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Early knowledge of word order in Palestinian Arabic: An eye-tracking study

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ABSTRACT

This paper addresses the underexplored realm of early parameter setting in language acquisition before the two-word stage, in a less researched language, Palestinian Arabic. Building on Franck et al.'s (2013) exploration of the verb–direct or indirect object/direct or indirect object–verb (VO/OV) parameter in infants exposed to French, we investigate the acquisition of the VO order (as opposed to OV) in 17-month-old native Palestinian Arabic infants using a combination of the preferential looking paradigm, the weird word order paradigm, and pseudo-verbs. The results from our study show that Palestinian Arabic infants have established VO by the age of 1;5 and ignore sequences of ungrammatical OV. This pattern is different from that of the adults, who do not ignore ungrammatical sequences. Additionally, we find no correlation between the infants' performance and vocabulary size or age within the range tested. The infants in the study constitute, with Mandarin infants in a similar study, the youngest age group to show sensitivity to the VO/OV contrast.

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1. Introduction

How word order parameters are set is a central question in the field of language acquisition. This is a challenging question, given the age at which the research available indicates that this takes place, at least for macroparameters. Studies investigating early syntactic development in infants (aged 1;1 to 2;0) have commonly utilized the intermodal preferential looking paradigm developed by Golinkoff et al. (1987). The intermodal preferential-looking paradigm is a low-demand procedure that measures the time course of gaze patterns of infants as young as 14 months (Fernald et al. 2008). The logic of this method is that children fixate their gaze significantly longer on a representation that matches what they are hearing (Hirsh-Pasek & Golinkoff 1996). Therefore, measures of eye fixation serve as a method to access comprehension and, by inference, syntactic representation by the infant. The purpose of this paper is to present a first study on the early acquisition of word order in Palestinian Arabic with preverbal infants and to compare the infants' performance to adult performance.

1.1. Background

Hirsh-Pasek & Golinkoff (1996) pioneered research on infants' sensitivity to word order using the preferential looking paradigm. They demonstrated that 17-month-old children understand active sentences such as *Big Bird is washing Cookie Monster*, even though the sentences are reversible, showing that children can identify AGENT and THEME based solely on word order. Similarly, Gertner et al. (2006) found that 21-month-old children could comprehend transitive sentences with a pseudo-verb, like *The girl is gorping the boy*, by correctly identifying actions where a girl is the AGENT and a boy is the THEME. However,

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these findings alone do not prove that children understand that in English objects follow the verb, as being able to identify the first determiner phrase (DP) as the argument receiving the AGENT theta role (as in the AGENT-first strategy, Bates & MacWhinney 1982, Lidz et al. 2001) would suffice to identify the target video representation, and so knowing the position of the object would not be strictly necessary to understand subject–verb–direct or indirect object (SVO). Franck et al. (2013) designed an experiment to address this issue, the first to investigate awareness in 19-month-old infants of the contrast between VO and OV languages. In their study they employed a combination of the preferential-looking paradigm, the weird word order (WWO) paradigm (Akhtar 1999), and the use of pseudo-verbs. As in the work of Akhtar (1999), the study (Akhtar 1999 presented infants with grammatical SVO and ungrammatical SOV sentences. Franck et al. (2013) predicted that, if French infants had set the VO parameter, they would exhibit a preference for the event matching the auditory stimulus in grammatical sentences. If grammaticality was guiding the gazing behavior, their behavior would be different when confronted with the ungrammatical SOV sequences. The decision of using pseudo-verbs aimed to explore whether infants possess abstract knowledge of word order or not. The pre-test introduced infants to puppets, screen presentations and novel actions without exposing them to the pseudo-verbs used in the experimental phase. No preference for the target videos with pseudo-verbs was predicted under usage-based theories (Abbot-Smith & Tomasello 2006; Tomasello 1992, 2000), which claim that at this stage infants have no access to abstract syntactic representations. In contrast, the hypothesis of early abstract word order representations would make one expect a preference for transitive scenes upon hearing SVO sequences in a language like French, even if a pseudo-verb was used. The transitive action video featured an AGENT acting on a PATIENT, while the distractor involved a reflexive video with both agents performing actions on themselves. The rationale behind this choice of distractor is to rule out the possibility that children are interpreting the sentence using an AGENT-first parsing strategy; if the distractor had depicted a transitive scene with theta role reversal, there would have been the possibility that infants interpret the sentence without resorting to grammatical knowledge of the VO/OV alternation (as can be argued for the results of Hirsh-Pasek & Golinkoff 1996). The results of Franck et al. (2013) not only indicated comprehension of the grammatical SVO sequences, but they also showed that infants ignored the ungrammatical SOV sequences. The authors' interpretation was that the VO parameter had been set prior to the age of the infants taking part in the experiment.

The setting of the VO/OV parameter was also explored by Gavarró et al. (2015) with an OV language, Hindi-Urdu, using the same combination of the preferential looking paradigm, the WWO paradigm and the use of pseudo-verbs. The results indicated that infants at 1;7 could parse the SOV sequences, grammatical in Hindi-Urdu, but had no preference for any video when exposed to an ungrammatical sequence (in the case of Hindi-Urdu, VSO, owing to the fact that Hindi-Urdu allows several word order variations, including SVO). These findings suggest that Hindi-Urdu infants, like French children, have set the value of the VO/OV parameter correctly by 19 months. In more recent work, Zhu et al. (2022) also replicated the study of Franck et al. (2013) with infants exposed to a VO language, Mandarin. The materials, methods and procedure were similar to those in the previous studies. The results indicated that Mandarin infants at a mean age of 1;5 showed a significant preference for videos illustrating the transitive actions when they heard the canonical SVO sequences (with a pseudo-verb); however, no preference was found when they heard the ungrammatical SOV order. Hence children exposed to Mandarin do parse VO but not OV at 1;5. Zhu et al. (2022) investigated the impact of age and vocabulary on children's performance. Their findings indicate that the preference for the transitive video over the reflexive video, when presented with a grammatical sentence, is not affected by either age ($p = .66$) or vocabulary ($p = .34$). Stated differently, there is no association between developmental factors (age and vocabulary) and performance in this context.

