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ARTICLE

Verb-based prediction during language processing: the case of Dutch and Turkish

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Abstract

This study investigated whether cross-linguistic differences affect semantic prediction. We assessed this by looking at two languages, Dutch and Turkish, that differ in word order and thus vary in how words come together to create sentence meaning. In an eye-tracking task, Dutch and Turkish four-year-olds ($N = 40$), five-year-olds ($N = 58$), and adults ($N = 40$) were presented with a visual display containing two familiar objects (e.g., a cake and a tree). Participants heard semantically constraining (e.g., "The boy eats the big cake") or neutral sentences (e.g., "The boy sees the big cake") in their native language. The Dutch data revealed a prediction effect for children and adults; however, it was larger for the adults. The Turkish data revealed no prediction effect for the children but only for the adults. These findings reveal that experience with word order structures and/or automatization of language processing routines may lead to timecourse differences in semantic prediction.

Introduction

Spoken language unfolds incrementally and at a fast pace. Children and adults typically have little difficulty accurately recognizing words in running speech (e.g., Allopenna, Magnuson, & Tanenhaus, 1998; Swingley, Pinto, & Fernald, 1999). One of the mechanisms responsible for this is prediction. Behavioural and neuropsychological studies have shown that both children (e.g., Borovsky, Elman, & Fernald, 2012; Friedrich & Friederici, 2005; Mani & Huettig, 2012; Nation, Marshall, & Altmann, 2003) and adults anticipate upcoming input during language comprehension (e.g., Altmann & Kamide, 1999; van Berkum, Brown, Zwitserlood, Kooijman, & Hagoort, 2005). However, less is known about whether cross-linguistic differences affect predictive processing. The aim of the current study is to address this gap in the literature by looking at two languages that differ in word order (Dutch vs. Turkish) and thus vary in how words come together to create sentence meaning.

A frequently used technique to examine semantic prediction during language processing is eye-tracking (Cooper, 1974; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). Using the Visual World Paradigm (VWP), participants' eye-movements to pictures on a visual display are recorded while they listen to sentences. Previous work has shown that adults and children look at the target object before the target word is uttered entirely (e.g., Allopenna *et al.*, 1998; Swingley *et al.*, 1999) or even before the target word is produced (e.g., Altmann & Kamide, 1999; Fernald, Zangl, Portillo, & Marchman, 2008; Mani & Huettig, 2012). Altmann and Kamide were the first to show that adults predict upcoming information during sentence comprehension. They presented semantically constraining sentences such as *The boy will eat the big cake* and neutral sentences such as *The boy will move the big cake* to participants, while they were viewing a display with objects (a boy, a cake, and some distractors). Their findings revealed that adults fixated the cake during the verb *eat* (vs. *see*) and prior to hearing the target word *cake.* Fernald *et al.* (2008) replicated this work by presenting similar types of sentences and two pictures on the screen to two-year-old children. The two-year-olds also looked at the target before it was heard in semantically constraining sentences. These studies demonstrate that both adults and children can use the semantic meanings of verbs to correctly predict an upcoming noun before it is heard.

Most of the studies mentioned above investigated languages in which the subject typically occurs prior to the verb while the object typically appears after it (Dryer, 2011). In such Subject–Verb–Object (SVO) languages, it is therefore not surprising that both adults and children effectively make use of verb information to predict upcoming referents. Users of SVO languages like English are used to having strict word order constraints. Therefore, the semantics of the verb and the order of the nouns demonstrate the role that each noun plays in a sentence. For example, in example (1) an English speaker would know that *the boy* is the agent of the verb *eat* and that what will follow is the patient (i.e., something edible).

(1) The boy eats the …

While about 35% of the languages in the world have SVO word order, around 42% have a canonical word order in which the verb follows its object (Dryer, 2011). These Subject–Object–Verb (SOV) languages are often characterized by flexible word order and the use of case to identify the role of each noun in a sentence. An example of such a language is Turkish. Although this language has a flexible word order, the most typical order is SOV (Erguvanlı, 1984). This pattern was also found in a corpus of Turkish child-directed speech (Slobin & Bever, 1982). In this corpus, five different words orders were detected but the SOV order was the dominant one accounting for about 48% of the speech data. Example (2) illustrates this predominant word order in Turkish.

(2) Çocuk keki yiyor
boy_{NOM} cake_{ACC} eats
'The boy eats the cake'

Dutch is also considered an SOV language, but combined with verb-second (V2) word order in main clauses (Zwart, 2011). V2 word order is a specific constraint on the position of the finite verb within a sentence (see (3)). Non-finite verbs and compound verbs, however, follow an SOV pattern in embedded clauses (see (4)). In this case, the finite verb (*have*) has been moved to second position and the non-finite verb (*eat*) remains in final position.

(3) De jongen eet de tart
The boy eats the cake
(4) De jongen heeft de taart gegeten
The boy has the cake eaten
'The boy has eaten the cake'

Children's development of word order has mostly been studied using off-line measurements (e.g., Akhtar & Tomasello, 1997; Gertner, Fisher, & Eisengart, 2006). In such studies, children listen to sentences with different word orders (canonical and non-canonical), and they subsequently need to perform an action (e.g., acting out the sentence or pointing to the picture that matches the sentence). This type of research has shown that children around the age of three years have acquired the canonical word order of their language (e.g., Candan, Küntay, Yeh, Cheung, Wagner, & Naigles, 2012; Slobin & Bever, 1982; see Küntay & Özge, 2014, for a review).

