

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

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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, for both first language (L1) speakers (Bock & Miller, 1991; Franck et. al., 2002) and second language (L2) speakers (Jiang, 2004; Foote, 2011). This study, with Turkish learners of English, investigated whether the mismatching intervening noun that is syntactically closer to the head noun (Vigliocco & Nicol, 1998) or the mismatching intervening noun linearly closer to the verb (Quirk et al., 1972) affected processing subject-verb number (S-V) agreement in the L2.

**Method:** Two eye-tracking experiments (Expts 1, 2) and a pen-and-paper gap-fill sentence completion task (Expt 3) were performed. The experimental sentences were declarative where the subjects were complex NPs made of a head noun and two post modifying PPs. The head noun was singular in Expt 1 and plural in Expt 2. The number feature of the middle noun (N2) and the local noun (N3) was manipulated, creating four conditions in all experiments (see Table 1 for details). In Expt 2, the singular nouns were modified by the numeral *one* to make them marked (Eberhard, 1997) and to test the effect of lexical cues in processing S-V agreement. Expt 3 had the same complex subjects as in Expts 1 and 2 but with gaps in the *copula be* position to be filled in. The participants (95 in total) had advanced proficiency in their L2. 48 participants took part in Expt 1; 47 of them participated in Expt 2. All participated in Expt 3.

**Results:** In Expts 1&2 six standard eye-tracking measures (first fixation, gaze (first-pass, in spill-over), regression path, re-reading and total duration and the probability of regression out) were entered into a mixed-effects linear/logistic regression analysis for the critical region (9th word, the verb) and spill-over region (two words following the verb). In both experiments, no mismatch conditions (SSS and PPP) were the baseline and the other three conditions were compared to them. In Expt 1, participants showed sensitivity to the mismatches (MMs) associated with the linearly closer noun (N3 MM) for three measures (total duration (marginal significance) and rereading duration  $t$ 's > 1.91,  $p$ 's ≤ .05, probability of regression out  $z = 2.47$ ,  $p < .05$ ) in the critical region and for one measure (first-pass reading time  $t = 2.19$ ,  $p < .05$ ) in the spill-over region. In Expt 2, participants showed sensitivity to the mismatches with the linearly closer noun (N3 MM, first fixation and gaze duration measures,  $t$ 's > 2.35,  $p < .05$ ), the syntactically closer noun (N2 MM, gaze duration,  $t = 1.99$ ,  $p < .05$ ) and to the mismatches with both (Total MM, for five measures excluding rereading duration,  $t$ 's > 2.01,  $p$ 's < .05,  $z = 1.98$ ,  $p < .05$ ) in the critical region; they showed sensitivity to N3 MM (regression path duration,  $t = 2.15$ ,  $p < .05$ ) in the spill-over region (see Table 2 for mean values and standard errors). In Expt 3, participants completed the sentences correctly 98.6% of the time ensuring that the Turkish speakers of L2 English had the knowledge of S-V agreement for these structures.

**Conclusion:** The results show that when there are no lexical cues to mark the number feature (Expt 1), Turkish learners of English are sensitive to linear distance in processing S-V agreement, unlike native speakers who were reported to be sensitive to syntactic distance for similar constructions (Franck et. al., 2002; Pearlmutter, 2000). This may be because L2 learners are more prone to interference during memory retrieval compared to native speakers (Cunnings, 2017). But when provided with lexical information (i.e., *one* in Expt 2), making the number feature of the mismatching noun marked (Eberhard, 1997), they show sensitivity to both linear and syntactic distance, suggesting that L2 speakers can do complex syntactic processing, similar to native speakers, when semantic cues are present (Cunnings, 2017). Their enhanced sensitivity to lexical cues confirms previous findings on L2 speakers' increased reliance on lexicosemantic and discourse-related information compared to L1 speakers (Felser, et al., 2003). Given previous findings on mismatch asymmetry (e.g., Bock, 1995) the results of Expt 2 are unlikely to be due to the mismatch between the plural head and the singular distractors.

**References:** Bock & Miller (1991). *Cogn Psychol*, 23, 45–93. Bock (1995). *Curr Dir Psychol Sci*, 56-61. Cunnings (2017). *Biling: Lang Cogn*, 20(4), 659 – 678. Eberhard (1997). *J Mem Lang*, 36, 147-164. Felser et al. (2003). *Appl Psycholing*, 24, 453-489. Foote (2010). *Appl Psycholing*, 32(1), 187-220. Franck et al. (2002). *Lang Cogn Process*, 17, 371-404. Jiang (2004). *Appl Psycholing*, 25, 603–634. Pearlmutter (2000). *J Psycholinguist Res*, 89-98. Quirk, et al. (1972). New York: Seminar Press. Vigliocco & Nicol (1998). *Cognition*, 68 (1).

**Table 1:** Examples of experimental items (S: singular, P: plural, MM: number mismatch between one of the intervening nouns and the head noun)

Example items in Experiment 1	Example items in Experiment 2
<b>SSS, No MM:</b> The daughter of the author of the book was pleased with the Nobel Prize.	<b>PPP, No MM:</b> The boys with the posters of the actresses were happy in the movie premiere.
<b>SPS, N2 MM:</b> The daughter of the authors of the book was pleased with the Nobel Prize.	<b>PSP, N2 MM:</b> The boys with one poster of the actresses were happy in the movie premiere.
<b>SSP, N3 MM:</b> The daughter of the author of the books was pleased with the Nobel Prize.	<b>PPS, N3 MM:</b> The boys with the posters of one actress were happy in the movie premiere.
<b>SPP, Total MM:</b> The daughter of the authors of the books was pleased with the Nobel Prize.	<b>PSS, Total MM:</b> The boys with one poster of one actress were happy in the movie premiere.

**Table 2:** 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
		<i>Mean (SE)</i>	<i>Mean (SE)</i>	<i>Mean (SE)</i>	<i>Mean (SE)</i>
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)
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)
Regression Path Duration (ms.)	No MM	274 (24.4)	348 (23.2)	266 (21.3)	308 (14.6)
	N2 MM	266 (17.5)	359 (22.5)	300 (25.1)	309 (21.8)
	N3 MM	316 (23.4)	331 (13.4)	303 (21.4)	357 (21)
	Tot MM	252 (14.2)	340 (17.3)	340 (32.6)	321 (16.3)
Rereading Duration (ms.)	No MM	56.8 (11.9)	156 (16.6)	87.9 (12.7)	126 (14)
	N2 MM	74.6 (14.4)	178 (20.7)	91.1 (14.1)	141 (15.9)
	N3 MM	105 (16.9)	162 (20)	79.1 (13.1)	149 (16)
	Tot MM	66.8 (13.8)	146 (16.1)	103 (13.2)	137 (13.6)
Total Duration (ms.)	No MM	274 (11.5)	443 (18.5)	307 (11.8)	390 (13.7)
	N2 MM	299 (13.9)	460(21.1)	313 (12)	386 (12.6)
	N3 MM	312 (14)	441 (17.9)	320 (11.9)	401 (13.9)
	Tot MM	264 (11.9)	444 (19.3)	347 (13)	407 (14.6)
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)