The current study aims to assess the setting of the VO parameter value (namely, the parameter that determines whether there is left-ward movement of the object or not) with the same method used in Franck et al. (2013), in a lesser studied language, Palestinian Arabic. As summarized, results thus far are available for French and Mandarin (both SVO languages) and Hindi-Urdu (an SOV language). Palestinian is also an SVO language, belonging, however, to a different language

family, the Semitic. Palestinian Arabic is also, of all the VO languages investigated thus far, the one with the richest morphological system (and the only one with discontinuous morphology). The value of the study is not only in replicating a result, but to carry out the experiment in a different language, thus widening the empirical coverage of this line of research. As in the original study of Franck et al. (2013), we consider our results against the usage-based account (Tomasello 1992, 2000), the AGENT-first strategy (Bates & MacWhinney 1982, Lidz et al. 2001), and the hypothesis that infants have set the VO parameter correctly owing to their abstract grammatical knowledge (as might be expected from generative approaches to language acquisition). Furthermore, we explore a very early age range, with younger infants than in the rest of studies except for the study on Mandarin.

Palestinian Arabic is spoken by approximately 6.8 million people in the area of Historical Palestine (Palestinian Central Bureau of Statistics 2022). It serves as the everyday spoken language used by Palestinians and is, therefore, the first language of the children. One of the main singularities of the Arabic-speaking countries is diglossia (Saiegh-Haddad & Henkin-Roitfarb 2014). Modern Standard Arabic is the variety mainly used for reading and writing, while Spoken Arabic remains the language of informal communication. Academic discussions often use a semi-standard form. At home and in the neighborhood, people use the local variant of Spoken Arabic, and that is the language that children are natively exposed to. Additionally, satellite TV, especially children's channels, exposes them to Standard Arabic from an early age.

Modern Arabic varieties, Palestinian Arabic included, are defined by their non-concatenative templatic morphology, which operates on a system of roots and patterns (McCarthy & Prince 1988, Ryding 2005). Palestinian Arabic has a relatively flexible word order and a rich verb agreement system, and it is a null subject language (Mousa 2019). A minimal amount of work on the acquisition of word order in Palestinian Arabic has been conducted, with the exception of Friedmann & Costa (2011) and Khamis-Dakwar (2011); in these two papers, the authors consider the word order preferences of children in an age range older than the one considered here.

1.2. Preliminaries: A corpus study of Palestinian Arabic

Since our study focuses on the acquisition of the order VO (in opposition to OV), we conducted a study to establish the most common word order patterns in Palestinian Arabic. This was achieved with a corpus analysis of child and child-directed speech of the Nazzal Corpus (https://childes.talkbank.org/access/Other/Arabic/Nazzal.html). We analyzed a total of 5,681 sentences for adults and 3,370 for children (age range: 1;6-4;6). SVO was the predominant order in sentences containing both subject and object, for children and adults, with 365 sentences in the adult (child-directed) speech sample (63%) and 224 sentences in the child sample (84.8% of sentences). Figure 1 shows the percentage of different word orders in children's production with both an overt subject and an overt object, while Figure 2 shows the percentage of different word orders in adults' child-directed speech for sentences with both an overt subject and an overt object. The results for adults align with the findings in the literature on the preferred SVO order of Palestinian Arabic, as opposed to the VSO order of Standard Arabic (Shlonsky 1997, Mohammad 2000).

From the 5,634 sentences produced by adults, 60.9% contained an overt object and, of these, 71.5% of the sentences displayed the VO order; OV was found in 28.5% of sentences with an object, all sentences with *wh-* movement. For the young children in the corpus, out of the 3,370 sentences they produced, 41.9% contained an overt object, and of these 94.1% displayed VO order; OV was found only in sentences with *wh-* movement, as in adult production.

The word order distribution for all adult sentences is presented in Table 1; here sentences with null and overt subject are included. In total, adults exhibited 50 different word orders in this sample of child-directed speech. Word orders that represented a percentage of productions below 1% are not detailed in the table, and are grouped under 'other'.

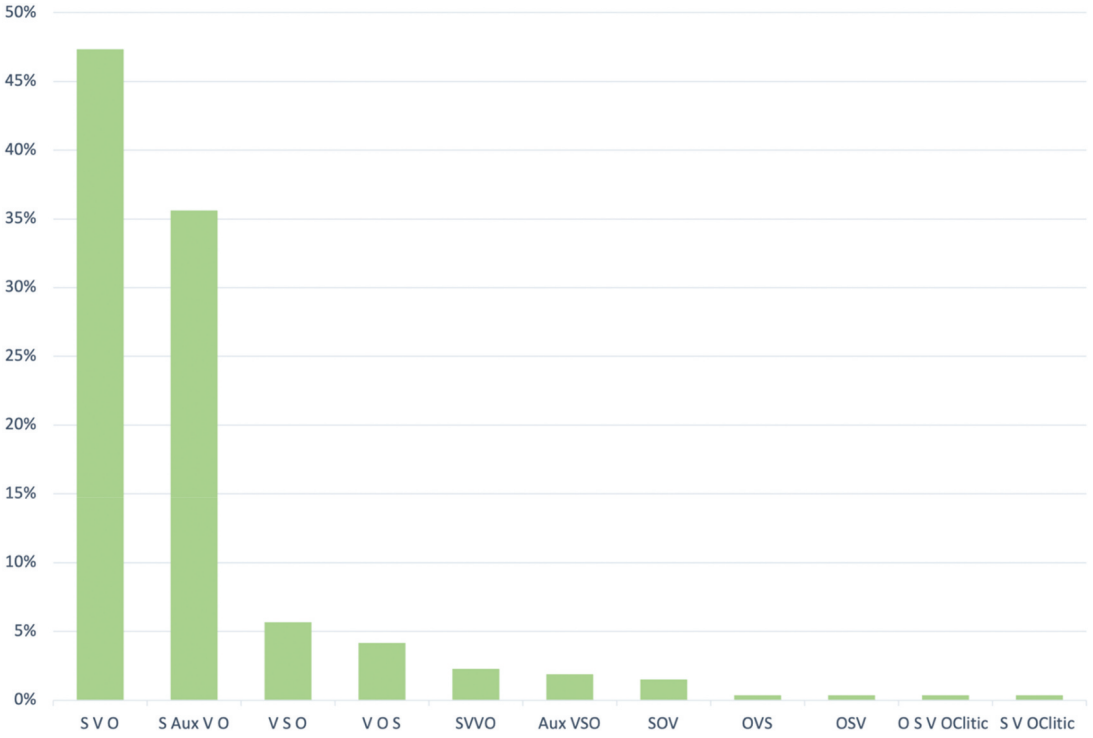

Figure 1. Frequency of different word orders of sentences with S, V, O, in children.