Only a few studies have looked at whether users of languages with flexible word order are able to use morphosyntactic information to predict upcoming elements in a sentence (on adults: Kamide, Altmann, & Haywood, 2003a; Kamide, Scheepers, & Altmann, 2003b; on children: Özge, Küntay, & Snedeker, under review; Özge, Marinis, & Zeyrek, 2013). For example, Kamide *et al.* (2003a) showed that Japanese adult speakers, whose canonical word order is SOV, used case marking to determine the next, upcoming referent.

Similarly, Özge *et al.* (under review) conducted two visual world paradigm experiments with four- and five-year-old Turkish children and adults. In their Experiment 1, they investigated whether Turkish participants were able to use the contrast between the nominative and the accusative case on the first argument to predict the thematic role of the second argument before it became available in verb-medial structures (i.e., SVO vs. OVS). In their Experiment 2, they used verb-final structures (i.e., SOV vs. OSV) to further test whether Turkish children could anticipate the second argument prior to the verb information. Their results showed that children, like adults, could use case marking on a noun to predict an upcoming referent in both verb-medial (Experiment 1) and verb-final (Experiment 2) structures. Moreover, Özge *et al.* (2013) investigated how adults processed word order variation online in a self-paced listening paradigm. Their goal was to examine whether object-initial sentences would pose any processing difficulty in verb-medial orders (i.e., OVS and SVO). Their results showed that a sentence-initial object NP did not pose extra processing costs compared to a sentence-initial subject NP. Instead, they showed that sentence-initial objects (OVS) were even processed faster than sentence-initial subjects (SVO). Processing of the verb in both sentence structures did not reveal any significant differences. And finally, the object following the SV string was processed faster than the subject following the OV string. The authors argued that the speed of this integration process depended on the frequency (i.e., subject drop occurs frequently in Turkish) and reliability (i.e., accusative case) of the linguistic structure.

In sum, the studies above demonstrated that speakers of languages like Turkish are adept at incremental interpretation of language based on reliable cues such as case (which cannot be purely formal, but in fact does map fairly transparently onto thematic roles). However, to our knowledge, it is unknown whether Turkish children and adults use the semantics of a verb as a cue to sentence meaning, as they rarely need to (at least in comparison to speakers of languages like Dutch and English). The current study will therefore investigate how MEANING is assigned incrementally during the interpretation of Turkish, a language with flexible word order. The current study examines whether Dutch and Turkish adults and children are able to use the semantics of the verb to predict the upcoming noun. We presented our participants with a similar visual world eye-tracking task to that of Mani and Huettig (2012). Participants saw a visual display containing two familiar objects (e.g., a cake and a tree) and, depending on their native language, they heard a semantically constraining sentence such as *De jongen eet de grote taart* or *Çocuk yiyor bu büyük keki* 'The boy eats the big cake', or a neutral sentence such as *De jongen ziet de grote taart* or *Çocuk görüyor bu büyük keki* 'The boy sees the big cake', while we tracked their eye-movements across the visual display.

Note that the auditory sentences contained only finite verbs. This restricted the Dutch sentences to (the fixed) SVO word order. We predict that the Dutch participants, both adults and children, will show a clear semantic prediction effect (i.e., more looks to the target *cake* in the semantically constraining than in the neutral condition) over time, replicating previous work (e.g., Altmann & Kamide, 1999; Mani & Huettig, 2012). Within the Dutch participants, we expect that this prediction effect will become stronger with age due to increased familiarity with the word order structure. That is, we predict that adults will show a larger effect over time (i.e., as the sentence unfolds) than the five-year-old children who, in turn, will show a larger effect over time than the four-year-olds.

For the Turkish participants, the sentences were also always presented in SVO word order. This structure is less frequently used in Turkish, as the typical, most frequent word order is SOV, and the verb thus usually arrives late in this language. We therefore predict different patterns for the Turkish than the Dutch participants. We expect that Turkish adults will show a prediction effect over time (i.e., as the sentence unfolds), as they have encountered the SVO structure throughout their lives and they know that this is an acceptable, though less frequent, structure. We also expect that frequency and reliability will play a role in prediction because they have been found to facilitate the processing of sentence-initial and (specifically) sentence-final objects, as opposed to subjects (Özge *et al.*, 2013). It is therefore possible that Turkish children will make less or no use of verb-based prediction, as they have less experience with the SVO structure, compared to Turkish adults. We thus predict an asymmetry between Turkish adults and children in terms of their semantic prediction skills.

Method

Participants

All participants were native speakers of Dutch or Turkish. Three age groups (four-year-olds, five-year olds, and adults) took part in this study, resulting in six groups. Table 1 illustrates an overview of the characteristics of each group. All participants were without any hearing problems and had normal, or corrected-to-normal, vision. Adults were paid for their participation. For the children, parents gave informed consent, and children were compensated with a toy.

