Top-down anticipation versus bottom-up lexical access: Which dominates eye movements in visual scenes?

Andrea Weber & Matthew W. Crocker, Saarland University
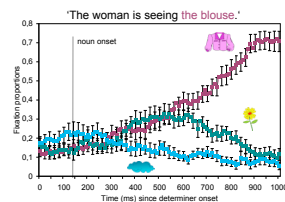
aweber@coli.uni-sb.de

INTRODUCTION

- During the recognition of spoken words multiple word candidates that match the speech input are activated and compete for recognition. Numerous eye-tracking studies have confirmed this phonological competition process [e.g., 1]: I.e., listeners fixate objects with names that overlap in onset with the name of a target object more than objects with unrelated names.
- Subsequent studies have shown that competitor activation is further modulated by lexical frequency: When asked to click on target pictures, English listeners fixate pictures of high frequency competitors more than pictures of low frequency competitors [2].
- Furthermore, in sentence context, semantic information from preceding verbs has been found to reduce competitor activation: Dutch listeners no longer fixate competitor pictures more than distractor pictures when a preceding verb constrains the subject noun phrase [3]. Similarly, English listeners start looking at pictures of suitable object noun phrases after semantically constraining verbs [4].
- Using eye tracking, the present study investigated the interaction of lexical frequency effects with effects from verb constraints in German.
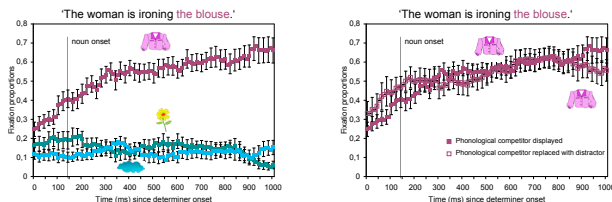
QUESTIONS

1. Can effects of preceding verb information be modulated by lexical frequency? Will high frequency competitors be activated even though semantic information from preceding verbs renders them unlikely word candidates; or do effects of lexical frequency only emerge when the preceding verb is not semantically constraining?
2. To the best of our knowledge, lexical frequency effects with eye tracking have only been observed with sentence contexts that are semantically quite empty ('Click on the …'). Are lexical frequency effects observable with other, varying sentence contexts?

METHOD

- Participants' eye movements were monitored while they listened to spoken sentences.
- 20 German SVO sentences with restrictive and unrestrictive verbs.
    - *„Die Frau bügelt/sieht die Bluse.“* ('The woman is ironing/seeing the blouse.')
- Displays showed an agent, a low frequency target (Bluse, 'blouse'), a high frequency phonological competitor (Blume, 'flower'), and a high frequency distractor (Wolke, 'cloud').
- Unrestrictive sentences were controlled for plausibility (e.g., it was equally likely that a woman sees a blouse or a flower).
- Objects in a display shared grammatical gender.
- 30 filler sentences with varying syntactic structures.

Experiment 1
- 24 German listeners
- Task: **listen to sentences and complete subsequent sentence recollection test**
- Auditory: "The woman is ironing/seeing the blouse."
- Visually: phonological competitor displayed or not

Experiment 2a
- 20 German listeners
- Task: **follow clicking instructions**
- Auditory: 'Click on the blouse/flower.'
- Visually: phonological competitor displayed

Experiment 2b
- 20 German listeners
- Task: **click on last argument in sentence**
- Auditory: 'The woman is seeing the blouse/flower.'
- Visually: phonological competitor displayed

RESULTS EXPERIMENT 1

'The woman is seeing the blouse.'

Unrestrictive verbs ('*The woman is seeing the blouse.*')
- When the verb was not semantically constraining the set of potential object arguments, German listeners fixated the picture of the phonological competitor flower significantly more than the distractor picture cloud (300-900 ms: $F_1[1, 23] = 10.92$, $p < .003$; $F_2[1, 19] = 7.94$, $p = .01$).
- Surprisingly, however, we found no effect of lexical frequency; the high frequency competitor flower was not fixated more than the low frequency target blouse.

'The woman is ironing the blouse.' 'The woman is ironing the blouse.'

