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Morphosyntactic predictive processing in adult heritage speakers: effects of cue availability and spoken and written language experience

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ABSTRACT

We investigated prediction skills of adult heritage speakers and the role of written and spoken language experience on predictive processing. Using visual world eye-tracking, we focused on predictive use of case-marking cues in verb-medial and verb-final sentences in Turkish with adult Turkish heritage speakers (N = 25) and Turkish monolingual speakers (N = 24). Heritage speakers predicted in verb-medial sentences (when verb-semantic and case-marking cues were available), but not in verb-final sentences (when only case-marking cues were available) while monolinguals predicted in both. Prediction skills of heritage speakers were modulated by their spoken language experience in Turkish and written language experience in both languages. Overall, these results strongly suggest that verb-semantic information is needed to scaffold the use of morphosyntactic cues for prediction in heritage speakers. The findings also support the notion that both spoken and written language experience play an important role in predictive spoken language processing.

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1. Introduction

In everyday life, people often generate predictions about what will happen next. People form these predictions automatically, relying heavily on their previous experiences. Language is no different; language users often form predictions about upcoming information during language comprehension while incrementally processing the rapid incoming speech signals (e.g. Altmann & Mirković, 2009; Dell & Chang, 2014; Federmeier, 2007; Ferreira & Chantavarin, 2018; Hale, 2001; Hickok, 2012; Huettig, 2015; Huettig et al., 2022; Kuperberg & Jaeger, 2016; Levy, 2008; Norris et al., 2016; Pickering & Gambi, 2018; Pickering & Garrod, 2013; van Petten & Luka, 2012). It is noteworthy that studies with monolingual speakers have shown robust prediction effects (e.g. Altmann & Kamide, 1999; Borovsky et al., 2012; Özge et al., 2019), whereas research with adult second language (L2) speakers has provided mixed findings (e.g. Foucart et al., 2014; Hopp, 2013, 2015; Mitsugi & MacWhinney, 2016). The varying prediction skills of adult L2 speakers are dependent on a diverse set of factors, including the timing and setting of language acquisition, the similarities and differences between the languages in question as well as the language experience of listeners (e.g. Kaan & Grüter, 2021; Karaca et al., 2021). This last factor is often argued to modulate prediction skills of monolingual speakers as well (e.g. Porretta et al., 2020).

One group of speakers that may provide new perspectives into the way we think about predictive processing is bilingual speakers who acquire both their languages in early childhood, such as heritage speakers. Heritage speakers are defined as "early bilingual[s] who grew up hearing (and speaking) the heritage language (L1) and the majority language (L2) either simultaneously or sequentially in early childhood (that is, roughly up to age 5; see Schwartz, 2004, Unsworth, 2005), but for whom L2 became the primary language at some point during childhood (at, around, or after the onset of schooling)" (Benmamoun et al., 2013, p. 133). As adults, they are exposed to and use both languages in their daily lives to varying degrees, which means that they may hear and use each of their two languages less than their monolingual peers. They furthermore differ from monolinguals because they have two concomitantly active languages in their minds, and they may experience cross-linguistic influence from one language to the other. Heritage speakers

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differ by definition from adult L2 speakers because they were exposed to both their languages early in childhood, and learnt their languages in naturalistic settings. Given their similarities to and differences from adult monolingual speakers and L2 speakers, examining adult heritage speakers' prediction skills would enable us to achieve a fuller understanding of the way language experience affects predictive processing in a bilingual mind. Therefore, in this study, we examine (1) whether adult Turkish heritage speakers are able to use case-marking cues in Turkish predictively to the same extent as adult monolingual speakers, and (2) to what extent factors related to language experience modulate their prediction skills.

1.1. Predictive processing in monolingual[1] and bilingual populations

Research on monolingual populations has shown that depending on the language they speak, listeners exploit different cues including verb semantics (e.g. Altmann & Kamide, 1999; Brouwer et al., 2019; Mani & Huettig, 2012) and morphosyntax (e.g. Brouwer et al., 2017; Özge et al., 2019), and that they also combine the cues to generate predictions (e.g. Borovsky et al., 2012). Even though prediction effects are robust, they also vary across individual speakers (see Huettig, 2015; Karaca et al., 2021 for a review). Several listener-related factors have been found to modulate prediction skills in monolinguals, including cognitive abilities (e.g. Huettig & Janse, 2016; Ito et al., 2018), vocabulary knowledge, literacy skills, and life-long experience with certain types of input (e.g. Mani & Huettig, 2012, 2014; Özkan et al., 2022; Porretta et al., 2020).

Non-listener-related factors have also been reported to modulate prediction skills, including the reliability of the cues across languages. For instance, the Competition Model (Bates & MacWhinney, 1989; Macwhinney, 2012) claims that the availability and reliability of cues in spoken and written language determine the validity of the cues, which then determines the strength of the cues. These cue properties are subject to cross-linguistic differences. Case-marking cues, for instance, may be treated as more reliable in some languages because they are more transparent (e.g. Russian, Turkish) compared to other languages (e.g. Hebrew, German), and therefore they may be used predictively (e.g. Meir et al., 2020). The reliability of different cues may furthermore vary within the same grammatical domain (e.g. Brouwer et al., 2017, for differential reliability of the gender-marked determiners in Dutch), or cue reliability may be diminished when listeners are exposed to non-target-like input (e.g. Hopp, 2016).