Material

Dutch and Turkish stimuli were created for the Dutch and Turkish experiment, respectively (see also Brouwer, Özkan, & Küntay, 2017, for the Dutch stimuli). Each

Table 1. Characteristics of the Participant Groups

Group	N	M_{AGE}	SD_{AGE}	Gender
Dutch adults	20	22	2;9	16 F, 4 M
Turkish adults	20	24	2;6	17 F, 3 M
Dutch children				
4-year-olds	20	4;5	0;3	12 F, 8 M
5-year-olds	39	5;4	0;4	15 F, 24 M
Turkish children				
4-year-olds	20	4;4	0;3	9 F, 11 M
5-year-olds	19	5;3	0;3	10 F, 9 M

experiment consisted of 24 displays with two coloured line-drawings. These visual displays were paired either with a semantically constraining sentence as in (5) (semantic condition) or with a neutral sentence as in (6) (neutral condition). The two objects corresponded to the target (e.g., *taart*, *kek* 'cake') or a distractor (e.g., *boom, ağaç* 'tree').

(5) De jongen eet de grote taart [semantic condition]
Çocuk yiyor bu büyük keki
'The boy eats the big cake'
(6) De jongen ziet de grote taart [neutral condition]
Çocuk görüyor bu büyük keki
'The boy sees the big cake'

Female native adult speakers of Dutch and Turkish recorded the test sentences (16 bits, 44100 Hz). For both languages each sentence consisted of a noun phrase, a verb, and a determiner–adjective–noun combination. The lengths of the different constituents in each sentence were measured in PRAAT (Boersma & Weenink, 2015). Both the Dutch and Turkish auditory stimuli were then minimally manipulated in PRAAT to adjust the duration of the region from verb onset until noun onset to 2400 ms. These stimuli were normalized to the same average level of 65 dB. The Dutch and Turkish sentences resembled each other as closely as possible, but in some cases a direct translation was not possible, largely due to a mismatch in the number of syllables between the translation pairs in the two languages. For instance, the adjective *rode* 'red' is a disyllabic word in Dutch, whereas its Turkish translation *kırmızı* contains three syllables. Therefore, a different adjective *beyaz* 'white' was used for the Turkish correspondent of the stimulus. In other cases, the translation pairs differed in number of words. This was primarily problematic for some verbs. Similarly to the adjectives, a different verb is preferred for cases where the Turkish translation corresponded to a noun–verb compound (e.g., *yardım etmek* 'to (do) help' was replaced with *bakmak* 'to look') (see 'Appendix'). The words used in the sentences were highly familiar to four- and five-year-olds (as based on a Dutch wordlist for four- to six-year-olds by Damhuis, de Glopper, Broers, & Kienstra, 1992). The target–distractor pairs never overlapped phonologically at onset and were equal in frequency.

Eight filler items were created for motivational purposes. They encouraged the children during the task (e.g., "you are doing a great job!"). Four different lists were created in which target position (left vs. right) and sentence (semantic vs. neutral) were counterbalanced. In each list the semantic, neutral, and filler trials were presented pseudo-randomly.

Norming task

Prior to the study, we conducted a norming study to evaluate whether our verbs predictively elicit the nouns to be tested. Twenty-four Dutch and 24 Turkish adults were asked to judge which would be a likely target when given the sentence beginning of their native language (e.g., "The boy eats the nice …"). Participants had to choose between two alternatives, which were the target and distractor presented in the eye-tracking experiments (e.g., 'cake' and 'book'). Performance on the semantic sentences was very high (99% correct for Dutch adults; 94% correct for Turkish adults), showing that our sentences effectively created semantically predictable contexts.

Procedure

For the Dutch children and adults the experimental session took place in a lab at Utrecht University. For some Dutch children the session took place at a Dutch primary school. For the Turkish children and adults the session took place in a lab at Koç University, Istanbul. For some Turkish children the session took place at a preschool. The Dutch children and adults sat in front of the screen of a Tobii T60 and the Turkish children and adults performed the eye-tracking task on a Tobii T120. However, we fixed the sampling rates to be the same across language groups. That is, we sampled the data at 60 Hz for both Dutch and Turkish participants. Stimuli were presented using E-Prime software. Before the start of the experiment, a 9-point calibration procedure was performed. Before each trial, children were shown a fixation cross in the middle of the screen, which they were instructed to fixate on before every trial (drift correction). Children were told that they would be seeing two pictures on the screen while hearing sentences. Their task was to listen carefully to these sentences, and to look at the pictures. The two pictures were shown 2000 ms before sentence onset and they remained on screen until sentence offset. The session lasted about 15 minutes.

Results

Figure 1 shows the proportion fixations to targets from verb onset for Dutch and Turkish adults and children (four- and five-year-olds). Numerically, all groups looked more at targets in the semantic than in the neutral condition. This pattern started during the unfolding of the verb. However, it is uncertain whether this numerical pattern holds statistically.

To assess whether the two curves that represent proportion fixations to targets in the semantic and the neutral condition differ statistically from each other over time across the different age groups, we used Generalized Additive Mixed Modeling (GAMM; Wood, 2006). GAMM is an extension of a generalized linear regression model in which non-linear terms (i.e., smooths) can be included besides linear relationships between predictors and the dependent variable. The smooth function is a weighted

