

Processing of number agreement in the L2: An eye-tracking study

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Introduction

AGREEMENT ATTRACTION (Bock & Miller, 1991)

In sentences with a complex subject (e.g., the key(s) to the cabinet(s)) number mismatch between the local noun (the cabinet(s)) and the head noun (the key(s)) results in errors in production and in slow-down in processing of the verb, especially when the local noun is plural (e.g. Bock & Miller, 1991; Bock & Cutting, 1992; Franck et al., 2002; Pearlmutter et al. 1999)

1. **Linear Distance Account:** The verb erroneously agrees with the closely preceding local noun instead of the head noun because due to memory limitations, speakers have difficulty in tracking the correct number feature from the head noun the verb (Bock & Miller, 1991; Quirk et al., 1972).

2. **Syntactic Distance Account:** Agreement attraction occurs due to the syntactic distance between the intervening noun and the head noun. The intervening noun which is closer to the head noun syntactically causes more interference in agreement assignment (Franck et al. 2002; Pearlmutter, 2000)

3. **The Markedness Account:** S-V errors occur when the local noun is plural and the head noun is singular as plural nouns have a marked number feature so they attract agreement. Singular nouns can only be marked by a numeral modifier (Eberhard, 1997).

4. **Cue-based Memory Retrieval Account:** Cues derived from the current context and grammatical knowledge, are matched against all previously encoded constituents in memory. The item which provides the best match is retrieved (Lewis & Vasisth, 2005). Although this account is not for S-V agreement per se, it provides valuable explanations for S-V agreement processes (Tanner & Bulkes, 2015; Wagers et al., 2009).

Previous Research on L1 Number Agreement

All studies in L1 S-V agreement found that number mismatch between the subject head and the local noun(s) created errors in production and difficulty in processing in L1 S-V agreement. However, different researchers explain the reason of agreement attraction with different accounts

- linear distance hypothesis (Bock & Miller, 1991; Bock & Cutting, 1992)
- syntactic distance hypothesis (Franck et al., 2002; Pearlmutter, 200; Vigliocco & Nicol, 1998)
- markedness account (Eberhard, 1997)
- head-overwriting and mismatch asymmetry (Pearlmutter et al., 1999)
- cue - based memory retrieval (Tanner & Bulkes, 2015; Wagers et al., 2009)

Previous Research on L2 Number Agreement

4. **The Shallow Structure Hypothesis:** It maintains that L2 speakers cannot process syntactically detailed computations and this does not change through increased proficiency or enhanced exposition to the language. Since their grammatical computations are less detailed than those by L1 speakers, L2 speakers must compensate for it by relying more on lexical, semantic or pragmatic information (Clahsen & Felser, 2006a, 2006b, 2006c). While some research showed L1 and L2 speakers are fundamentally different in their processing, in line with Shallow Structure, some showed they are similar:

- Jiang (2004), Keating (2009) showed processing of agreement in L1 and L2 are different
- Foote (2011), Lago & Felser (2018), Song (2015) showed that the processing of agreement in L1 and L2 are similar.

Current Study

Previous research (Franck et al., 2002; Lago & Felser, 2018; Pearlmutter, 2000) showed L1 speakers sensitive to syntactic distance in production/processing. Shallow Structure Hypothesis (Clahsen 2006) predicts L2 speakers sensitive to linear distance, but not syntactic distance as they cannot make syntactically detailed computations.

- Are Turkish learners of English sensitive to syntactic distance similar to L1 speakers in processing of S-V agreement? Or are they different from L1 speakers as suggested by the Shallow Structure Hypothesis and are insensitive to structural information in their processing of S-V agreement in English?
- Does the sensitivity to linear/syntactic distance change when there is lexical information in the sentence?

Online Experiments, Eye-tracking (Experiments 1 & 2)

Materials: Similar to the complex subjects of Franck et al. (2002), Lago & Felser (2018), Pearlmutter (2000)

- The experimental sentences were declarative where the subjects were complex NPs made of a head noun and two post modifying PPs such as *the article by the editor of the newspaper*.
- The head noun was singular in Experiment 1 and plural in Experiment 2. The number feature of the middle noun (N2) and the local noun (N3) was manipulated, creating number mismatch (MM) and four conditions in all experiments. See the following lists:

➤ Example items in Experiment 1

SSS, No MM: The daughter of the author of the book was pleased with the Nobel Prize.

SPS, N2 MM: The daughter of the authors of the book was pleased with the Nobel Prize.

SSP, N3 MM: The daughter of the author of the books was pleased with the Nobel Prize.

SPP, Total MM: The daughter of the authors of the books was pleased with the Nobel Prize.

➤ Example items in Experiment 2

PPP, No MM: The boys with the posters of the actresses were happy in the movie premiere.

PSP, N2 MM: The boys with one poster of the actresses were happy in the movie premiere.

PPS, N3 MM: The boys with the posters of one actress were happy in the movie premiere.

PSS, Total MM: The boys with one poster of one actress were happy in the movie premiere.

