2023. Proceedings of the Workshop on Turkic and Languages in Contact with Turkic 8. 211–225.

Comprehending Turkish Sentences using Word Order, Thematic Roles, and Case

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Abstract. A core aspect of sentence comprehension is assigning thematic roles such as agents and patients to nouns. Turkish, a flexible word order language with accusative case-marking, allows us to compare the relative effect of word order, case-marking, and thematic reversibility in sentence comprehension. We conducted two spoken language comprehension experiments to investigate the relationships among these factors. Native Turkish-speaking adults were faster and more accurate in comprehending sentences with default word order than those with scrambled word order; case-marked sentences than non-casemarked sentences; and sentences with thematically irreversible nouns than those with reversible nouns. The effect of word order depended on the reversibility of the nouns, and case-marking had little-to-no effect on comprehension when the nouns were thematically irreversible. Our results suggest that while Turkish speakers use multiple cues to map thematic roles onto nouns, there are diminishing returns of facilitation with each additional source of information. These results give support to race-based models of sentence comprehension.

Keywords. psycholinguistics; sentence processing; word order; Turkish; accusative case-marking; comprehension; thematic roles; reversibility

1. Introduction. A core aspect of sentence comprehension is assigning thematic roles such as agent and patient to the noun phrases (NPs) in sentences. While some sentences are permanently ambiguous (i.e., they have two meanings even after the sentence is over), all sentences are initially temporarily ambiguous. This makes sentence processing a computationally daunting challenge as comprehension is incremental. Consider (1).

(1) While Anna dressed the baby was spitting food on the floor. (Christianson et al. 2001)

When processing (1), most readers interpret *the baby* as the object NP of the verb *dressed*. People usually recognize their error at *was spitting* because at this point there is no NP available to serve as the subject of *was spitting*. People realize the only grammatical parse of the sentence is one in which *dressed* is an intransitive verb, and *the baby* is the subject NP of *was spitting*. Sentences like (1) are called garden-path sentences because people initially misparse the sentence and must go back and reanalyze the sentence (Frazier, 1987). Similar to illusions in perception research, garden-path sentences are a valuable tool in psycholinguistics for investigating the mechanism of sentence processing (Frazier & Fodor, 1978).

Certain linguistic features of a language can help conversation partners avoid garden-paths. For example, overt case-marking on phrases often lets the parser determine what the grammatical role of a given noun phrase is. Compare (1) to (2).

(2) While Anna dressed he was spitting food on the floor.

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People do not garden-path when they parse (2) because the nominatively case-marked pronoun *he* must be the subject of an upcoming clause and not the object of *dressed* (which would have been *him*). In this way, the presence of overt case-marking informs the listener as to an NP is a subject or an object of a sentence. Because there is a robust mapping between the grammatical roles of an NP and that NP's thematic role in the sentence (Fillmore 1968; Dowty 1991; Kako, 2006), for languages with strict word order, the linear position of an NP in a sentence provides important clues about its thematic role. For example, almost all English sentences have SVO word order. Because subjects tend to be agents and objects tend to be themes or patients (Fillmore 1968; Dowty 1991; Kako, 2006), English speakers can be relatively confident that, in a Noun-Verb-Noun (NVN) sequence, the first NP is the agent and the second NP is the patient/theme of the verb, even when none of the NPs are overtly case-marked.

The word order of Turkish is much more flexible than that of English. For example, in Turkish, when an object has an overt accusative marker (O_{acc}), all possible word orders ($SO_{acc}V$, SVO_{acc}, $O_{acc}VS$, $O_{acc}SV$, $VO_{acc}S$, VSO_{acc}) are grammatical (Kornfilt, 2003). However, when the object does not have an overt accusative case-marker ($O_{\emptyset}$), only $SO_{\emptyset}V$ and $O_{\emptyset}VS$ are grammatical (Erguvanli & Taylan, 1984; Kural, 1992; Erguvanli & Zimmer, 1994). The fact that, in Turkish, SOV and OVS sentences are grammatical both with and without overt accusative case-marking allows us to compare the relative effect of word order and overt case-marking of the nouns in a balanced design using $SO_{acc}V$, $O_{acc}VS$, $SO_{\emptyset}V$, $O_{\emptyset}VS$ sentences.

It should be noted that, even though overt case-marking allows word order flexibility in Turkish, SOV is the pragmatically neutral (i.e., default) word order and subject-initial sentences are much more frequent than object-initial ones in every day and formal speech (Slobin & Bever, 1982; Kornfilt, 1984, Batman-Ratyosyan, 2003). The fact that most Turkish sentences are subject-initial means that it is reasonable for Turkish speakers to assume, as a computational short-cut, that the first NP in a sentence is the subject. Thus, we would expect both default word ordering and accusative case-marking on the object to have a facilitatory effect on comprehension. On the flip side, sentences with scrambled word orders ($O_{acc}VS$ and $O_{\emptyset}VS$) or ones without accusative case-marking on the object ($SO_{\emptyset}V$ and $O_{\emptyset}VS$) should be more difficult to comprehend. Finally, while they *are* grammatical, scrambled word order sentences with no accusative case-marking (i.e,. $O_{\emptyset}VS$ sentences) should be especially difficult to comprehend, because until the very last syllable, they could be SVO_{acc} sentences.

Discourse context, plausibility and world knowledge may also affect the ease with which people understand sentences. Consider the unordered set of phrases in (3) and (4). In (3), *the cat* and *the mouse* are equally plausible candidates for being both the "see-r" (i.e., the agent) and the "see-n" (i.e., the patient). In contrast, the only plausible interpretation for (4) is that *the cat* is the "see-r" (i.e., the agent) and *the ball* is the thing "see-n" (i.e., the patient).

(3) {the cat}, {the mouse}, {saw}

(4) {the cat}, {the ball}, {saw}

Sentences with NPs like (3) where either NP can plausibly be the agent or a patient are called thematically reversible sentences, and sentences with NPs like (4) where one NP can only plausibly be an agent and the other can only plausibly be the patient are called thematically irreversible sentences. In the first experiment all the experimental sentences were thematically reversible. In the second experiment, half of the sentences were thematically reversible and half were thematically irreversible. By include both types of sentences, in Experiment 2, we can investigate the relative impact of semantic plausibility, word order and overt case-

marking on sentence comprehension. For example, it might be that case-marking expedites sentence processing, but only when sentences are thematically reversible.

2. Experiment 1

2.1. Participants**.** Forty-two native Turkish-speaking adults from Istanbul, Turkey participated. Data from one participant was eliminated because debriefing revealed that the participant was not a native speaker of Turkish. Data from a second participant was eliminated because the participant performed at chance for all four conditions of the experiment. Turkish was the first and only language learned during childhood for the remaining 40 participants. The mean age of these participants was 33.9 years (SD =13.4 years), with 19 participants being male and 21 being female. None of the participants reported a history of speech, hearing, or language disorders.