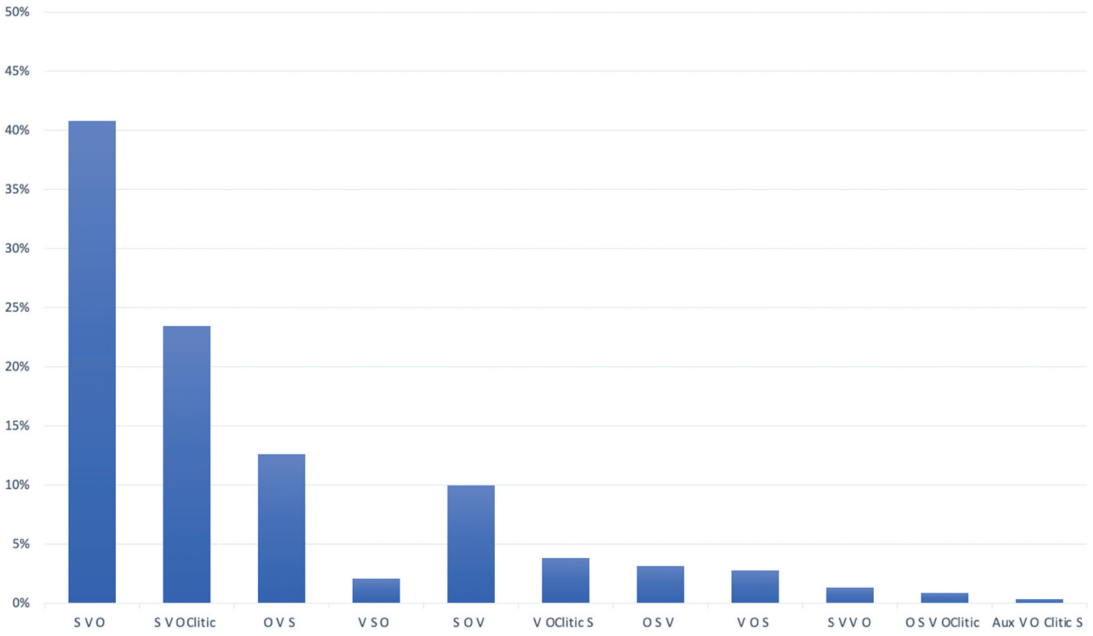

Figure 2. Frequency of different word orders of sentences with S, V, O in adults.

Table 1. Frequency and percentage of different word orders, Palestinian Arabic-speaking adults.

Word order	Count	Percentage (%)
V	1026	18.21
V O	743	13.18
V PP	389	6.9
V O_{Clitic}	387	6.87
O V	373	6.62
S Pred.	369	6.55
V O_{Clitic} O	268	4.75
S V	236	4.19
S V O	203	3.6
S V O_{Clitic}	134	2.38
V V	123	2. 18
AUX V	116	2.06
S V PP	112	1.99
O AUX V	94	1.67
AUX V O	87	1.54
V S	84	1.49
O V PP	77	1.37
O V S	72	1.28
V V O	63	1.12
AUX V PP	63	1.23
O AUX	58	1.03
Other	557	9.89
Total	**5,634**	

Abbreviations: V = verb; S = subject; O = direct or indirect object; PP = prepositional phrase; AUX = auxiliary verb.

The corpus study allows us to establish that VO is the predominant order when V and O are present; OV, conversely, is ungrammatical in the declarative sentences of Palestinian Arabic. It appeared exclusively in the form of *wh*-questions in adult and child production.

Notice that the results of our study of spontaneous production differ from previous results on Palestinian Arabic regarding the acquisition of SV/VS and SVO/VSO orders: resorting to repetition tasks, Friedmann & Costa (2011) and Khamis-Dakwar (2011) found a preference for the VS order (over SV) up to age 2;6. There may be methodological reasons for the contrast (Khamis-Dakwar 2011, for example, reached her conclusions on the basis of less than half of the children's answers, and the pragmatic context of repetition may have favored some word orders over others). Since we focus on the position of objects, rather than subjects, the discrepancies between the findings of Friedmann & Costa (2011), and Khamis-Dakwar (2011), and our own, should they be corroborated, have no implications for the design of our experimental study.

2. Present study

The current research aims to investigate syntactic knowledge of the VO parameter in typically developing infants exposed to Palestinian Arabic in the age range between 1;3 and 1;7 – an age range slightly lower than that of the original experiment conducted for French; we also aim to compare the results with those of a control group of Palestinian Arabic adult speakers.

2.1. Predictions

The prediction of our study is that, on the one hand, if Palestinian infants have set the value of the VO parameter at 17 months, they will look at the event that matches the auditory stimulus longer than at the event that does not when hearing the grammatical SVO sentences, while no such preference might be expected in the ungrammatical condition. Consequently, above-chance looks at a scene matching

a grammatical sentence are expected, as well as chance performance upon the presentation of the ungrammatical sentence. On the other hand, if infants acquire word order through lexicalized learning (Abbot-Smith & Tomasello 2006; Tomasello 1992, 2000), neither grammatical nor ungrammatical sentences will be parsed if pseudo-verbs are used and infants are exposed to these pseudo-verbs for the first time in the course of the experimental phase of the experiment—they simply will not have had time to build a template for that lexical item. Conversely, the AGENT-first strategy predicts the same performance with SVO and SOV, as the AGENT appears first in both; the prediction then is that infants will direct their gaze towards the target video in both conditions. Adults are generally not tested in this kind of experiment, as it is assumed that adults will understand the target sentences and accordingly direct their gaze to the target video. However, since this experiment involves ungrammatical sentences, it seemed relevant to test adults to see their performance with grammatical compared to ungrammatical sentences.

In what follows we detail the methods used with both populations (infants, adults), and then present the participants of each study with their respective results.