Research on predictive processing in the L2 has yielded mixed findings, with some studies reporting prediction effects comparable to monolingual speakers (e.g. Foucart et al., 2014; Hopp, 2013), and others demonstrating smaller to no effects of prediction (e.g. Hopp, 2015; Mitsugi & MacWhinney, 2016). Using morphosyntactic cues predictively in the L2 have been argued to be problematic due to limited availability of cognitive resources needed for predictive processing. Under a prediction-by-production account, the comprehenders form predictions by going through earlier (i.e. semantic encoding) and later stages (i.e. syntactic and phonological encoding) of language production, which requires time and cognitive resources (Pickering & Gambi, 2018). As a result, L2 speakers may not reach the later stages of the production process in time to generate predictions at a (morpho)syntactic or phonological level (Ito & Pickering, 2021). L2 speakers may also weight the cost of generating predictions based on certain cues against its benefits differently than monolingual speakers. Under the utility accounts (Kuperberg & Jaeger, 2016), prediction may not always be the most efficient way of processing language (e.g. when the task is too challenging). To optimise their language processing efficiency, comprehenders adjust their predictive behaviour (i.e. what to predict and whether to predict) based on calculations of cost-benefit trade-offs of generating predictions. The outcome of this cost-benefit analysis may not be the same for monolinguals and L2 speakers, because of cross-linguistic influence, variation in language experience, and the context of acquisition. As a result, L2 speakers may weight certain cues to be more or less reliable compared to monolingual speakers (Kaan & Grüter, 2021).

Studies with adult L2 speakers have shown that predictive cues are more likely to be used efficiently when they are shared between the two languages of the adult L2 speakers (e.g. Foucart et al., 2014; Frenck-Mestre et al., 2019; Hopp & Lemmerth, 2018; van Bergen & Flecken, 2017) than when they are not (e.g. Martin et al., 2013; Hopp, 2015; Mitsugi & MacWhinney, 2016). For instance, Frenck-Mestre and colleagues (2019) found that neither Kazakh-Korean nor French-Korean adult L2 speakers were able to use case-marking cues predictively in Korean, yet the effects observed for L2 speakers with Kazakh as L1 and French as L1 were also different from each other. More precisely, the Kazakh-Korean L2 speakers' performance patterned more similarly to that of monolingual Korean speakers than the French-Korean L2 speakers, which may be explained by Kazakh language being more similar to Korean in terms of case-marking compared to French. Similar findings were also reported for Russian-German

L2 speakers who were able to use case-marking cues predictively (Schlenter & Felser, 2021), meaning that having an L1 with a transparent and rich case-marking system (i.e. Russian) facilitates prediction skills in the L2 (i.e. German). When compared to studies that reported no predictive use of case morphology in the L2 when the L1 does not mark case information (e.g. Hopp, 2015; Mitsugi & MacWhinney, 2016), these findings suggest that having the same type of cues in two languages may facilitate predictive processing in adult L2 speakers.

It is important to note here that these findings do not mean that adult L2 speakers can never generate predictions when a cue is not present in their first language. Depending on their language proficiency and experience, they may be able to do so. Indeed, Hopp (2013), for instance, reported that English-German adult L2 speakers who assigned correct gender on nouns in a production task were able to use gender cues predictively, whereas those with less target-like gender assignment were unable to do so. L2 proficiency and experience might also partly explain the prediction effects reported in Schlenter and Felser (2021) study and lack thereof in Frenck-Mestre et al. (2019) study. The L2 speakers in the former study had high L2 proficiency and had been living in the L2 country for 8 years on average, while the ones in the latter had only been taking L2 classes for three semesters. Such a reasoning would also be in line with Foucart (2015), who stated that enhanced L2 experience may facilitate L2 speakers' prediction skills because of their increased familiarity with L2 structures and with co-occurrences between words and structures. Overall, it is clear that language experience plays a prominent role in L2 predictive processing.

Our understanding of prediction skills in bilingual speakers has almost exclusively been informed by adult L2 speakers. As a result, what we know about predictive processing in a bilingual mind and the role of mediating factors are biased towards a bilingual group who learnt a second language later in life (usually via formal instruction), with a fully-acquired L1 system. There are a couple studies that examined the predictive processing in heritage speakers who are exposed to both languages in early childhood and whose two languages develop more or less in parallel.