2.2. Stimuli. Participants listened to four types of Turkish sentences that differed orthogonally in word order (SOV vs. OVS) and whether the object had overt accusative case (O_{acc}) or not ($O_{ø}$). Each of the 4 sentence types (5a: $SO_{acc}V$, 5b: $SO_{ø}V$, 5c: $O_{acc}VS$, 5d: $O_{ø}VS$) appeared once in 36 scenarios that were defined by a unique verb with NPs for a total of 144 experimental sentences. All the experimental sentences contained thematically reversible, animate nouns referring to people or animals. If a scenario contained a noun that referred to an animal, the other noun also referred to an animal. The same was true for nouns referring to people.

(5) Quartet of Sentence Types for the Scenario 'The cat saw the mouse.'

a.	Kedi	fare-yi	gör-dü.	
	cat	mouse-ACC	see-PST-3SG.SBJ	
b.	Kedi	fare	gör-dü.	
	cat	mouse	see-PST-3SG.SBJ	
c.	Fare-yi	gör-dü	kedi.	
	mouse-ACC	see-PST-3SG.SBJ	cat	
d.	Fare	gör-dü	kedi.	
	mouse	see-PST-3SG.SBJ	cat	

After listening to a sentence, participants answered a written two-alternative forced-choice comprehension question. Half of the time, the question queried the object (e.g., *Hangisi görüldü?*, 'Which one was seen?'), and half of the time, the question queried the subject (e.g., *Hangisi gördü?,* 'Which one saw it?'). Across the experiment, all 4 sentence types were followed by an object-asking question and subject-asking question equally often. Participants did not have a time limit for answering the question, and they did not receive feedback as to whether their answer was correct or incorrect. Eleven catch trials were interspersed among the experimental sentences. The structure of the sentences in the catch trials was the same as in the experimental trials, but one of the response options included an NP that was not part of the original sentence. The catch trials asked for the subject and object equally often. The order of the sentences was pseudorandomized with the following restrictions: no more than 3 sentences with the same word order appeared in a row, no more than 3 sentences with the same case-marking value appeared in a row, and no more than 2 of the same sentence type appeared in a row.

2.3. Materials and Equipment. The sentences were said by a native Turkish-speaking woman who was unaware of the hypotheses being investigated. Sentences were recorded in a sound-isolated booth using a Roland Edirol R-09 recorder and a Shure SM10 head-mounted microphone at 44.1 kHz sampling rate. The audio files were trimmed using Praat (Boersma, 2001), with the onset of sentences being the first clear upswing and the end of

sentences being the point at which the waveform became indistinguishable from background noise. Sennheiser HD202 headphones were used to present stimuli sentences to participants. The experimental platform FindingFive (FindingFive Team, 2019) was used to control the experiment and record participants' responses.

2.4. Procedure. The experiment was conducted in a quiet, isolated room with the experimenter present. Participants first completed a demographics questionnaire followed by 4 practice trials to familiarize them with the experimental procedure and allow them to ask questions about the procedure. During the experiment, no feedback was given about whether participants' answers were correct or incorrect. The syntactic structures of practice trials differed from that of the experimental trials, but the procedure was the same. First, participants heard a sentence. Then after a 300 millisecond buffer, a written question appeared on the center of the computer screen simultaneously with the two possible answers beneath it. Participants indicated whether they thought the left or the right answer was correct by hitting the "A" key for the left option and the "L" key for the right option. Throughout the experiment, the options were always such that the first NP in the target sentence was on the left side, and the second NP on the right side. Over the course of the experiment, the correct option occurred equally often on the left and right sides. Three hundred milliseconds after participants chose their option, the next trial began. Participants were told to go as quickly as they could without sacrificing accuracy. Participants were allowed to take a break halfway through the experiment. After completing the experiment, they were interviewed and debriefed. The experiment was approved by the Rutgers Human Subject IRB.

3. Results. FindingFive recorded the amount of time that elapsed between when a comprehension question appeared on the screen and when participants responded (i.e., participants' reaction times, RTs). Trials with RTs that were shorter than 200ms or longer than 10 seconds made up less than 0.01% of the data and were discarded from all analyses. Participants' accuracy data were analyzed with a mixed-effects logistic regression model in R using lme4 (Bates, Mächler, Bolker & Walker, 2015). Sum-coded variables were used for word order (SOV/OVS) and case-marking (+/- casemarking), and participant and scenario served as random intercepts. The model revealed that participants were more accurate on SOV than OVS sentences (93% and 77.3%, $z = 16.45$, $p < .001$, OR = 1.2), and on case-marked than non-casemarked sentences (91% and 81.7%, $z = 9.96$, $p < .001$, OR = 1.11). As shown in Figure 1, word order and case-marking interacted ($z = 3.67$, $p < .001$), with OVS-SOV difference being approximately 60% greater for non-casemarked sentences than case-marked sentences.

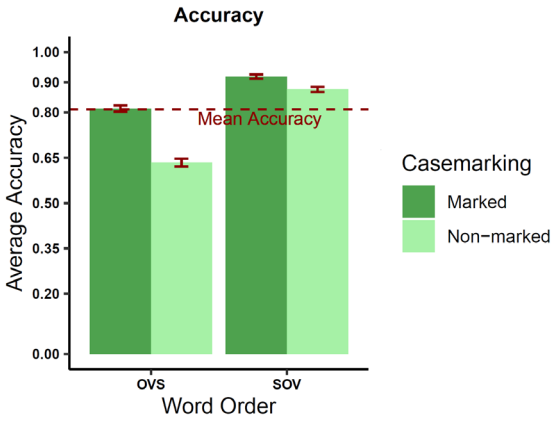

Figure 1. Accuracy rates for Experiment 1 (Error bars = standard errors).

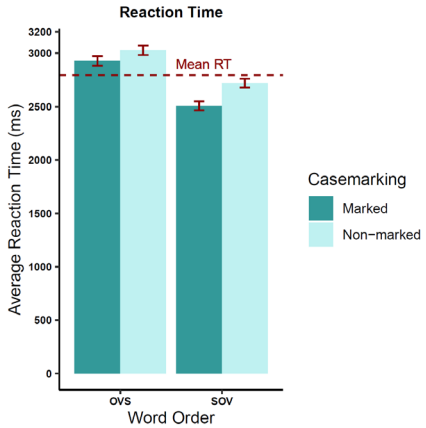

Figure 2. Reaction Times for Experiment 1 (Error bars = standard errors).