2.2. Methods

2.2.1. Experimental design

The design follows that used by Franck et al. (2013) combining the preferential looking paradigm, the WWO paradigm, and pseudo-verbs. The word orders chosen for the experiment are SVO and SOV, and mirror those utilized by Franck et al. (2013) and Zhu et al. (2022), facilitating precise cross-linguistic comparisons. Each sentence was paired with two videos, depicting transitive and reflexive modes of action, along with the auditory stimuli. In the transitive action video, the AGENT executed an action on the PATIENT, while, in the reflexive action video, both characters performed the same action on themselves. The videos used were the original ones from Franck et al. (2013). Common animal characters, such as a dog, a horse, a donkey, a cow, a lion, and a sheep, were introduced with the definite article *al* 'the' and featured in the videos.

The experiment included two sessions: training and testing. During the training session, participants were familiarized with the characters in the experimental videos while auditory stimuli asked the participant to look at a given character, that is, *ʃu:f, mi:n fi: ho:n, ha:d l-kalb* 'Look, who is here, it's the dog'. The puppets were presented on one half of the screen for 6 seconds, whereas the other half of the screen remained blank. This was followed by a phase with the simultaneous presentation of two characters on opposite sides of the screen while asking about one of them i.e., *ʃu:f, ʃa:jef l-baqara? we:n l-baqara?* 'Look, do you see the cow? Where is the cow?'. As in the previous phase, a blank screen that lasted 2 seconds was displayed before introducing each item. Finally, participants were introduced to the novel actions in the experimental videos without using the pseudo-verbs. Consequently, videos of the novel actions were paired with sentences like *ʔetˤtˤalaʕ, ʃu: bisˤi:r?* 'Look, what is happening?'. At the end of the training session, a short cartoon video with a Teletubbies landscape was presented. Participants were given a short break before proceeding to the experimental session.

During the experimental session, six videos were represented with two scenes each, one depicting a transitive action, the other one a reflexive action, lasting 18 seconds. The six test items were presented in random order, with the presentation of the target and reverse actions counterbalanced across the left and right sides of the screen. All videos began with a baseline sentence that draw the child's attention, e.g., *ʔetˤtˤalaʕ, ʃa:jef ʃu: bisˤi:r?* 'Look, what is happening?' that lasted for 3 seconds, followed by three repetitions of the experimental sentences. As a result, the gazing time was recorded in four windows: the baseline (from 0 to 4 seconds), and three sequential exposures of the test sentences (Sentence 1, Sentence 2, Sentence 3) starting at 5, 10, and 15 seconds.

2.2.2. Stimuli

Two pseudo-verbs were used to ensure that children do not rely on lexical knowledge to process the sentences. These pseudo-verbs adhered to the morphophonological features of Palestinian Arabic;

they were presented with a progressive marker *b-* at the start of the verb to indicate a present tense form (Jarrar et al. 2014) followed by an agreement marker *e* (e.g., *besayyeʕ*) for the third person masculine singular or *t* (e.g., *btemraʃ*) for the third person feminine singular. To decide on the pseudo-verbs to be used, fourteen native speakers validated the pseudo-verbs to ensure naturalness. The selected pseudo-verbs, *besayyeʕ* (corresponding to "put a crown on someone's head") and *bemraʃ* (corresponding to "put someone's head under a net"), represented different non-lexicalized actions. *besayyeʕ* was employed in the grammatical SVO order, while *bemraʃ* was used in the ungrammatical SOV order, as presented in Table 2. The experimental protocol can be found in Appendix. Different verbs were used for different conditions, and, as pointed out by an anonymous reviewer, it would have been advisable to use the same verb for the two conditions (grammatical and ungrammatical) so that differences in performance could not be attributed to the use of different pseudo-verbs; this step was not taken to adhere to the original design and make the results comparable to those in the previous studies.

The sentences were recorded by the first author, a female native speaker of Palestinian Arabic from Ramallah, Palestine, in a soundproof lab. Praat (computer software for speech analysis) was used to cut the utterances to ensure that all repetitions were the same lengthwise, and Adobe Premier Pro CC 2017 (v. 11.0.2) was used to combine the audio with the videos. Once the stimuli were chosen, the next step was to run the experiment using the following procedure.

2.2.3. Procedure

The procedure closely followed that of Franck et al. (2013). For infants, upon parents and infants' arrival at the lab in the Department of Applied Medical Sciences, Faculty of Medicine and Health Sciences, An-Najah National University, Nablus, Palestine, the experimenter explained the procedure, obtained parental consent and general information, and collected vocabulary CDI checklists. Infants were individually tested, seated on their caregiver's lap approximately 60 cm from a computer screen in a quiet room. Parents were instructed to keep their eyes closed during the experiment, refraining from guiding their children, while open eyes were allowed during the training session. In the case of adults, the procedure only included the request of demographic data to the participants and then participants were administered the experiment. The entire session lasted for 10 to 15 minutes. With the procedural steps in place, the experiment began with an essential calibration phase and the setup of eye-tracking equipment to capture participants' gaze behavior.

The experiment commenced with a 9-point calibration, followed by the training session, and eye movement recording took place from the beginning of training to the end of the experiment. The participants' eye gaze was recorded using a Tobii Pro X3-120 infrared eye-tracking camera operating at 120 hz, connected to a computer running Tobii StudioTM (v3.4.8) for data recording and analysis. The Regions of Interest (RoI) were identified in the videos and corresponded to the areas of the screen depicting the transitive and reflexive events. After data collection, we proceeded to the analysis.

Table 2. List of experimental sentences.

Grammatical SVO sentences	ʔel-kalb besayyeʕ leħma:r. 'The dog PSEUDO-VERB the donkey.' ʔel-ʔasad besayyeʕ leħsˁa:n. 'The lion PSEUDO-VERB the horse' ʔel-baqara betsayyeʕ ʔel-xaru:f. 'The cow PSEUDO-VERB the sheep.'
Ungrammatical SOV sentences	ʔel-baqara ʔel-ʔasad btemraʃ. 'The cow the lion PSEUDO-VERB' leħma:r ʔel-kalb bemraʃ. 'The donkey the dog PSEUDO-VERB' ʔel-xaru:f leħsˁa:n bemraʃ. 'The sheep the horse PSEUDO-VERB'

Abbreviations: SVO = subject, verb, direct or indirect object.