- ■ Phonological competitor displayed
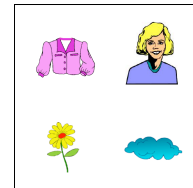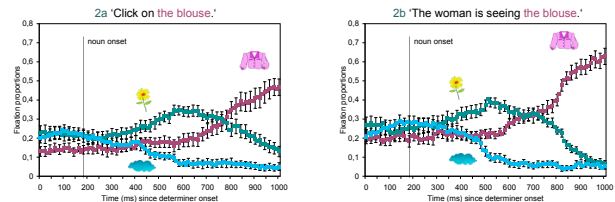- □ Phonological competitor replaced with distractor

Restrictive verbs ('*The woman is ironing the blouse.*')
- We found no activation of the competitor flower when the preceding verb was excluding it as a likely word candidate; the competitor flower was not fixated more than the distractor cloud (300-900 ms: F_1 & $F_2 < 1$).
- Looks to the target blouse started to increase with the onset of the determiner; this suggests that fixations were planned already during the verb.
- In addition to the absence of competitor activation in trials with restrictive verbs, activation of the target blouse was not modulated by the presence of a high frequency competitor; blouse was fixated equally often whether a high frequency phonological competitor was displayed or not.

REFERENCES
[1] Allopenna, P., Magnuson, J., & Tanenhaus, M. (1998). Tracking the time course of spoken word recognition using eye movements: Evidence from continuous mapping models. *Journal of Memory and Language*, 38, 419-439.
[2] Dahan, D., Magnuson, J., & Tanenhaus, M. (2001). Time course of frequency effects in spoken-word recognition: Evidence from eye movements. *Cognitive Psychology*, 42, 317-367.
[3] Dahan, D., & Tanenhaus, M. (2004). Continuous mapping from sound to meaning in spoken-language comprehension: Immediate effects of verb-based thematic constraints. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 30, 498-513.
[4] Altmann, G., & Kamide, Y. (1999). Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition*, 72, 247-264.

RESULTS EXPERIMENT 2

2a 'Click on the blouse.'   2b 'The woman is seeing the blouse.'

Experiment 2a
- As before, German listeners fixated the competitor flower more than the distractor cloud (300-900 ms: $F_1[1, 19] = 66.32$, $p < .001$; $F_2[1, 19] = 48.99$, $p < .001$).
- Unlike before, however, when asked to click on the blouse, German listeners fixated the high frequency competitor flower significantly more than the low frequency target blouse (300-700 ms: $F_1[1, 19] = 20.76$, $p < .001$; $F_2[1, 19] = 6.24$, $p < .03$) thereby showing an effect of lexical frequency.

Experiment 2b
- This result was replicated in Experiment 2b when the target, participants were told to click on, was embedded in SVO sentences with varying unrestrictive verbs.
- The competitor flower was fixated more often than the distractor cloud (300-900 ms: $F_1[1, 19] = 45.67$, $p < .001$; $F_2[1, 19] = 28.34$, $p < .001$), but flower was also looked at more often than the target blouse (300-700 ms: $F_1[1, 19] = 6.19$, $p < .03$; $F_2[1, 19] = 3.01$, $p > .09$).

GENERAL DISCUSSION

- In Experiment 1, German listeners only activated phonological competitors when preceding verb information was semantically unrestrictive. When preceding verbs were constraining the set of potential object referents, phonological competitors that were implausible were not considered anymore even though they were higher in lexical frequency than the target.
- The results suggest that eye movements to object referents were governed by selectional restrictions alone. Participants in Experiment 1 used verb information immediately to anticipate upcoming object referents. Lexical frequency effects, on the other hand, could not have emerged prior to the onset of the object referent. This time difference might have been responsible for the lack of a frequency effect in Experiment 1.
- However, the fact that in sentences with unrestrictive verbs, high frequency competitors were only activated more than low frequency targets when participants were instructed to click on the object referent, suggests that frequency effects in eye tracking are sensitive to task specific demands.
- We are currently re-running Experiment 1, using the same materials but instructing participants to click on the object referents (rather than just listen to the sentences). If the clicking task is crucial for frequency effects, we expect to find more looks to the high frequency competitor than the low frequency target for trials with unrestrictive verbs and possibly competitor activation for trials with restrictive verbs.