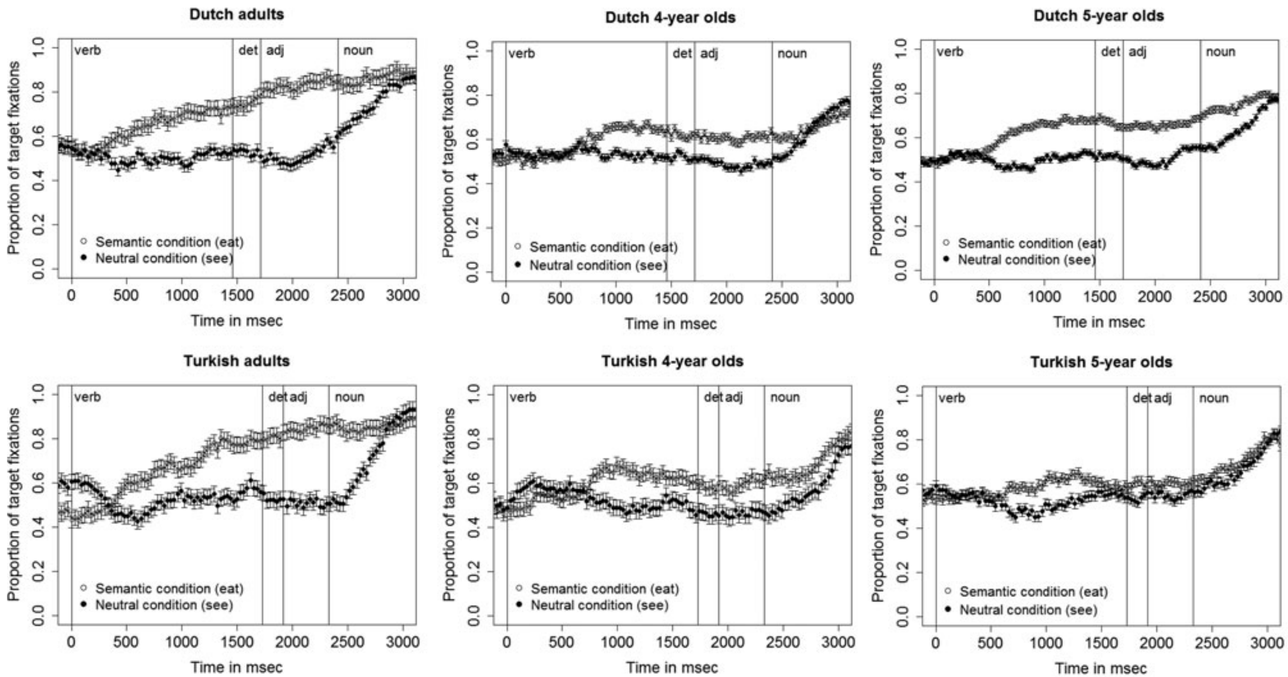

Figure 1. Timecourse of fixating to targets with SE bars in the semantic (*The boy eats the big cake*) and the neutral condition (*The boy sees the big cake*) for Dutch and Turkish adults, and four-year-olds and five-year-olds.

sum of a set of base functions that each has a different shape, resulting in a non-linear curve. GAMM is particularly suited for analyzing timecourse data (Nixon, van Rij, Mok, Baayen, & Chen, 2016; van Rij, Hollebrandse, & Hendriks, 2016), as it is able to (1) determine linearity or non-linearity on the basis of the data, (2) analyze continuous variables (e.g., time) and non-linear interactions, (3) include random effects, and (4) deal with autocorrelation.[1] The analyses were conducted in R (version 3.2.2; R Core Team, 2018) using the package mgcv 1.8.20 (Wood, 2009). The results were plotted using the itsadug 2.3 R package (van Rij, Wieling, Baayen, & van Rijn, 2015). For reproducibility, the data and commands used for the analysis are available in the Supplementary materials: S1 File (Dutch data), S2 File (Turkish data), and S3 File (analysis script) (available at <https://doi.org/10.1017/S0305000918000375).

A logistic GAMM was fitted (using the binomial family), as our dependent variable was binary (target fixation: 1, distractor fixation: 0). As Wieling (2012, p. 129) points out: "Logistic regression does not model the dependent variable directly, but it attempts to model the probability (in terms of logits) associated with the values of the dependent variable. A logit is the natural logarithm of the odds of observing a certain value (in our case, a target fixation)." In the model summary, the parameter estimates will therefore correspond to the likelihood of target fixation (expressed as the log of odd ratios).

To identify whether our predictors Condition (semantic vs. neutral) and Age (adults vs. four-year-olds vs. five-year-olds) were significant, we included smooths modeling the DIFFERENCE between two original smooths (cf. Wieling, under review). For example, we measured the difference between the original smooth for the semantic condition and the original smooth for the neutral condition. If such a difference smooth is significant, this indicates that the additional complexity of distinguishing the levels of our predictors is required. To fit such a model, we created binary (i.e., dummy) variables which are equal to 0 for one level of the categorical variable and 1 for the other level. For example, Condition was converted into the binary variable *IsSemantic* (semantic condition: 1, neutral condition: 0), to explicitly test for the non-linear difference between the two conditions (i.e., a semantic prediction effect). As we were interested in the timecourse of processing, a smooth for the predictor *Time* was also included (30 ms time bins). The time-window from verb onset until noun onset was selected for analysis. Each binary variable was included as a non-linear interaction with *Time*, to test whether the levels of the predictors showed variations in gaze pattern over time. In addition, non-linear random effects over *Time* for participants and items were included.

Note that the analyses can only be conducted within each language separately, as there are timing differences in the length of the constituents in our sentences across languages. For example, the offset of the verb occurs 260 ms earlier in our Dutch sentences than in our Turkish sentences. We will therefore present the Dutch and Turkish data separately.