2.2.4. Data analysis

The analysis included only infants with a gaze sample percentage of 55% (following Franck et al., 2013. The analysis plan was identical to that of the previous eye-tracking studies within this paradigm (Franck et al. 2013, Zhu et al. 2022). The data analysis was conducted with R, version 4.0.4. Mean comparison was performed using bivaried paired student t-tests and non-parametric Wilcoxon signed-rank tests, while total fixation duration was assessed using Linear mixed-effects models, which are suitable for analyzing continuous variables, employing the lme4 package in R (Bates et al. 2015). The dependent variable was the total fixation duration in milliseconds for each trial. Fixed effects comprised Scene (transitive and reflexive), Window (Baseline Sentence, Sentence 1, Sentence 2, Sentence 3) and their interaction. The full model included a random intercept for subject and a random slope for items within subjects, which allows us to account for individual differences in baseline responses while also capturing variability in how participants respond to different items (Formula in R: Fixation ~ Scene*Window+ (1|Subject)+ (1+Items|Subject)). Then we explored the effect of age in months (as continuous variable) and vocabulary (both production and comprehension, as continuous variable) on windows that showed a significant effect of Condition with the total fixation time as dependent variable and Condition, Vocabulary, Age and their interactions as factors (Formula in R: Fixation ~ Condition*CDI comprehension*CDI production*Age+ (1|Subject)+ (1+Items|Subject)).

Additional analyses were conducted to assess proportional looking time. The proportion of looking time at the transitive scene (calculated over the total looking time to the transitive and reflexive videos) was also calculated and compared to chance level (defined as 50%) using the nonparametric Wilcoxon signed-rank test. Proportions of fixation, which range from 0 to 1, follow a multinominal distribution rather than a normal distribution. Consequently, traditional linear mixed-effects or ANOVA methods based on normal distribution cannot be applied directly. Therefore, we employed generalized linear mixed models (GLMMs), which do not require a normal distribution (Bolker et al. 2009), with the proportion of looking time to the transitive scene as a dependent variable and the four windows (Baseline, Sentence 1, Sentence 2, Sentence 3) and condition (grammatical, ungrammatical) as factors with participants and items as random effects. The model utilized the 0- to 4-second window as a baseline to estimate the evolution of looking preferences in subsequent intervals. This baseline enabled us to evaluate changes in preferential looking attributable to the introduction of the linguistic stimuli, excluding extraneous preferences. Finally, we also explored the effect of age and vocabulary on proportions of fixations to the transitive video using generalized linear models on ROIs that showed a significant effect of Condition.

2.3. Infants

2.3.1. Participants

Data were collected in Palestine from thirty-five healthy infants, 18 boys and 17 girls, aged 1;3 to 1;7 (Mean age in months 17.6, SD = 1.4). We used a parental questionnaire, specifically designed for our study, which assessed the infants' developmental milestones and medical history, and was administered prior to the commencement of the study. All participants were exposed to Palestinian Arabic. Children with a history of language delay, language disorders, hearing loss or congenital malformations were excluded from the study. Eleven participants were excluded due to either a low percentage of gaze sample (lower than 55%) (9 infants) or technical failure (2 infants); as a result, the results of 24 participants were analyzed. This falls within the usual sample size for this kind of experiment.

The Arabic Communicative Development Inventory (Arabic CDI-Words Only; Abdelwahab et al. 2021) is an online standardized parental assessment tool to screen language development in children between 0;8 and 2;6. It includes 100 standard words whose comprehension and production are

assessed; the maximum score is therefore 100. It was used to assess the language development of the infants, to ensure that there were no signs of language impairment. The CDI scores were also used to measure the effect of vocabulary size on the children's performance. The infants who took part in the experiment had an age range of 1;3 to 1;7, with a mean comprehension in the CDI of 43.1 words (SD = 14.3), and a range of 24 to 73 words, and a mean production of 14.9 words (SD = 6), and a range of 3 to 29 words.

2.3.2. Results

The mean looking time to each scene (transitive and reflexive) of both conditions (grammatical and ungrammatical) of each of the four windows (Baseline, Sentence 1, Sentence 2 and Sentence 3) were taken into account as presented in Table 3.

Paired t tests were used on mean looking time. Results revealed that infants looked significantly longer to the transitive action in the grammatical condition in the second presentation of the sentence ($t(53) = 2.04$, $p = .047$, $d = .28$). No significant preference was found in the baseline, nor on the first or the third presentations of the grammatical sentence. No significantly longer looks at any video were found in the ungrammatical condition either. These results were confirmed by Linear mixed-effects models that found a significant effect of scene after the second presentation of the sentence ($\beta = 571$, $SE = 220$, $t = 2.59$, $p = .01$). Linear mixed-effects models ran on the second window showed a significant effect of condition, no main effect of age ($p = .73$), no interaction between condition and age ($p = .91$), nor condition and CDI production score ($p = .89$), nor condition and CDI comprehension score ($p = .87$). Besides, the Four-way interaction, which refers to the interaction between condition, age, and vocabulary (both production and comprehension) was not significant either ($p = .85$). Their lack of significance suggests that the effect does not depend on age, nor on vocabulary production or comprehension scores.

The proportions of total fixation time to transitive scenes over the transitive and reflexive scenes was calculated in the four windows. As shown in Figure 3, the preference for the transitive over the reflexive scene in the grammatical condition emerges in the first presentation (mean = .5811), increases at the second presentation (mean = .6108), and peaks in the third presentation of the test sentence (mean = .6591).

The proportions of total fixation time to transitive scenes over the transitive and reflexive scenes were computed using the Wilcoxon signed-rank test. The analysis against chance level reveals a significant preference for the transitive over the reflexive scenes in the second ($Z = -2.04$, $p = .041$, $r = .28$) and third ($Z = -3.13$, $p = .002$, $r = .43$) presentations of the grammatical sentence. In the ungrammatical condition, there was no significant preference for the transitive scenes in any of the four frames ($p > .05$).

A main effect was only found for grammatical conditions using GLMMs. Hearing grammatical sentences triggered more fixations on the transitive scene ($\beta = .18$, $SE = .09$, $z = 2.03$, $p = .042$) during the second presentation of the sentence. However, no significant effects were found in the ungrammatical condition ($p = .31$). This indicates that infants did not show a preference for either scene when exposed to ungrammatical sentences. Then, we explored the effect of age and vocabulary on

Table 3. Mean looking time in ms across the four time windows of the transitive and transitive scenes in the grammatical and ungrammatical, infants.