RTs for all trials were analyzed with a mixed-effects linear regression in R using lme4 (Bates, Mächler, Bolker & Walker, 2015). Sum-coded variables were used for the two levels of word order and case-marking, and participant and scenario served as random intercepts. The RT results were generally consistent with the accuracy results: the model revealed that participants were faster on SOV than OVS sentences (2582 ms and 2926 ms, $t = 10.86$, $p < .001$, $d = .23$), and on case-marked than non-casemarked sentences (2652 ms and 2856 ms, $t = 6.47$, $p < .001$, d = .10). The interaction between word order and case-marking was not statistically significant ($t = 1.27$, $p = .20$), though the pattern for RTs (Figure 2) was similar to that for accuracy (Figure 1). When RTs for incorrect trials were eliminated, the results were virtually identical with main effects of word order (2570 ms and 2943 ms, $t = 10.89$, $p < .001$, $d = .26$) and case-marking (2660 ms and 2853 ms, $t = 5.66$, $p < .01$, $d = .10$), but no significant interaction between the two factors ($t = 0.89$, $p = .4$).

To summarize, as predicted, participants were slower and less accurate in comprehending sentences that had scrambled word order than those with default word order, and they were slower and less accurate in comprehending sentences that lacked overt case-marking than those that had overt case-marking. Finally, as predicted, participants had the most difficulty understanding sentences that were both scrambled and did not have overt accusative case (i.e., $O_{\emptyset}VS$ sentences). There was no detectable speed-accuracy trade-off for either word order or overt case-marking.

4. Interim Discussion. Although word order and case-marking both affected participants' ability to understand sentences, word order had a larger effect. For example, participants were faster and more accurate on $SO_{\emptyset}V$ sentences than $O_{acc}VS$ sentences. This is somewhat surprising because, as mentioned above, accusative case-marking unambiguously indicates a noun is an object, whereas being sentence-initial is only a probabilistic cue that a noun is a subject (and not an object). Apparently, starting a sentence with an object has such a detrimental effect on sentence comprehension that even if the object receives overt accusative case-marking, the sentence is still difficult to process. Over the course of the experiment, participants may have learned that OVS sentences were overrepresented and thus, the garden-path effect of word order may have become attenuated. Indeed, as shown in Table 1, overall, participants garden-pathed on OVS sentences 50% more often in the first than final third of the experiment (35% vs. 22%, respectively). As discussed above, $O_{\emptyset}VS$ sentences are particularly susceptible to garden pathing because they can either be $O_{\emptyset}VS$ or SVO_{acc} until the final syllable of the sentence. Consistent with this, participants misunderstood almost half of the $O_{\emptyset}VS$ sentences during the first third of the experiment. The garden-path effect became somewhat attenuated, but even during the final third of the experiment, participants were still misunderstanding almost 30% of the $O_{\emptyset}VS$ sentences (see Table 1).

	Reversible $SO_{acc}V$	Reversible $SO_{\emptyset}V$	Reversible $O_{acc}VS$	Reversible $O_{\emptyset}VS$
First Third	91.0% (2440 ms)	85.3% (2700 ms)	75.1% (2799 ms)	55.3% (3005 ms)
Final Third	92.1% (2444ms)	92.2% (2659 ms)	86.9% (2720 ms)	70.1% (2903ms)

Table 1. Performance on the first and final third of the sentences in Experiment 1

Finally, participants were faster and more accurate in $SO_{acc}V$ sentences than $SO_{\emptyset}V$ sentences. Recall that a NNV sequence can be grammatical either as $O_{acc}SV$ or $SO_{acc}V$ or $SO_{\emptyset}V$. Consider the four sentences in (6), all of which start with two NPs.

(6) a. Çocuk yağmur-u duydu. ($SO_{acc}V$)
child rain-ACC hear-PST-3SG.SBJ

'The child heard the rain.'

b. Çocuk yağmur duydu. ($SO_øV$)
child rain hear-PST-3SG.SBJ
'The child heard the rain.'

c. *Yağmur çocuk duydu. ($O_øSV$)
rain child hear-PST-3SG.SBJ

d. Yağmuru çocuk duydu. ($O_{acc}SV$)
rain-ACC child hear-PST-3SG.SBJ
'The child heard the rain.'

When the object is case-marked, both the $SO_{acc}V$ and $O_{acc}SV$ sentences are grammatical with the same meaning (6a, 6d). However, when the object is not case-marked (6b, 6c), only $SO_øV$ (6b) sentences are grammatical. This means that $N_øN_øV$ sequences must be SOV[2]. Thus, once participants know that neither the first nor the second noun has an accusative case-marker, participants should know that a sentence is SOV. Given this, it is somewhat surprising that our participants had more difficulty understanding $SO_øV$ sentences than $SO_{acc}V$ sentences.

In Experiment 1, default word order and overt accusative case-marking both had a measurable facilitatory effect on sentence comprehension. But are the effects of these factors diminished for thematically irreversible sentences like in (4) 'the cat saw the ball'? In other words, if the propositional content of a sentence reduces the possibility of garden-pathing, do listeners make fewer errors and respond more quickly to thematically irreversible sentences irrespective of their word order and case-marking?

There is extensive literature on the influence of definiteness on both sentence production and sentence processing. Silverstein (1986, as cited in Kizilkaya et al., 2022) proposed a hierarchy of referentiality shown in (7).

(7) $1^{st}/2^{nd}$ person pronoun > 3^{rd} person pronoun > name > human > non-human animate > inanimate

In this formulation, an NP is more likely to be the subject and the agent of a sentence if it is higher in the hierarchy, and it is more likely to be the object and the patient/theme of a sentence if it is lower in the hierarchy. Consistent with this, Krause and von Heusinger (2019) found that Turkish speakers' preference for case-marked vs. non-casemarked objects interacted with whether the object was human, non-human but animate (i.e., animals), or inanimate, with the preference for case-marking increasing the higher the NP was in the hierarchy. In a similar vein, Kizilkaya, Levy-Forsythe, and von Heusinger (2022) found that Turkish speakers were more likely to accusatively case-mark object NPs that refer to humans compared to ones that refer to inanimate objects. On the comprehension side, Demiral, Schlesewsky and Bornkessel-Schlesewsky (2008) reported that participants gave higher acceptability ratings and had lower RTs when sentence-initial objects were inanimate than when they were animate; suggesting that when a noun is inanimate, it is easier to process it as an object than a subject.