[1]There is a dependency involved in analyzing time-series data. Specifically, the residuals (i.e., the difference between the fitted values and the actual values) of subsequent time-points in the time series will be correlated (i.e., autocorrelation). This means that each additional time-point compared to the previous one only yields relatively little extra information. If such a dependency is not entered into the model, it is likely that the strength of the effects is severely overestimated (Wieling, under review).

Dutch eye-gaze data

Table 2 summarizes the results of the best model fit. The estimates of the parametric coefficients show that the four- and five-year-olds numerically give rise to lower target fixations compared to adults (intercept). However, the parametric part is less informative, as it does not distinguish between our conditions or time values. The deviance explained by the model is 10.1%.

The smooth terms show the significance of the non-linear patterns associated with Age over Time. They directly indicate significance of the difference between target fixations in the semantic versus the neutral condition. The binary smooth [*s(Time):IsSemantic*] reveals that the non-linear pattern for the difference between the two conditions over time is significant, indicating that our Dutch participants demonstrate a semantic prediction effect over time. Moreover, the significant binary smooth [*s(Time):IsAdultSemantic*] shows that the adults' non-linear pattern for the difference between the semantic and the neutral condition contrasts with the four- and five-year-olds. This pattern is illustrated in Figure 2. The Dutch adults are represented by the solid curve and the Dutch children by the dotted curve. These data indicate that the adults show a stronger semantic prediction effect than the two child groups. Note, however, that the binary smooth [*s(Time):IsSemantic*] was significant, indicating that both child groups also benefitted from the semantic as opposed to the neutral condition in their predictive sentence processing.

Note that in an earlier model we also included a binary smooth to compare the four-year-olds to the five-year-olds (and the adults). However, that smooth did not reach significance and was therefore taken out of the model. Finally, non-linear random effects over time were significant for both participants and items.

Turkish eye-gaze data

Table 3 summarizes the results of the best model fit for the Turkish data. The estimates of the parametric coefficients show that adults (intercept) numerically give rise to slightly higher target fixations compared to the four- and five-year-olds. The deviance explained by the model is 11.3%.

The smooth terms show the significance of the difference between target fixations in the semantic versus the neutral condition. The binary smooth *[s(Time):IsSemantic]* reveals that the non-linear pattern for the difference between the two conditions over time is not significant, indicating that the semantic prediction effect is not present across all our participants. More specifically, the significant binary smooth [*s(Time):IsAdultSemantic*] shows that the adults' non-linear pattern for the difference between the semantic and the neutral condition contrasts with the four- and five-year-olds. This pattern is presented in Figure 3. The adults (solid curve) show a prediction effect, whereas the four- and five-year-olds do not show such an effect (dotted curve). Note that an earlier model showed no differences between the four-year-olds and the five-year-olds (and the adults). As this smooth was not significant, it was taken out of the model. Finally, non-linear random effects over time were significant for both participants and items.

General discussion

The present study examined whether Dutch and Turkish children and adults, whose languages differ in word order, are able to extract information from the verb and use

Table 2. Summary of the Dutch Results of the GAM Model

Parametric coefficients:	Estimate	SE	*z*-value	*p*-value
(Intercept)	0.15	0.12	1.21	.23
Age4/5	−0.06	0.11	−0.49	.62
Smooth terms:	**Edf**	**Ref.df**	**Chi.sq**	***p*-value**
s(Time):Adult	2.01	2.32	2.96	.28
s(Time):Age4/5	4.96	5.74	11.70	.06
s(Time):IsSemantic	3.18	3.45	10.18	.03
s(Time):IsAdultSemantic	2.01	2.01	9.24	.01
s(Time, Participants):Conditionneutral	325.01	727.00	688.66	< .001
s(Time, Participants):Conditionsemantic	361.17	727.00	894.77	< .001
s(Time, Items):Conditionneutral	126.02	215.00	383.18	< .001
s(Time, Items):Conditionsemantic	133.54	215.00	450.81	< .001

Notes. Since Condition was converted into a binary variable, 'Semantic' models the difference curve. A positive estimate indicates that this predictor increases target fixations, while a negative estimate indicates the opposite effect. The explained deviance of this model is 10.1%.

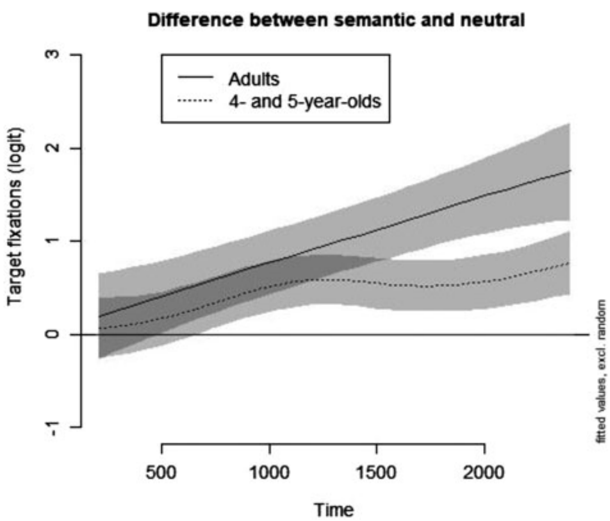

Figure 2. Non-linear smooths (fitted values, excluding. random effects) for the Dutch adults (solid line) and the Dutch four- and five-year-olds (dotted line). The pointwise 95%-confidence intervals are shown by shaded bands.

