Which man did who see*  $\geq$  (4) *What did who see* ?

### III. Prefer interveners that have more accessible referents

- Previous support: Increasing the accessibility of an NP intervener reduces processing difficulty (Warren & Gibson, 2002).
- Predictions: Questions with interveners like *which man* are at least as acceptable as questions with bare *wh*-words like *who* as the intervener:

(5) *Which man did which woman see* ?  $\geq$  (3) *Which man did who see* ?

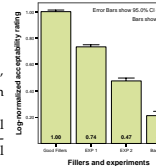
### A Note on the Accessibility of WH-phrases

- Wh*-phrases occur without a specified, identifiable referent in mind.
- More accessible *wh*-phrases reduce the space of possible referents: *which NP* > *what/who*
- Support from Frazier & Clifton (2002) where *wh*-phrases are identified as better antecedents for pronouns, indicating that *wh*-phrases mark higher accessibility.

### Are all Superiority violations ungrammatical? NO

- SUVs are observed in corpora (see Arnon et al., 2005) and are significantly more acceptable than core ungrammaticality examples (see Figure 1).
- Wh*-dependencies without Superiority 'violations' (all items in Exp 1) were less acceptable than simple sentences ('Good Fillers' in Figure 1)
- Wh*-dependencies with Superiority 'violations' (all items Exp 2) were less acceptable than non-'violating' ones but better than ungrammatical sentences ('Bad Fillers' in Figure 1)

Figure 1: Overall Acceptability Ratings



## Experiment 2: Does acceptability decrease when wh-fillers and interveners are less accessible?

**Design** - 2 x 2

*wh*-FILLER (first *wh*-phrase: *which NP* vs. *bare what*)

*wh*-INTERVENER (second *wh*-phrase: *which NP* vs. *bare who*)

Manipulating the accessibility by choosing either the more accessible *wh*-phrase or less accessible bare *wh*-phrases.

### Materials

20 items (all Superiority 'violations'; each in 4 conditions presented below) plus 26 fillers:

*Mary wondered what who read?* (BARE.BARE)  
*Mary wondered which book who read?* (WHICH.BARE)  
*Mary wondered what which boy read?* (BARE.WHICH)  
*Mary wondered which book which boy read?* (WHICH.WHICH)

## RESULTS

### Do less accessible wh-interveners decrease acceptability? YES

- Main effect of *wh*-intervener accessibility ( $F(1,1,37) = 64.5, F(2,1,19) = 248.1, P_s < .001$ ).

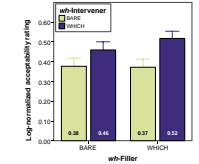
### Do less accessible wh-fillers decrease acceptability? YES

- Main effect of *wh*-filler accessibility ( $F(1,1,37) = 19.2, F(2,1,19) = 15.7, P_s < .001$ )

### Do the accessibility of the wh-filler and wh-intervener interact? YES

- There was a significant interaction between the accessibility of the *wh*-filler and that of the *wh*-intervener ( $F(1,1,37) = 9.9, F(2,1,19) = 9.8, P_s < 0.01$ ):
  - Having a less accessible *wh*-intervener (e.g. bare *wh*-item) always decreases acceptability, regardless of the *wh*-filler.
  - Having a more accessible *wh*-filler increased acceptability only when the *wh*-intervener was more accessible ("which NP").

Figure 4: Accessibility of FILLER x INTERVENER



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