These studies suggest that thematic reversibility, case-marking, and word order may interact and influence sentence comprehension in complicated ways. To investigate this possibility, in a

[2] As an anonymous reviewer insightfully pointed out $O_øSV$ sentences are acceptable in Turkish in certain contexts and with certain prosody, such as in contrastive contexts (e.g.,"I hear you like kale." "No, SPINACH I like. KALE I can't stand.") However, in our experiments, sentences were said without any context and with neutral prosody.

second experiment we added the variable of thematic reversibility of nouns to our previous design, crossing word order, case-marking, and thematic reversibility orthogonally. To our knowledge, this is the first Turkish study that has investigated the three factors simultaneously.

5. Experiment 2

5.1 Participants. Forty-five native Turkish-speaking adults participated in the study. Data from one participant was eliminated because the participant performed at chance on all eight conditions of the experiment. Turkish was the first and only language learned during childhood for the remaining 44 participants (Gender, M = 19, F = 25 & M_{Age} = 29.9 years, SD_{Age} = 8.9 years). None of the participants reported a history of speech, hearing, or language disorders.

5.2 Stimuli. Participants listened to eight types of Turkish sentences (see examples (8) and (9)) that varied orthogonally in word order (SOV vs. OVS); whether the object received overt accusative case-marking (O_{acc} vs. $O_{ø}$); and whether the nouns in the sentence were thematically reversible (r) or irreversible (i). Thirty different verbs appeared once in each of the 8 sentence types appeared shown in (8) and (9) for a total of 240 experimental sentences.

(8) Quartet for the **thematically reversible** scenario 'The cat saw the mouse.'

a.	Kedi	fare-yi	gör-dü.		(reversible $SO_{acc}V$)
	cat	mouse-ACC	see-PST-3SG.SBJ		
b.	Kedi	fare	gör-dü.		(reversible $SO_{ø}V$)
	cat	mouse	see-PST-3SG.SBJ		
c.	Fare-yi	gör-dü		kedi.	(reversible $O_{acc}VS$)
	mouse-ACC	see-PST-3SG.SBJ		cat	
d.	Fare	gör-dü		kedi.	(reversible $O_{ø}VS$)
	mouse	see-PST-3SG.SBJ		cat	

(9) Quartet for the **thematically irreversible** scenario 'The cat saw the ball.'

a.	Kedi	top-u	gör-dü.		(irreversible $SO_{acc}V$)
	cat	ball-ACC	see-PST-3SG.SBJ		
b.	Kedi	top	gör-dü.		(irreversible $SO_{ø}V$)
	cat	ball	see-PST-3SG.SBJ		
c.	Top-u	gör-dü		kedi.	
	ball-ACC	see-PST-3SG.SBJ		cat	(irreversible $O_{acc}VS$)
d.	Top	gör-dü		kedi.	
	ball	see-PST-3SG.SBJ		cat	(irreversible $O_{ø}VS$)

There was a catch trial approximately every 15 target trials, for a total of 16 catch-trials. The structure of the catch trial sentences was the same as the experimental sentences, but one of the two response options had an NP that was not present in the catch trial sentence. Experimental and catch trial sentences were recorded in a sound-isolated booth by the same native Turkish speaking woman as in Experiment 1, who was still unaware of the purposes of the experiments. The preparation of the stimuli sentences was identical to that used in Experiment 1.

5.3 Procedure. The experimental procedure was the same as in Experiment 1, with two exceptions. First, because Experiment 2 was twice as long as Experiment 1, participants were given three breaks. Second, the pseudo-randomization criteria also included thematic reversibility, with no more than three sentences with the same thematic reversibility appearing in a row.

6. Results. The accuracy data were analyzed with a mixed-effects logistic regression in R using lme4 (Bates, Mächler, Bolker & Walker, 2015). Sum-coded variables were used for the two levels of word order, case-marking, and thematic reversibility, and participants and scenarios served as random intercepts. Trials with RTs that were less than 200ms or more than 10 seconds made up approximately 0.1% of the data and were discarded from all analyses. Participants were more accurate on SOV than OVS sentences (95.3% and 91%, $z = 9.49$, $p < .001$, OR = 1.4), on case-marked than non-casemarked sentences (94.8% and 91.7%, $z = 7.01$, $p < .001$, OR = 1.29), and on thematically irreversible sentences than thematically reversible sentences (95.3% and 91.1%, $z = 9.38$, $p < .001$, OR = 1.41). The effect of word order interacted with case-marking ($z = 2.63$, $p < .01$, see Figure 3), where the accuracy difference between SOV and OVS sentences were approximately 75% larger when the object lacked overt case-marking. Word order also interacted with thematic reversibility ($z = 7.65$, $p < .001$). Of note, the accuracy difference between SOV and OVS sentences was almost 9 times greater for thematically reversible sentences than thematically irreversible sentences. Case-marking and reversibility also interacted with each other ($z = -2.72$, $p < .01$). The accuracy difference between case-marked and non-casemarked sentences was approximately 130% larger for thematically reversible sentences than thematically irreversible sentences. Finally, the three-way interaction between word order, case-marking, and thematic reversibility was statistically significant ($z = 2.19$, $p < .05$, see Figure 3).

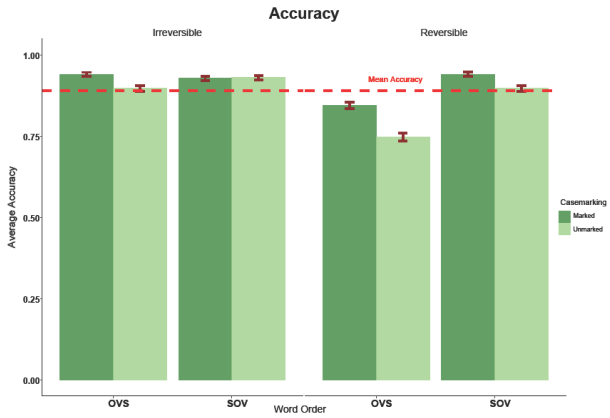

Figure 3. Accuracy rates for Experiment 2 (Error bars = standard errors).

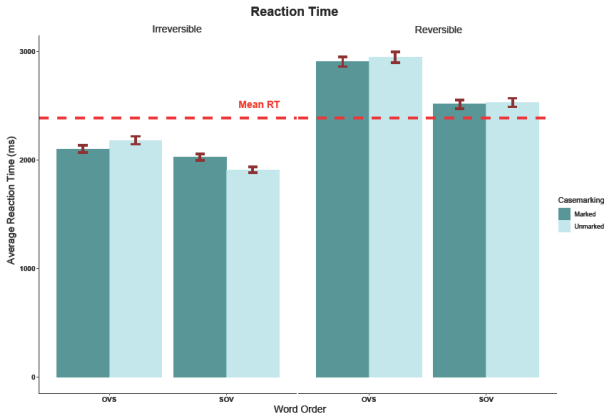

Figure 4. Reaction Times for Experiment 2 (Error bars = standard errors).