this information to predict an upcoming noun. In Dutch, the finite verb is always in second position, therefore sentences with finite verbs look like SVO. Turkish, however, has a flexible word order (based on pragmatic constraints), of which the most typical order is SOV. Turkish language users are therefore less familiar with the

Table 3. Summary of the Turkish Results of the GAM model

Parametric coefficients:	Estimate	SE	*z*-value	*p*-value
(Intercept)	0.07	0.11	0.69	.49
Age4/5	0.07	0.13	0.58	.56
Smooth terms:	**Edf**	**Ref.df**	**Chi.sq**	***p*-value**
s(Time):Adult	1.04	1.06	0.91	.37
s(Time):Age4/5	1.01	1.01	1.80	.67
s(Time):IsSemantic	2.13	2.18	2.94	.18
s(Time):IsAdultSemantic	2.00	2.00	17.65	< .001
s(Time, Participants):Conditionneutral	356.79	529.00	1084.70	< .001
s(Time, Participants):Conditionsemantic	343.85	529.00	961.32	< .001
s(Time, Items):Conditionneutral	143.47	215.00	513.20	< .001
s(Time, Items):Conditionsemantic	140.54	215.00	437.28	< .001

Notes. Since Condition was converted into a binary variable, 'Semantic' models the difference curve. A positive estimate indicates that this predictor increases target fixations, while a negative estimate indicates the opposite effect. The explained deviance of this model is 11.3%.

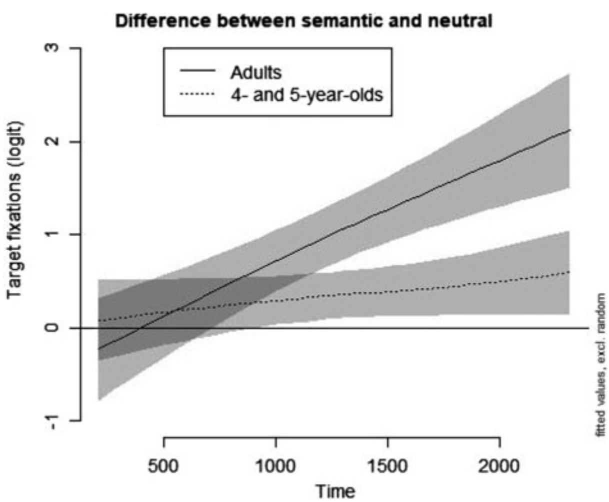

Figure 3. Non-linear smooths (fitted values, excluding random effects) for the Turkish adults (solid line) and the Turkish four- and five-year-olds (dotted line). The pointwise 95%-confidence intervals are shown by shaded bands.

SVO structure used in this study than Dutch language users. To assess whether this difference in word order between the languages matters for their predictive behaviour, we conducted a visual-world eye-tracking experiment. We presented Dutch and Turkish four-year-olds, five-year-olds, and adults with two familiar objects on a visual display while they heard semantically constraining and neutral sentences in their native language (e.g., *De jongen eet/ziet de grote taart* or *Çocuk yiyor/görüyor bu büyük keki* 'The boy eats/sees the big cake'). For each language group, we analyzed whether they showed a semantic prediction effect (i.e., difference between looks to targets in the semantic vs. the neutral condition) across different ages over time.

Our Dutch data demonstrated a semantic prediction effect over time for all our age groups (see also Brouwer *et al.*, 2017). This replicates previous work with children and adults with different native languages such as English (e.g., Altmann & Kamide, 1999) and German (Mani & Huettig, 2012). Adults showed a stronger prediction effect than the four- and five-year-olds. This finding is in line with a usage-based approach (Bybee, 1985, 1995; Langacker, 1988; Tomasello, 2000) in which experience plays a key role. Due to accumulated experience with the V2-rule, the adults may be able to create stronger links between verbs and their arguments than children, creating higher probabilities of pre-activating appropriate nouns on the basis of the verb. Alternatively, it may (also) be possible that this difference between adults and children has to do with automatization of language processing routines (e.g., faster lexical access and more efficient online sequencing and integration of linguistic material).

Prediction ability in the Dutch children's two age groups did not differ significantly from each other. This finding contradicted our expectation. We expected that the five-year-olds would show a larger effect than the four-year-olds. As Dutch four-year-olds already have fairly robust knowledge of SVO sentences with finite verbs (Jordens, 1990), it is perhaps not surprising that the five-year-olds did not do significantly better. It is possible that an older age group would show an increase compared to four-year-olds. This might reveal a developmental pattern. Alternatively, it would be interesting to manipulate the amount of experience under more controlled settings. For example, Roth (1984) provided children with additional experience and feedback on processing relative clauses (experimental group). This significantly improved children's comprehension rates compared to a group of controls who only received training in processing other structures. Roth argued that the experience with relative clauses led to improved processing efficiency. A similar experience-based process may be at work for linking verbs to arguments.

The results of the Turkish participants showed a semantic prediction effect for the adults. This demonstrates that Turkish adults, who had sufficient experience with the SVO word order throughout their lives, are able to use the verb to predict the upcoming noun. However, the semantic prediction effect was absent for the four- and five-year-olds. This indicates that they were not able to make use of the semantics of the verb to predict the noun in the sentence.