Participants:

- 95 Turkish learners of English with advanced proficiency
- 48 participants in Experiment 1
- 47 participants in Experiment 2

Procedure:

- Read the sentences silently & answer comprehension questions
- EyeLink 1000 Plus to track eye-movements

Data Cleaning:

- fixations < 80 ms merged with nearby fixations (1 degree visual angle)
- fixations < 80 ms, > 800 ms eliminated

Data Analysis:

- Mixed effects linear/logistic regression
- The verb region (9th word, corresponding to copula *be*)
- The spill-over region (two words following copula *be*)
- fixed factors: Condition (No MM, N2 MM, N3 MM, Total MM. No MM condition is the baseline and other three conditions were compared to it)
- random factors: subjects, items
- measures: six standard eye-tracking measures

Results:

Mean values for four conditions with standard errors in parentheses for six standard eye-tracking measures in Experiment 1 & Experiment 2 (Expt: Experiment; CR: Critical Region, SR: Spill-over Region; Tot: Total)

		Expt 1		Expt 2	
		CR	SR	CR	SR
First Fixation Duration (ms.)	No MM	221 (6.51)	230 (5.27)	217 (4.85)	235 (4.71)
	N2 MM	214 (6.62)	232 (5.51)	227 (5.86)	233 (4.44)
	N3 MM	227 (6.66)	233 (6.19)	232 (5.7)	241 (5.38)
	Tot MM	207 (5.84)	226 (4.82)	235 (5.9)	231 (4.88)
	Mean (SE)	224 (6.56)	285 (9.12)	226 (5.3)	282 (7.54)
Gaze /First pass Duration (ms.)	No MM	224 (6.56)	285 (9.12)	226 (5.3)	282 (7.54)
	N2 MM	217 (6.83)	303 (10.1)	248 (8)	286 (8.3)
	N3 MM	239 (7.64)	307 (10.1)	253 (8.4)	301 (9.42)
	Tot MM	212 (6.09)	292 (8.86)	249 (6.93)	285 (8.86)
	Mean (SE)	274 (24.4)	348 (23.2)	266 (21.3)	308 (14.6)
Regression Path Duration (ms.)	No MM	266 (17.5)	359 (22.5)	300 (25.1)	309 (21.8)
	N2 MM	316 (23.4)	331 (13.4)	303 (21.4)	357 (21)
	N3 MM	252 (14.2)	340 (17.3)	340 (32.6)	321 (16.3)
	Tot MM	56.8 (11.9)	156 (16.6)	87.9 (12.7)	126 (14)
	Mean (SE)	74.6 (14.4)	178 (20.7)	91.1 (14.1)	141 (15.9)
Rereading Duration (ms.)	No MM	74.6 (14.4)	178 (20.7)	91.1 (14.1)	141 (15.9)
	N2 MM	105 (16.9)	162 (20)	79.1 (13.1)	149 (16)
	N3 MM	66.8 (13.8)	146 (16.1)	103 (13.2)	137 (13.6)
	Tot MM	274 (11.5)	443 (18.5)	307 (11.8)	390 (13.7)
	Mean (SE)	299 (13.9)	460 (21.1)	313 (12)	386 (12.6)
Total Duration (ms.)	No MM	312 (14)	441 (17.9)	320 (11.9)	401 (13.9)
	N2 MM	264 (11.9)	444 (19.3)	347 (13)	407 (14.6)
	N3 MM	264 (11.9)	444 (19.3)	347 (13)	407 (14.6)
	Tot MM	274 (11.5)	443 (18.5)	307 (11.8)	390 (13.7)
	Mean (SE)	.057 (.023)	.076 (.019)	.045 (.017)	.0463 (.013)
Probability of Regression Out (ms.)	No MM	.057 (.023)	.076 (.019)	.045 (.017)	.0463 (.013)
	N2 MM	.113 (.03)	.065 (.017)	.077 (.021)	.0488 (.014)
	N3 MM	.161 (.034)	.088 (.02)	.0802 (.022)	.0702 (.016)
	Tot MM	.080 (.027)	.095 (.02)	.103 (.023)	.0751 (.017)

In Experiment 1

Sensitivity to gender (mis)matches associated with the accessible antecedent in regression path duration at the spillover region, $t = 3.27, p < .01$.

In Experiment 2

Sensitivity to the accessible antecedent in regression path duration, rereading duration, total duration and probability of regression out (t 's > 1.96, p 's < .05, $z = 2.05, p < .05$) at the disambiguating region and in regression path duration at the spillover region ($t = 2.05, p < .05$).

Antecedent Identification Task in English (Experiment 3)

- A pen-and-paper antecedent identification task
- **Participants:** 95 participants (the ones taking part in Experiments 1 & 2)
- **Materials:** the critical sentences were the same as those in Experiments 1 & 2 but to test the L2 speakers' knowledge of binding constraints they were presented with/without discourse context.
- **Results:** participants chose the local and c-commanding antecedent as the referent of the reflexive (> 79%), but in contexts with a discourse prominent inaccessible antecedent, the accessible antecedent choices were reduced, $z = 5.14, p < .001$.

Conclusion

- Turkish learners of English can be native-like in their antecedent retrieval behavior for reflexives although their integration of linguistic information (both structural and non-structural) in this process could be delayed.
 - Structural information – evident only in measures reflecting later stages of processing (e.g., regression path duration)
 - Discourse-related information – evident only in antecedent identification task
- No effect of the discourse prominence and linear proximity of the inaccessible antecedent in the initial stages of antecedent retrieval processes
- L2 learners were slower than native speakers in their integration of structural and non-structural information compared to native speakers in Sturt (2003), which can be attributed to L2 learners' slower processing speed (Hopp, 2006).

References

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