The RT data were analyzed with a mixed-effects linear regression in R using lme4 (Bates, Mächler, Bolker and Walker, 2015). Sum-coded variables were used for the two levels of word order, case-marking, and thematic reversibility, and participant and scenario served as random intercepts. The RT results were generally consistent with the accuracy results: participants were faster on SOV than OVS sentences (2620 ms and 2888 ms, $t = 12.52$, $p < .001$, $d = .12$) and on thematically irreversible sentences than thematically reversible sentences (2431 ms and 3077 ms, $t = 29.22$, $p < .001$, d = .28). Word order and case-marking interacted ($t = 2.25$, $p < .05$, d = .02, see Figure 4), with the RT difference between SOV and OVS sentences being approximately 50% larger when the object noun did not have overt accusative case-marking compared to when it did. Finally, there was a significant two-way interaction between word order and reversibility ($t = 5.1$, $p < .001$, d = .05), with the RT difference between SOV and OVS sentences being 130% larger in thematically reversible sentences than thematically irreversible sentences. The effect of case-marking did not pass the threshold for statistical

significance, nor did the two-way interaction between case-marking and thematic reversibility or the three-way interaction. When the thematically reversible sentences in were analyzed separately, case-marking still did not influence RTs. Recall that in Experiment 1 participants only heard thematically reversible sentences but in Experiment 2 they heard both thematically reversible and irreversible sentences. The fact that interspersion of irreversible sentences makes the processing of reversible sentences different (i.e., compared to processing them in isolation) indicates how the parser's priors on the relative advantage of existing cues (i.e., case-marking) update in response to the presence of a new cue (i.e., thematically irreversible NPs). Similar to the results of Experiment 1, there were no detectable speed-accuracy trade-offs. The results were virtually identical when reaction times for incorrect trials were eliminated with main effects of word order (2613 ms and 2900 ms, $t = 12.81$, $p < .001$, $d = .11$) and thematic reversibility (2660 ms and 2853 ms, $t = 30.16$, $p < .001$, $d = .26$) and two-way interactions between word order and case-marking ($t = 2.14$, $p < .05$, $d = .02$) and word order and thematic reversibility ($t = 6.67$, $p < .001$, $d = .06$).[3]

As was the case in Experiment 1, over the course of Experiment 2, thematically reversible OVS sentences became weaker garden paths, with OVS sentences being misinterpreted twice as often during the first third than final third of the sentences in Experiment 2 (see Table 2). As shown in Table 3, for thematically irreversible sentences, only O $_{\emptyset}$VS sentences induced garden-pathing, and this effect had largely disappeared by the final third of the experiment.

	Reversible $SO_{acc}V$	Reversible $SO_{\emptyset}V$	Reversible $O_{acc}VS$	Reversible $O_{\emptyset}VS$
First Third	93.5% (2509 ms)	83.1% (2712 ms)	76.2% (2944 ms)	66.0% (3061 ms)
Final Third	95.2% (2368 ms)	92.8% (2325 ms)	90.8% (2795 ms)	82.0% (2667ms)

Table 2. Performance on the First and Final Third of the Reversible Sentences in Experiment 2.

	Irreversible $SO_{acc}V$	Irreversible $SO_{\emptyset}V$	Irreversible $O_{acc}VS$	Irreversible $O_{\emptyset}VS$
First Third	90.7% (2161 ms)	89.7% (1958 ms)	91.8% (2095 ms)	84.5% (2377 ms)
Final Third	95.4% (1802 ms)	95.2% (1847 ms)	94.8% (2067 ms)	92.2% (2055 ms)

Table 3. Performance on the First and Final Third of the Irreversible Sentences in Experiment 2.

7. Discussion. In this study we investigated the effects of word order, accusative case-marking, and thematic reversibility of sentences on spoken sentence comprehension. Our aim was to empirically determine the relative strength of each factor and to determine how the factors interact with each other. In the first experiment, we investigated how word order and accusative case-marking affects the speed and accuracy with which Turkish speakers understand thematically reversible sentences that cannot be understood simply by knowing the meanings of the individual words (e.g., the cat, the mouse, saw). To investigate how semantic content affects sentence comprehension, in the second experiment, we also included thematically irreversible sentences where the meanings of individual words strongly constrain the propositional content of the whole sentence (e.g., the cat, the ball, saw).

[3] Because there were a fair number of incorrectly answered trials, they were separately analyzed. Participants were still faster on thematically irreversible sentences or SOV sentences, with reversibility having a stronger effect than word order. The rest of the estimates (i.e., case-marking, interaction terms) were statistically insignificant.

In both experiments, participants were slower and less accurate on scrambled sentences compared to default word order sentences. However, this word order effect was substantially attenuated when either or the object was case-marked, the sentence was thematically irreversible, or both. Both word order and thematic reversibility had larger influences than case-marking, and the size of their effects on accuracy were similar. However, for RTs, the effect of thematic reversibility was twice as large as the effect of word order. The facilitatory effect of overt case-marking was detectable in both accuracy and RT data for Experiment 1, and in accuracy for Experiment 2. The fact that case-marking aided comprehension (i.e., the performance difference between $SO_{acc}V$ and $SO_{ø}V$ sentences) is consistent with listeners using cues that, from a computational point, are redundant. Alternatively, the result is consistent with participants building all possible parses of all word orders, even those that would be ungrammatical under current conditions (e.g., $O_{ø}SV$ with neutral prosody). As stated previously, we hypothesized that sentences with thematically irreversible nouns would be much less likely to induce garden-pathing during sentence comprehension than sentences with thematically reversible nouns. The fact that our participants were slower and less accurate on thematically reversible sentences than thematically irreversible sentences supports this hypothesis.

Previous literature has revealed that the effect of word order on sentence comprehension varies from language to language. Bornkessel and Schlesewsky (2006) found that listeners experienced local processing difficulty for scrambled German sentences, even ones with contrastive stress. Hagiwara, Soshi, Ishihara and Imanaka (2007) reported that Japanese listeners had higher P600 responses (which are associated with syntactic processing difficulty in the neurolinguistics literature) for long-distance scrambled sentences (but not middle-distance scrambled sentences) compared to default word order sentences. In contrast to Hagiwara et al.'s (2007) Japanese results, Özge, Marinis, Zeyrek & Özge (2013) report that Turkish listeners were faster at processing sentence-initial objects with accusative markers compared to sentence-initial subjects with nominative (i.e., bare) marking (which is the canonical way to begin a Turkish sentence). Özge et al. argue that the sentences that began with an overtly case-marked object were easier to process than the subject-initial sentences because the overt accusative case-marker unambiguously marks the first noun as object, whereas the first noun in a subject-initial sentence (which is not overt case-marked) could resolve as either a non-casemarked object or a subject.