Note that, ideally, we would have preferred to analyze the data from our two language groups in one statistical model. However, it appeared to be impossible to create identical stimuli sets for the two languages (e.g., timing differences). A way around this would be to manipulate our stimuli to align onsets and durations of the critical constituents to reduce between-item differences. The drawback of such manipulations is that the resulting stimuli often sound less fluent and natural, thereby negatively influencing ecological validity. We would like to speculate, though, on an explanation for the numerical differences between the Dutch and the Turkish children's eye-gaze patterns (see Figure 1, especially the five-year-olds).

In Turkish, word order variations take place as a function of discourse pragmatics (Erguvanlı-Taylan, 1987). Sentence-initial position is reserved for the topic (i.e., the entity that the discourse is about), while the focus (i.e., the entity that introduces new or contrastive information) is placed in the immediately preverbal position. Postverbal position, on the other hand, is the site where backgrounded arguments are located (Erguvanlı-Taylan, 1979; Erkü 1983; Göksel & Özsoy, 2000, 2003; İşsever 2003). In Turkish, SVO therefore indicates a topicalized/focused subject and a backgrounded object. Corpus-based and experimental research on Turkish-speaking children's acquisition of word order indicates that they have early sensitivities to such pragmatically motivated word order variations (Batman-Ratyosyan & Stromswold, 2002; Demir, So, Özyürek, & Goldin-Meadow, 2012; Ekmekçi, 1979, 1986; Küntay, 2002). These early sensitivities emerge in children's spontaneous productions as early as 19 months (Ekmekçi, 1986) and become stronger at ages four and five (Sağın-Şimşek, 2016). For instance, unlike three-year-olds, Turkish-speaking four- and five-year-olds did not perform above chance in a comprehension task of reversible actions in uninflected OVS frames, which was attributed to their knowledge that these structures are pragmatically infelicitous when presented as isolated sentences (Stromswold & Batman-Ratyosyan, 1999). These studies indicate that Turkish-speaking children perceive word order as a discourse-pragmatic device and exhibit difficulties in comprehending non-canonical structures in the absence of appropriate discourse context.

Turkish-speaking children also perceive word order as a structural device for sentence interpretation. For instance, two-year-old Turkish-speaking children, like their English-speaking peers, could use the canonical word order of their language to identify participant roles in simple transitive sentences by looking longer to the correct video clips that were associated with the sentence they heard (Candan *et al.*, 2012). However, Turkish-speaking children displayed more frequent switches of looks between the two scenes compared to their English-speaking peers, suggesting more uncertainty with their event choice, which was solely based on canonical word order. In fact, numerous studies indicate that Turkish-learning children consistently rely on case markers more than word order as a structural cue to sentence meaning and as a strategic device for online comprehension and prediction (e.g., Göksun, Küntay, & Naigles, 2008; Özge *et al.*, 2013; Özge et al., under review; Slobin & Bever, 1982).

In sum, word order might not be as available as a cue for Turkish-speaking children compared to their Dutch-speaking peers to process the argument structure and to pre-activate appropriate nouns on the basis of the verb. For Dutch children, SVO word order (i.e., the V2-rule) signals that a direct object will follow a transitive verb; hence verb semantics can be used to anticipate this direct object. For Turkish children, SVO word order does not always guarantee that a direct object will appear following a transitive verb because Turkish also allows frequent noun ellipsis. For this reason, Turkish children may have failed to anticipate, or even avoided anticipating, the pragmatically backgrounded postverbal direct object, which could potentially be elided. It is thus conceivable that flexible and pragmatically motivated word order variation in the input of the Turkish as opposed to the Dutch children led to differences between the two child samples with respect to the semantic prediction effect. The different mechanisms for deriving SVO structures (i.e., Turkish: pragmatic rules; Dutch: structural rules) may have played a role here. The prediction effect observed for the Turkish adults, on the other hand, could be attributed to their much longer experience with such non-canonical constructions.

Recently, researchers have started looking at what makes people good versus bad predictors. For children, it has been found that receptive (Borovsky *et al.*, 2012) and productive vocabulary size (Mani & Huettig, 2012) play an important role in semantic prediction. The current work adds to this discussion because our data have demonstrated that it is also important to take into account the linguistic factor of word order when investigating verb-based prediction. In particular, it is important to consider the frequency and the reliability with which a certain word order occurs in a language. This is consistent with previous work (Özge *et al.*, 2013; Özge *et al.*, 2015). Further research needs to be done to see which other linguistic and/or cognitive factors might play a role in languages with different word order structures.

Taken together, our findings reveal that experience with word order structures and/or automatization of language processing routines plays an important role for semantic prediction. Differences in word order in typologically distinct languages create different distributional information for language learners. This idea has also been proposed for previous work on relative clause comprehension (Fitz, Chang, & Christiansen, 2011; Wells, Christiansen, Race, Acheson, & MacDonald, 2009). In line with those studies, it seems that the ability to semantically predict emerges gradually and as a function of exposure to the distributional and specific properties of a language. Future work should validate our explanations further by looking at other ages and other languages with different word order systems.

Supplementary Materials. For supplementary materials: S1 File (Dutch data), S2 File (Turkish data), and S3 File (analysis script), please visit <https://doi.org/10.1017/S0305000918000375>.

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Appendix

Sentences used in the Dutch and Turkish eye-tracking task. The two versions of each sentence are presented on the same line, with the semantically constraining sentence first. The distractor object of each sentence is within parentheses.