	Grammatical		Ungrammatical	
	Transitive	Reflexive	Transitive	Reflexive
Baseline (0-5s)	6204 (1936.5)	5046 (1743.9)	6204 (1730.7)	5949 (2040)
Sentence 1 (6-11s)	5093 (1693.9)	4770 (1413.4)	4217 (1602)	5084 (1568.2)
Sentence 2 (12-17s)	**4517 (1697.9)***	3849 (1126.3)	5310 (1562.9)	3377 (1201.5)
Sentence 3 (18-23s)	5414 (1352.5)	4765 (895.3)	5266 (1464.7)	3981 (1123.8)

Standard deviations in parenthesis.
*p <.05 (in bold).

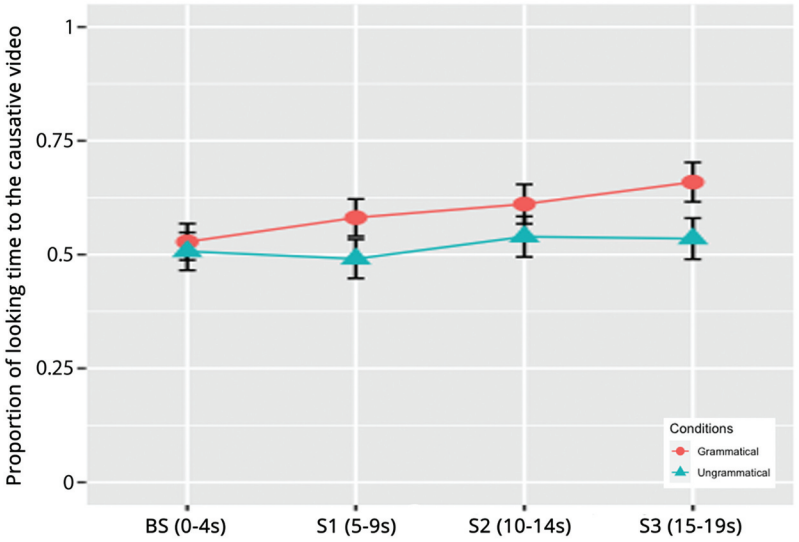

Figure 3. Proportions of looking time to the transitive scene in the four windows, children. **Abbreviations**: BS, Baseline Sentence; S1, Sentence 1; Sentence 2; Sentence 3.

proportions of fixation to the transitive video using generalized linear models on the windows that showed a significant effect (i.e., Sentence 2 in the grammatical condition), and we found no main effect of age (p = .43), no main effect of CDI Comprehension score (p =. 14), nor CDI production score (p = .99). This confirms again that the increased preference found for the transitive video over the reflexive video when a grammatical sentence is presented is independent from age and vocabulary.

2.4. Adults

2.4.1. Participants

The adult participants were twenty native Palestinian Arabic speakers with a mean age of 35 years (age range = 18-65, SD = 13.6) recruited in the west bank in Palestine. The materials and procedure were the same as those employed with infants (except for the fact that adults were sitting individually). The data analysis was the same as the one conducted on the infants' data.

2.4.2. Results

The mean looking time in milliseconds across the four frames of the transitive and reflexive scenes in both conditions (grammatical and ungrammatical) for adults is presented in Table 4.

Paired t-tests were conducted on mean looking time, revealing that adults looked significantly longer to the transitive action in the grammatical condition during the first ($t(117) = 24.87$, $p < .001$,

Table 4. Mean looking time in ms across the four time windows of the transitive and reflexive scenes in the grammatical and ungrammatical, adult.

	Grammatical		Ungrammatical	
	Transitive	Reflexive	Transitive	Reflexive
Baseline (0-5s)	**2510.6 (966.9)*** **	1828.9 (793)	2048.9 (974.2)	2360.3 (1031.1)
Sentence 1 (6-11s)	**3670.4 (1011.4)*** **	827 (665)	2520.4 (16291.6)	1881.5 (1482)
Sentence 2 (12-17s)	**3988.6 (1284.9)*** **	345.8 (396.5)	**3071.3 (2037.1)*** **	1362.8 (1538)
Sentence 3 (18-23s)	**3997.5 (1308.3)*** **	345.8 (407.2)	**2910 (2216.9)*** **	1391.6 (1750.4)

***$p < .001$ (in bold)

Cohen's d = 3.32), second (t(117) = 27.22, p < .001, Cohen's d = 3.83), and third presentations of the grammatical sentence (t(117) = 26.68, p < .001, Cohen's d = 3.80), as well as in the baseline window (t (117) = 5.61, p < .001, Cohen's d = .77). Adults also looked significantly longer to the transitive action in the ungrammatical condition, but only during the second (t(59) = 3.95, p < .001, Cohen's d = .95) and third (t(59) = 3.22, p = .002, Cohen's d = .76) presentations of the ungrammatical sentence.

The calculation of the proportions of total fixation time on transitive scenes (over transitive and reflexive scenes) indicated a significant preference for transitive over reflexive scenes in the grammatical condition during the three presentations of the grammatical sentence (Mean Sentence 1 = .819, Mean Sentence 2 = .906, and Mean Sentence 3 = .885, respectively), as well as in the baseline (Mean = .5786). In the ungrammatical condition, a significant preference for transitive scenes emerged during the second and third presentations of the ungrammatical SOV sentence (Mean Sentence 2 = .665, and Mean Sentence 3 = .697, respectively).

While an unexpected significant preference was observed in the baseline, the difference in preference for the transitive scene notably increased during the three presentations of the grammatical sentence. In contrast to children, adults also demonstrated a willingness to interpret ungrammatical sentences, as shown in Figure 4.

The calculation of the proportions of total fixation time to transitive scenes (over the transitive and reflexive scenes) against chance level (50%) reveals a significant preference for the transitive over the reflexive scenes in the grammatical condition in the three presentations of the sentence (Z = -5.540, p = .00, r = .71; Z = -6.08, p = .00, r = .78; and Z = -5.153, p = .00, r = .66 respectively). During the ungrammatical condition, adults showed a significant preference for the transitive scenes in the second and third presentation of the ungrammatical SOV sentence (Z = -3.39, p = .001, r = .44; and Z = -3.60, p = .00, r = .46, respectively).