Our results shed further light on the discussion of the role of word order in sentence comprehension. We found that, in Turkish, having default word order facilitates the comprehension of sentences that are thematically reversible, but not those that are thematically irreversible. Furthermore, having overtly case-marked objects increases the accuracy of thematically reversible scrambled word order sentences. The speed advantage (faster RTs) provided by case-marking for thematically reversible scrambled word order sentences was apparent when participants *only* heard thematically reversible sentences throughout the experiment. Finally, participants never were better (i.e., faster and more accurate) on object-initial sentences than sentence-initial ones.

Our results also show that while each linguistic factor (i.e., default word order, accusative case-marking, thematic irreversibility of nouns) facilitates comprehension, thematic reversibility had the largest effect, followed by word order, followed by case-marking. We find this somewhat surprising because presence of overt accusative case-marking definitely establishes that a noun is an object, whereas the word order and meanings (e.g., animacy) of nouns are only probabilistic cues about their grammatical roles. After all, not all Turkish sentences are subject-initial (e.g., only 67% of sentences that have a subject, object, and verb are subject-initial, Batman-Ratyosyan, 2003), and not all sentences have subjects that are animate nouns and objects that are inanimate

nouns (e.g., "The newspaper criticized the politician."). The fact that word order and thematic reversibility both played a larger role than case-marking may suggest that the parser puts more weight on probabilistic world knowledge as to what a noun can do or be, compared to a more linguistic/grammatical source of information.[4]

Finally, our findings indicate that the facilitatory effects of word order, overt morphology and real-world knowledge do not grow linearly. In other words, with each additional cue, the marginal gain in comprehension grows smaller. For example, there was little to no difference in accuracy or reaction times between reversible and irreversible $SO_{acc}V$ sentences, nor was there a difference between case-marked and non-casemarked irreversible SOV sentences. Similarly, if all cues helped additively with no limit, one would expect irreversible case-marked SOV sentences (i-$SO_{acc}V$) to have higher accuracy and/or lower RTs than irreversible case-marked OVS sentences (i-$O_{acc}VS$). This was not the case. On the one hand, these results could reflect a ceiling effect for accuracy, where higher performance is simply not possible due to the mathematical limitation of accuracy measurement (i.e., between 0-100%). However, if this were the case, we would still expect to find an additive faciliatory effect of each additional cue for RTs because there is no ceiling effect for RTs. Again, this was not the case – people were not faster at understanding sentences that had three cues (e.g., irreversible $SO_{acc}V$) than they were for sentences with two cues (e.g., irreversible $O_{acc}VS$). Our results indicate that participants "decide" what a sentence means once they have gathered what they believe is enough information to parse the sentence. The result is that they process sentences faster, but occasionally, they succumb to garden-paths and misparse sentences. Thus, we argue that our findings are consistent with unrestricted race models (i.e., "good-enough" approach) of sentence processing (e.g., Ferreira, Bailey & Ferraro, 2002; Van Gompel, Pickering, Pearson & Liversedge, 2005).

If listeners employ whatever information they can to arrive at *a* meaning of a sentence, then we would expect that they would gather and use information about suprasegmental features of the sound stream as they parse sentences (Fodor, 2002; Carlson, 2009). Indeed, listeners appear to be able to make use of small differences in frequency, volume and duration of elements to help inform their parsing processes in Japanese (Ferreira & Yoshita, 2003) and English (Rehrig, Knutsen, Schrum, de Lacy & Stromswold, 2017; Knutsen, Stromswold & Kleinschmidt, 2019). If this is also true for Turkish, the prosody of particular experimental sentences might make Stromswold (2021) found that native Turkish speakers produce sentences with scrambled word order in a prosodically different way than sentences with default word order sentences and similarly, they produce sentences that have objects that are overtly case-marked differently from those that do not. Overall, we found that Turkish speakers' contours for sentences that were harder to process (i.e., scrambled word order, no accusative case-marking, or both) showed an increase in fundamental frequency and intensity in the pre-verbal region, and a sharp decrease afterwards in contrast to the sentences that were easier to process (i.e., default word order, has accusative case-marking) which were more monotonic overall in their contours (Ergin, 2020).

In our comprehension experiments, there was substantial variability even within a sentence type. For example, accuracy and reaction times for $O_{ø}VS$ sentences varied for different scenarios.

[4] It is possible that our results reflect that we used offline measures of comprehension measures. In other words, any processing advantage provided by overt case-marking in the moment may become obsolete after the entire sentence is processed. If one were to use methods designed to capture processing difficulty at each word in real-time (i.e., ERP, eye-tracking), one might find, at least on the object, a greater effect for case-marking.

Perhaps this variability reflects that prosody was a more helpful cue for some sentences than others. The prosodic differences among items might also explain why our participants sometimes misunderstood sentences that should not have posed any processing difficulty (e.g., irreversible $SO_{acc}V$ sentences). In other words, some thematically irreversible $SO_{acc}V$ sentences may have been said with prosody that makes them more susceptible to garden-pathing.

The dynamic interplay between word order, case-marking, and thematic reversibility may become more transparent if suprasegmental characteristics of the sentences are evaluated simultaneously with the other factors. Currently, we are running experiments with band-pass filtered versions of the sentences of Experiments 1 and 2. This band-pass filtering removes all lexical, morphological, and phonological information, leaving only a sentence's prosodic contour intact. Despite this, preliminary analyses suggest that, overall, participants correctly guessed the word order of the filtered sentence at well-above chance. Our preliminary analyses also indicate that participants were more accurate at guessing the word order for some sentences than others, and some participants were better at guessing the word order of sentences than others. These results suggest that people can use a sentence's prosody as a cue for its word order, though the ability to do so varies among participants and among sentences.

By simultaneously investigating how different facets of language (syntax, morphology, semantics, and prosody) interact and affect people's interpretation of sentences in typologically different languages, we can get a deeper and richer understanding of the mechanisms that underlie language comprehension. The experiments presented in this paper are an attempt to do that.

References

Baker, Mark C. 1997. Thematic roles and syntactic structure. In Elements of grammar: *Handbook in Generative Syntax* , 73-137. Dordrecht: Springer Netherlands.

Bates Douglas, Martin Mächler, Ben Bolker, & Steve Walker. 2015. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67(1), 1–48. doi:10.18637/jss.v067.i01.