Dutch	Turkish
De jongen eet/ziet de grote taart (boom) The boy eats/sees the big cake (tree)	*Çocuk yiyor/görüyor bu büyük keki (saat)* The boy eats/sees this big cake (clock)
De jongen wast/pakt de groene broek (plant) The boy washes/gets the green trousers (plant)	*Çocuk yıkıyor/alıyor bu yeşil bezi (balon)* The boy washes/gets this green towel (balloon)
De jongen slaapt/staat in het mooie bed (gras) The boy sleeps in/stands in the nice bed (grass)	*Çocuk uyuyor/duruyor bu güzel yatakta (çimen)* The boy sleeps/stands in this nice bed (grass)
De jongen bouwt/ziet het rode huis (geld) The boy builds/sees the red house (money)	*Çocuk yapıyor/görüyor bu beyaz evi (taş)* The boy builds/sees this white house (stone)
De jongen drinkt/krijgt de koude melk (bank) The boy drinks/gets the cold milk (couch)	*Çocuk içiyor/taşıyor bu soğuk sütü (bank)* The boy drinks/gets this cold milk (bench)
De jongen speelt op/staat op de blauwe fluit (kast) The boy plays/stands on the blue flute (closet)	*Çocuk çalıyor/koyuyor bu mavi davulu (şişe)* The boy plays/puts this blue drum (bottle)
De jongen rijdt op/kijkt naar het bruine paard (schaap) The boy rides/looks at the brown horse (sheep)	*Çocuk biniyor/oynuyor bu siyah ata/atla (kuş)* The boy rides/plays with this black horse (bird)
De jongen schiet op/wacht op de oude beer (kip) The boy shoots/waits for the old bear (chicken)	*Çocuk vuruyor/öpüyor bu yaşlı ayıyı (tavuk)* The boy shoots/kisses this old bear (chicken)
Het meisje rijdt op/kijkt naar de oude fiets (steen) The girl rides on/looks at the old bike (stone)	*Kız biniyor/oynuyor bu eski trene/trenle (taş)* The girl rides on/plays with this old train (stone)

(*Continued*)

(*Continued.*)

Dutch	Turkish
Het meisje leest/brengt het mooie boek (raam) The girl reads/brings the nice book (window)	*Kız okuyor/getiriyor bu güzel kitabı (dolap)* The girl reads/brings this nice book (wardrobe)
Het meisje gooit/ziet de rode bal (schoen) The girl throws/sees the red ball (shoe)	*Kız atıyor/görüyor bu beyaz topu (diz)* The girl throws/sees this white ball (knee)
Het meisje draagt/koopt de blauwe jurk (kaars) The girl wears/buys the blue dress (candle)	*Kız giyiyor/ kaldırıyor bu mavi ceket (dosya)* The girl wears/puts away this blue jacket (folder)
Het meisje eet/geeft de koude peer (doos) The girls eats/gives the cold pear (box)	*Kız yiyor/veriyor bu soğuk eti (dağ)* The girls eats/gives this cold meat (mountain)
Het meisje opent/ziet de groene deur (lamp) The girl opens/sees the green door (light)	*Kız açıyor/görüyor bu yeşil kapıyı (lamba)* The girl opens/sees this green door (lamp)
Het meisje aait/hoort de bruine poes (vis) The girl strokes/hears the brown cat (fish)	*Kız okşuyor/duyuyor bu siyah kediyi (balık)* The girl strokes/hears this black cat (fish)
Het meisje melkt/helpt de grote koe (hond) The girl milks/helps the big cow (dog)	*Kız sağıyor/bakıyor bu büyük ineği/ineğe (köpek)* The girl milks/looks at this big cow (dog)
De jongen eet/draait de grote kers (hoed) The boy eats/turns the big cherry (hat)	*Çocuk yiyor/seviyor bu büyük tostu (yay)* The boy eats/loves this big toast (bow)
De jongen knipt/tekent het bruine haar (dak) The boy cuts/draws the brown hair (roof)	*Çocuk kesiyor/tutuyor bu siyah saçı (ok)* The boy cuts/holds this black hair (arrow)
De jongen draagt/krijgt de rode bril (kop) The boy wears/gets the red glasses (cup)	*Çocuk giyiyor/taşıyor bu beyaz bereyi (kupa)* The boy wears/carries this white beret (mug)
De jongen draagt/brengt het groene hemd (glas) The boy wears/brings the green shirt (glass)	*Çocuk giyiyor/getiriyor bu yeşil gömleği (bardak)* The boy wears/brings this green shirt (glass)
Het meisje drinkt/krijgt de koude thee (muts) The girl drinks/gets the cold tea (woollen hat)	*Çocuk içiyor/taşıyor bu soğuk çayı (zil)* The girl drinks/carries this cold tea (bell)
Het meisje verft/haalt het mooie hek (brood) The girl paints/gets the nice fence (bread)	*Kız boyuyor/dokunuyor bu güzel çiti/çite (kol)* The girl paints/touches this nice fence (arm)
Het meisje wast/kleurt de blauwe trui (jas) The girl washes/colours the blue sweater (jacket)	*Kız yıkıyor/boyuyor bu mavi kazağı (çiçek)* The girl washes/colours the blue sweater (flower)
Het meisje eet/pakt de oude kaas The girl eats/gets the old cheese	*Kız yiyor/alıyor bu eski muzu (tüy)* The girl eats/gets the old banana (feather)

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