3. Discussion

Replicating the method of Franck et al. (2013), we conducted experiments with 17-month-old native Palestinian Arabic infants using eye tracking techniques, as well as a group of adult speakers. The study involved testing both grammatical SVO and ungrammatical SOV sentences featuring pseudo-verbs. The findings revealed a significant preference among Palestinian Arabic infants for scenes illustrating

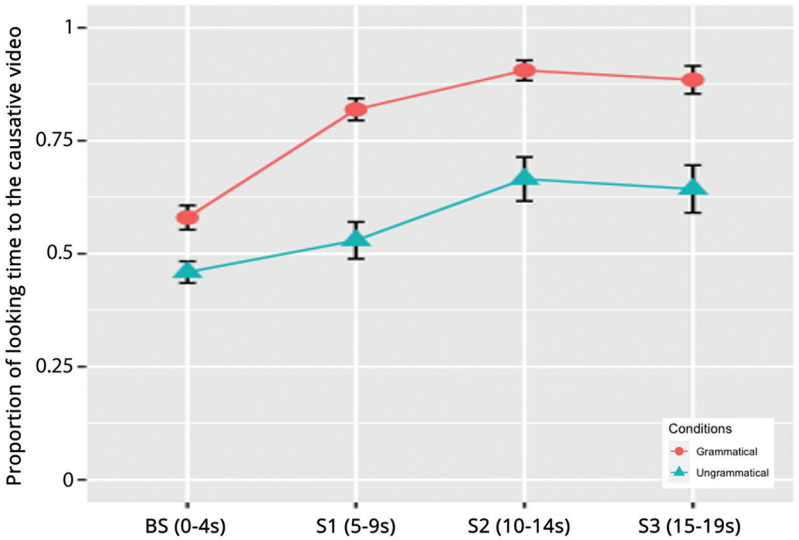

Figure 4. Proportions of looking time to the transitive scene in the four windows, adults. **Abbreviations**: BS, Baseline Sentence; S1, Sentence 1; Sentence 2; Sentence 3.

transitive events when exposed to grammatical SVO sentences during the second presentation of the sentence. However, no significant effects were found in the baseline window nor in any of the windows of the ungrammatical SOV condition. The effect was significant only in the 10-14s window (i.e., the second presentation of the sentence), which seems to indicate that we are seeing the initial emergence of these abilities. The relative weakness of the effect may have to do with the fact that infants often lose interest in the stimuli on the third presentation, and so finding a random behaviour on the third presentation is not surprising. Importantly, the effect found on the second window is absent when ungrammatical sentences are presented, which means that the infants are sensitive to the grammatical structure of the sentences they hear. This sensitivity indicates early language processing. Admittedly, as pointed out by an anonymous reviewer, there were a relative high number of excluded participants. The reasons for exclusion included looking outside the Region of Interest or having a participant's eyelids closed due to a blink. Using infant seats might have reduced data loss, but infants generally exhibit more natural behavior when seated on their mother's lap, which also allows for greater freedom of movement (Hessel et al. 2015). We see no reason to think that our results are biased because of the number of excluded participants.

Similar results were observed in Palestinian Arabic-speaking adults, who exhibited prolonged gaze time at transitive scenes in response to grammatical sentences. Interestingly, adults also directed their attention to transitive scenes in the case of ungrammatical SOV sentences, a behavior not observed in infants. Based on our analysis of the Palestinian Arabic corpus and in consonance with previous studies (Shlonsky 1997, Maamouri 1998, Saiegh-Haddad 2003 for Palestinian Arabic), when subject and object are present, SVO is the predominant order in Palestinian Arabic with transitive verbs, but adults appear to be willing to assign an interpretation to the ungrammatical SOV sentences in our study. In the case of SOV, it took longer for adults to fixate on the target video (from the first presentation to the second presentation of the sentence), and therefore there was a latency. This latency in the SOV condition is consistent with the idea that SVO is the preferred order in Palestinian Arabic. Even if with a latency, the preference for transitive scenes in the ungrammatical condition may be expected if the performance of adults, whose advanced cognitive and linguistic capabilities equip them with extensive knowledge, is not guided by word order alone. Furthermore, in Palestinian Arabic, verbs are highly inflected, agreeing with the subject in number, gender, and person. Inflection may therefore induce adults to assign an interpretation to an ungrammatical sequence. Few studies have reported adult performance in the kind of study reported; the study of Zhu et al.'s (2022) on Mandarin is the only published result. Mandarin-speaking adults exhibited a significant preference for the transitive video during the three presentations of grammatical sentences ($p < .001$ each), but no such preference was observed in the ungrammatical condition. This contrasts sharply with what happened in the experiment conducted with Palestinian Arabic-speaking adults. We can only speculate that SOV with animate DPs is more markedly ungrammatical in Mandarin than it is in Palestinian Arabic.

Comparing our results with previous studies within the same framework, our findings align with the results for French (Franck et al. 2013), Hindi-Urdu (Gavarró et al. 2015), and Mandarin Chinese (Zhu et al. 2022). Despite differences in video length and frame count across the studies, as well as crosslinguistic variation (VO vs. OV), certain observations can be made. Notably, the emergence of the preference for transitive scenes in the grammatical condition varied, with Palestinian Arabic displaying a later effect compared to Hindi-Urdu (where the effect was significant in the 6-10 second window) and Mandarin (where it appeared in the 5-9 second window) but occurring earlier than in French (where the effect emerged in the 12-16 second window). This may relate to the younger mean age of the infants tested in Palestinian Arabic (age range: 1;3 to 1;7) compared to those in Hindi-Urdu (age range: 1;7-1;8). However, the effect also appeared later in French, despite the infants being order (age range: 1;7-1;8), and our results are also weaker than in Mandarin, even though in that study infants had a mean age of 1;5 (age range:1;1-1;9). Some crosslinguistic differences exist between Palestinian Arabic and Mandarin, with the first being a highly inflected language (with subject-verb agreement for person, number

and gender), and Mandarin showing no morphological variation, neither in the verbal nor in the nominal domain. However, there seems to be no reason why these differences would make us expect different performance in comprehension at 17 months. Moreover, the difference in the results for the two languages is not categorical: we only have a difference in terms of the strength of the response, but the pattern is the same. Our results are not in line with those of Candan et al. (2012), who argued for crosslinguistic differences being at the source of earlier or later comprehension. It appears that there is insufficient evidence to support a cross-linguistic difference in the emergence of early syntax in terms of fundamental macroparameters or features. This holds true for languages such as Palestine Arabic, Mandarin, French, and Hindi-Urdu, despite differences in word order, morphological system, case marking, and the presence or absence of null arguments. Future research on a wider variety of languages should shed light on this issue.