Batman-Ratyosyan, Natalie. 2003. The Acquisition of Word Order and Morphology in Turkish. Ph.D. Dissertation. Rutgers – State University of New Jersey – New Brunswick.

Boersma, Paul. 2001. Praat, a system for doing phonetics by computer. *Glot International* 5:9/10, 341-345.

Bornkessel, Ina, & Matthias Schlesewsky. 2006. The role of contrast in the local licensing of scrambling in German: Evidence from online comprehension. *Journal of Germanic Linguistics*, 18(1).

Carlson, Katy. 2009. How prosody influences sentence comprehension. *Language and Linguistics Compass*, 3(5), 1188-1200.

Christianson, Kiel, Andrew Hollingworth, John Halliwell, & Fernanda Ferreira. 2001. Thematic roles assigned along the garden path linger. *Cognitive Psychology*, 42(4), 368-407.

Christianson, Kiel, Carrick Williams, Rose T. Zacks, & Fernanda Ferreira. 2006. Younger and older adults' "good-enough" interpretations of garden-path sentences. *Discourse Processes*, 42(2), 205-238.

Dowty, David. 1991. Thematic proto-roles and argument selection. *Language*, 67(3), 547-619.

Demiral, Şükrü B., Matthias Schlesewsky, & Ina Bornkessel-Schlesewsky. 2008. On the universality of language comprehension strategies: Evidence from Turkish. *Cognition*, 106(1), 484-500.

Ergin, M. Yarkin. 2020. Prosodic Marking of Case and Word Order in Turkish Sentences (Master's thesis, Rutgers - The State University of New Jersey, School of Graduate Studies).

Ergin, M. Yarkin & Karin Stromswold. 2021. Garden-path sentences are prosodically marked in Turkish. Conference talk presented at X-PPL 2021, Crosslinguistic Perspectives on Processing and Learning.
Erguvanli, Eser E. 1984. The Function of Word order in Turkish Grammar (Vol. 106). University of California Press.
Erguvanli, Eser E. & Karl Zimmer. 1994. Case marking in Turkish indefinite object constructions. In *Annual Meeting of the Berkeley Linguistics Society*, 20(1), 547-552.
Ferreira, Fernanda, Karl G. Bailey, & Vittoria Ferraro. 2002. Good-enough representations in language comprehension. *Current Directions in Psychological Science*, 11(1), 11-15.
Ferreira, Victor. S., & Hiromi Yoshita. 2003. Given-new ordering effects on the production of scrambled sentences in Japanese. *Journal of Psycholinguistic Research*, 32(6), 669-692.
Fillmore, Charles J. 1968. Lexical entries for verbs. *Foundations of Language*, 373-393.
FindingFive Team. 2019. FindingFive: A web platform for creating, running, and managing your studies in one place. FindingFive Corporation (nonprofit), NJ, USA. https:/www.findingfive.com.
Fodor, Janet D. 2002. Psycholinguistics cannot escape prosody. In *Speech Prosody* 2002, International Conference.
Frazier, Lyn, & Janet D. Fodor. 1978. The sausage machine: A new two-stage parsing model. *Cognition*, 6(4), 291-325.
Frazier, Lyn. 1987. Sentence Processing: A tutorial review. Chapter from: M. Coltheart (Ed.). *Attention and Performance 12: The Psychology of Reading* (p. 559–586). Lawrence Erlbaum Associates, Inc.
Hagiwara, Hiroko, Takahiro Soshi, Masami Ishihara, & Kuniyasu Imanaka. 2007. A topographical study on the event-related potential correlates of scrambled word order in Japanese complex sentences. *Journal of Cognitive Neuroscience*, 19(2), 175-193.
Kako, Edward. 2006. Thematic role properties of subjects and objects. *Cognition*, 101(1), 1-42.
Kizilkaya, Semra, Zarina Levy-Forsythe, & Klaus von Heusinger. 2022. Affectedness and differential object marking in Turkish and Uzbek. *Linguistics*, 60(6), 1907-1941.
Knutsen, Sten, Karin Stromswold, & Dave Kleinschmidt. 2019. Segmental duration as a cue to sentence structure. Poster presented at 32nd annual CUNY Sentence Processing conference, Boulder CO. March 29 – 31, 2019.
Kornfilt, Jaklin. 2003. Scrambling, subscrambling, and case in Turkish. In Simin Karimi (Ed.) *Word Order and Scrambling*, 125-155.
Kornfilt Jaklin. 1984. Case Marking, Agreement, and Empty Categories in Turkish. PhD. thesis. Department of Linguistics, Harvard University.
Krause, Elif, & Klaus von Heusinger. 2019. Gradient effects of animacy on differential object marking in Turkish. *Open Linguistics*, 5(1), 171-190.
Kural, Murat. 1992. Scrambling and mixed positions in Turkish. In *North East Linguistics Society*, 22(1), 18.
Novick, Jared M., Sharon Thompson-Schill, & John C. Trueswell. 2008. Putting lexical constraints in context into the visual-world paradigm. *Cognition*, 107(3), 850-903.
Rehrig, Gwendolyn, Sten Knutsen, Nicolaus Schrum, Paul de Lacy, Karin Stromswold. 2017. The long and short of it: The role of verb stem vowel duration in sentence processing. Poster presented at the 39th Annual Meeting of the Cognitive Science Society, Hilton London Metropole, London, UK.
Silverstein, Michael. 1986. Hierarchy of features and ergativity. *Features and Projections*, 25.
Slobin, Dan. I., & Thomas G. Bever. 1982. Children use canonical sentence schemas: A crosslinguistic study of word order and inflections. *Cognition*, 12, 229-265.

Özge, Duygu, Theodors Marinis, Deniz Zeyrek, & Umut Özge. 2013. Object-first orders do not pose a challenge during processing for Turkish speakers. In *Proceedings of the 8th Workshop on Altaic Formal Linguistics*, pp. 269-80.

van Gompel, Roger P., Martin J. Pickering, Jamie Pearson, & Simon P. Liversedge. 2005. Evidence against competition during syntactic ambiguity resolution. *Journal of Memory and Language*, 52(2), 284-307.

Appendix A. Experiment 1 Stimuli Sentences ($SO_{acc}V$ version shown)

Verb	Turkish	Translation
belittle	Sporcu işadamını küçümsedi.	The athlete belittled the businessman.
bring	Hemşire doktoru getirdi.	The nurse brought the doctor.
catch	Kaplan maymunu yakaladı.	The tiger caught the monkey.
chase	Eşek öküzü kovaladı.	The donkey chased the ox.
cheat on	Kadın adamı aldattı.	The woman cheated (on) the man
criticize	Romancı şairi yerdi.	The novelist criticized the poet.
divorce	Manken müzisyeni boşadı.	The model divorced the musician.
embarass	Baba oğlu utandırdı.	The dad embarassed the son.
enrage	Zürafa fili kızdırdı.	The giraffe enraged the elephant.
greet	Adam kadını karşıladı.	The man greeted the woman.
impress	Delikanlı kadını etkiledi.	The young-man impressed the woman.
kill	Taksici minibüsçüyü öldürdü.	The taxi-driver killed the bus-driver.
kiss	Prenses prensi öptü.	The princess kissed the prince.
like	Kız oğlanı sevdi.	The girl liked the boy.
please	Dayı yeğeni sevindirdi.	The uncle pleased the nephew.
point-out	Editör gazeteciyi gösterdi.	The editor pointed (to) the journalist.
praise	Elektrikçi tesisatçıyı övdü.	The electrician praised the plumber.
protect	Öğrenci öğretmeni korudu.	The student protected the teacher.
push	Koyun kuzuyu itti.	The sheep pushed the lamb.
recognize	Zebra aslanı farketti.	Zebra recognized the lion.
reprimand	Balıkçı kasabı azarladı.	The fisherman reprimanded the butcher.
save	Bakan başkanı kurtardı.	The minister saved the president.
scan	Müfettiş komutanı süzdü.	The inspector scanned the commander.
scare	Geyik ormancıyı korkuttu.	The deer scared the forester.
search	Çocuk yetişkini aradı.	The child searched (for) the grown-up.
see	Kedi fareyi gördü.	The cat saw the mouse.
shame	Nine komşuyu ayıpladı.	The grandma shamed the neighbor.
sniff	Tavşan sincabı kokladı.	The rabbit sniffed the squirrel.
spoil	Amca teyzeyi şımarttı.	The uncle spoiled the aunt.
spy-on	Uşak temizlikçiyi gözetledi.	The butler spied on the maid.
stab	Tacir hırsızı bıçakladı.	The merchant stabbed the thief.
surprise	Bahçıvan çöpçüyü şaşırttı.	The gardener surprised the trashman.
take-away	Polis komiseri götürdü.	The police took away the chief.
trick	Simitçi büfeciyi kandırdı.	Simit-seller tricked the shop-clerk.
tug	Abla kardeşi çekiştirdi.	The sister tugged the sibling.

watch	Büyükbaba çocuğu izledi.	The grandad watched the child.

Appendix B. Experiment 2 Stimuli Sentences ($SO_{acc}V$ version shown)

Thematically reversible	Thematically irreversible
Sincap tavşanı ısırdı. 'The squirrel bit the rabbit'	Kurt kemiği ısırdı. 'The wolf bit the bone'
Doktor hemşireyi getirdi. 'The doctor brought the nurse'	Garson baklavayı getirdi. 'The waiter brought the baklava'
Kuş maymunu yakaladı. 'The bird caught the monkey'	Köpek frizbiyi yakaladı. 'The dog caught the frisbee'
Kraliçe kralı kutladı. 'The queen celebrated the king'	Dede bayramı kutladı. 'The granddad celebrated the holiday'
Eşek öküzü kovaladı. 'The donkey chased the ox'	Kedi lazeri kovaladı. 'The cat chased the laser'
Romancı şairi yerdi. 'The novelist criticized the poet'	Eleştirmen romanı yerdi. 'The critic criticized the novel'
Onbaşı askeri buldu. 'The sergeant found the soldier'	Turist haritayı buldu. 'The tourist found the map'
Müşteri tezgahtarı karşıladı. 'The client greeted the shop-clerk'	Mezarcı korteji karşıladı. 'The gravedigger greeted the convoy'
Bülbül güvercini duydu. 'The nightingale heard the pigeon'	Fare zili duydu. 'The mouse heard the bell'
İşçi kamyoncuyu tuttu. 'The worker hired the trucker'	İşadamı arabayı tuttu. 'The businessman hired the car'
Kadın adamı tekmeledi. 'The woman kicked the man'	Çocuk tenekeyi tekmeledi. 'The child kicked the can'
Prenses prensi öptü. 'The princess kissed the prince'	Nine ekmeği öptü. 'The grandma kissed the bread'
Balerin baleti kaldırdı. 'The ballerina lifted the dancer'	Hamal kutuyu kaldırdı. 'The porter lifted the box'
Manken menajeri beğendi. 'The model liked the manager'	Terzi kıyafeti beğendi. 'The tailor liked the dress'
Danışan terapisti dinledi. 'The client listened (to) the therapist'	Hizmetçi şikayeti dinledi. 'The servant listened (to) the complaint'
Editör gazeteciyi gösterdi. 'The editor pointed to the journalist'	Protestocu pankartı gösterdi. 'The protestor pointed to the picket sign'
Ajan tetikçiyi zehirledi. 'The agent poisoned the hitman'	Haydut kuyuyu zehirledi. 'The bandit poisoned the well'
Müdür asistanı övdü. 'The manager praised the assistant'	Yönetmen filmi övdü. 'The director praised the movie'
Öğrenci öğretmeni korudu. 'The student protected the teacher'	Bekçi depoyu korudu. 'The custodian guarded the depot'
Kuzu koyunu itti. 'The lamb pushed the sheep'	Goril taşı itti. 'The gorilla pushed the rock'
Yazar filozofu alıntıladı. 'The writer quoted the philosopher'	Yargıç paragrafı alıntıladı. 'The judge quoted the paragraph'
Aslan zebrayı farketti. 'The lion recognized the zebra'	Geyik tehlikeyi farketti. 'The deer recognized the danger'
Bakan başkanı kurtardı. 'The minister saved the president'	Kaptan mücevheri kurtardı. 'The captain saved the jewelry'
Müfettiş komutanı süzdü. 'The inspector scanned the commander'	Mimar binayı süzdü. 'The architect scanned the building'
Fil zürafayı gördü. 'The elephant saw the giraffe'	Ceylan dereyi gördü. 'The deer saw the river'
İnek domuzu kokladı. 'The cow sniffed the pig'	Rakun çöpü kokladı. 'The raccoon sniffed the trash'
Temizlikçi uşağı gözetledi. 'The maid spied on the butler'	Dedektif sokağı gözetledi. 'The detective spied on the street'
Sanık avukatı durdurdu. '' The defendant stopped the lawyer'	Direktör projeyi durdurdu. 'The director stopped the project'
Görevli komiseri götürdü. 'The attendant took-away the chief'	Kurye pizzayı götürdü. 'The courier took-away the pizza'
Hırsız polisi izledi. 'The thief watched the police'	Çiftçi treni izledi. 'The farmer watched the train'