In terms of vocabulary comprehension and its putative relation to syntactic development, Palestinian Arabic vocabulary scores (53, range = 30-73) were higher than those for Mandarin Chinese (43, range = 0-102) but lower than for French (87, range = 8-389). Interestingly, no correlation between vocabulary size and comprehension was identified, consistent with findings in Mandarin, where the relation was explored. The lack of an age and vocabulary size effect implies that knowledge of VO is established earlier than 17 months of age; otherwise, we would expect a heterogeneous behavior determined by language development —conclusion already reached by Zhu et al. (2022).

In addressing the question of whether infants in the age range of 1;3 to 1;7 possess abstract syntactic representations of word order, our results argue against a usage-based analysis (Tomasello 1992, 2000, 2003; see also McCauley & Christiansen 2019 for a recent study). The absence of lexical knowledge ensured by the use of pseudo-verbs suggest that infants' parsing of VO order indicates the presence of abstract knowledge; the fact that infants ignore ungrammatical SOV sequences also argues for the presence of abstract representations. We have shown that the acquisition of word order begins well before infants have built a sizeable lexicon (mean comprehension: 43 words), and this knowledge is sufficiently abstract to allow infants to parse sentences with pseudoverbs, so that they are not acting in a piecemeal fashion. Furthermore, just like Franck et al. (2013), Gavarró et al. (2015), and Zhu et al. (2022), our study refutes the claim that infant comprehension is based on an AGENT-first strategy (Bates & MacWhinney 1982, Lidz et al. 2001), as infants in our experiment displayed differential behavior in SVO and SOV, despite both experimental sentences being AGENT-first.

4. Conclusions and future research

In summary, this study aimed to explore the early acquisition of word order in Palestinian Arabic before the onset of the two-word production stage in infants with a mean age of 1;5. Utilizing the preferential-looking paradigm and pseudo-verbs, we investigated the VO/OV alternation. The experimental findings indicate that infants within the age range tested have established a value for the VO parameter, with no significant impact observed based on age or vocabulary size. This suggests that knowledge of VO is acquired before 1;5. Let us stress that our experiment involved infants with a mean age of 1;5, younger than in most VO/OV studies using the preferential looking paradigm with the exception of Zhu et al. (2022). While effects were comparatively weaker than in Mandarin, with significantly longer looks to the target observed only in one window, they remain consistent with Very Early Parameter Setting (Wexler 1998). The reason for the weaker effect found in Palestinian Arabic requires further investigation. The results do not support item-based accounts of language acquisition, nor an AGENT-first strategy as guiding infant comprehension. Rather, they add to the existing literature on the setting of the VO/OV parameter for French, Hindi-Urdu and Mandarin in showing knowledge of language-specific grammatical features. Future investigation should address one limitation of the study, namely the narrow age range tested; to consider the relation between the setting of the VO parameter and vocabulary development, one would need participants in a wider age range; while extending the age range at the older end is not problematic, extending it to younger infants presents a serious methodological challenge. Beyond acquisition, we found that Palestinian adults, unlike

Mandarin adults, interpreted ungrammatical SOV sequences. Investigating whether this relates systematically to the grammar of these languages also remains for future research.

Ethical considerations

The present study was approved by the Comissió d'Ètica en l'Experimentació Animal i Humana of the Universitat Autònoma de Barcelona, CEEAH approval number CA23.

Data availability statement

Raw data were generated and are available on the OSF website at https://osf.io/qfd5b/?view_only=f0083c01344b4d3c8ee09d36aaa0320e. Derived data supporting the findings of this study can be obtained from the corresponding author upon request.

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Disclosure statement

No potential conflicts of interest are reported by the authors(s).

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Appendix

Phase		Audio
Familiarization	Character identification	ʃu:f, mi:n fi: ho:n? ha:d ʔel-kalb. 'Look, who's here? It's the dog' ʃu:f, mi:n ha:d? ha:d leħma:r. 'Look, what's this? It's the donkey' ʔetˤtˤalaˤ, ʃa:yef mi:n fi: ho:n? ha:d ʔel-ʔasad. 'Look, do you see who's here? It's the lion' ʃu:f, mi:n ho:n? ha:d leħsˤa:n. 'Look, who's here? It's the horse' ʃu:f, mi:n ho:n? hay ʔel-baqara. 'Look, who's here? It's the cow' ʔetˤtˤalaˤ, ʃa:yef mi:n fi: ho:n? ha:d ʔel-xaru:f. 'Look, do you see who's here ? It's the sheep'
	Simultaneous presentation	ʃu:f, ʃa:yef ʔel-kalb? we:n ʔel-kalb 'Look do you see the dog? Where is the dog?' ʃu:f, ʃa:yef leħma:r? we:n leħma:r? 'Look do you see the donkey? Where is the donkey?' ʃu:f, ʃa:yef ʔel-ʔasad? we:n ʔel-ʔasad? 'Look do you see the lion? Where is the lion?' ʃu:f, ʃa:yef leħsˤa:n? we:n leħsˤa:n? 'Look do you see the horse? Where is the horse?' ʃu:f, ʃa:yef ʔel-baqara? we:n ʔel-baqara? 'Look do you see the cow? Where is the cow?' ʃu:f, ʃa:yef ʔel-xaru:f? we:n ʔel-xaru:f? 'Look do you see the sheep? Where is the sheep?'
	The novel actions	ʔetˤtˤalaˤ, ʃu: bsˤi:r? 'Look, what is happening?'
Testing	Grammatical sentences (SVO)	ʔel-kalb besayyeˤ leħma:r. 'The dog PSEUDO-VERB the donkey.' ʔel-ʔasad besayyeˤ leħsˤa:n. 'The lion PSEUDO-VERB the horse.' ʔel-baqara betsayyeˤ ʔel-xaru:f. The cow PSEUDOV-f the sheep.'
	Ungrammatical sentences (SOV)	ʔel-baqara ʔel-ʔasad btemraʃ 'The cow the lion PSEUDO- leħma:r ʔel-kalb bemraʃ. 'The donkey the dog PSEUDO-VERB.' ʔel-xaru:f leħsˤa:n bemraʃ 'The sheep the horse PSEUDO-VERB

Abbreviation: S = subject; V = verb; O = direct or indirect object.