The few available studies with heritage speakers have shown that they are able to generate predictions in their heritage language based on cues that are not present in their other language. For instance, English-dominant heritage speakers of gender-marking languages (i.e. Spanish and Polish) were able to use gender cues predictively even though such cues are not shared between English and the heritage language. Heritage speakers have sometimes been reported to be slower than the control group (i.e. Fuchs, 2021 for Spanish heritage speakers; Sekerina, 2015 for Russian heritage speakers; but cf. Fuchs, 2022 on Polish heritage speakers), and to use a more limited range of morphosyntactic cues predictively. For example, Sekerina (2015) found that heritage speakers of Russian were able to use the plural and feminine gender markers predictively, but not for the masculine marker while monolingual speakers of Russian were able to use all.

At the same time, when the same type of cue is present in their two languages, heritage speakers have been shown to even outperform their monolingual peers in the majority language. For instance, Meir and colleagues (2020) reported that Russian-Hebrew bilingual children were able to use case-marking cues to generate predictions in their heritage language Russian, similar to Russian-speaking monolingual children but slower, as well as in the majority language. Interestingly, Hebrew-speaking monolingual children – who were the same age as bilingual children – were unable to do so. This finding indicates that cross-linguistic influence in the form of acceleration is observed from Russian, in which case-marking is transparent and thus a reliable cue, to Hebrew, in which case-marking is impoverished and thus a relatively less reliable cue. In sum, it is clear that early and parallel exposure to both languages may benefit prediction skills of bilingual speakers.

Similar to adult L2 speakers, heritage speakers' prediction skills have also been found to be modulated by their language experience (e.g. Parshina et al., 2022). For instance, in an eye-tracking reading task, English-dominant Russian heritage speakers' prediction abilities in Russian have been reported to be facilitated by their higher literacy experience in Russian as well as by their oral reading fluency in English (Parshina et al., 2022). This finding suggests that written language experience in both languages facilitates predictive processing during reading in the heritage language and that the effect of certain experiences may be transferred between languages.

These initial findings on heritage speakers, from a limited number of studies, point to an intricate picture in terms of how predictive cues from two languages interact with each other, and how language experience modulates predictive processing. It remains unclear, however, how exactly or which aspects of language experience modulate predictive processing in spoken language comprehension when two languages are learnt more or less in parallel. The present study aims to fill this gap by examining the role of spoken and written language experience on the prediction skills of heritage speakers based on case-marking cues in Turkish, under the influence of Dutch.

1.2. The case of Turkish

Turkish is characterised by relatively flexible word order, and in its canonical order the verb follows the object (Erguvanlı, 1984). In a written newspaper corpus (Milliyet Corpus, Özge et al., 2019), the verb-final word orders were reported to be more frequent (SOV, OSV; 36%) than the verb-medial word orders (SVO, OVS; 16%), while the verb-initial word orders were the least frequent (VSO, VOS; 3%). In an adult corpus, around half the sentences starting with a noun phrase (NP) were subject-initial (52%) and the rest object-initial (METU-Sabancı Treebank, Oflazer et al., 2003 as cited in Demiral et al., 2008). The high percentage of object-initial word order in Turkish is due to the argument-drop feature of Turkish, since almost 70% of clauses with a transitive verb were found to involve subject-drop in the same corpus (Çakıcı, 2005).

The high frequency of object-initial word order in Turkish means that the first NP cannot always be assigned an agent role. Instead, thematic relations are identified using case-marking. Direct objects are obligatorily marked with an accusative case when they are definite, specific or referential (e.g. Ketrez & Aksu-Koç, 2009), and matrix clause subjects are marked with a nominative case, which is not overtly realised. Sentences (1) and (2) illustrate SOV and OSV word orders, respectively.

(1)	Tilki	tavşanı	yiyecek.
	foxØ	rabbit-ACC	eat-FUT
	The fox will eat the rabbit.		

(2)	Tavşanı	tilki	yiyecek.
	rabbit-ACC	foxØ	eat-FUT
	The fox will eat the rabbit.		

Monolingual Turkish-speaking children appropriately use canonical and non-canonical word orders as well as the accusative case early on (e.g. Sağın-Şimşek, 2016; Ketrez & Aksu-Koç, 2009). For example, at the age of two, they have been shown to correctly comprehend and act-out object-first and subject-first sentences, suggesting that they were able to use nominative and accusative case markers to figure out the argument structure of the sentences (Slobin & Bever, 1982). At the same time, when no case-marking is provided (i.e. with non-specific and indefinite direct objects) they were able to use word order to successfully assign thematic roles but with higher uncertainty compared to children speaking a non-case-marking language (i.e. English) (Candan et al., 2012). In sum, case-marking serves as a reliable cue for Turkish-speaking monolingual children from very early on, and it may be prioritised over word order for interpreting argument structure.

Case-marking morphology and word order preferences have been argued to vary more in Turkish spoken by heritage speakers compared to monolingual speakers. For instance, Turkish-heritage speakers living in the Netherlands sometimes use unconventional (accusative) case-marking and individual word order constructions with partial influence from Dutch, although only to a limited extent (Doğruöz & Backus, 2009; Sevinç, 2012; Şahin, 2015). Furthermore, heritage speakers of Turkish living in Germany were reported to over-extend the use of definite noun phrases, marked with accusative case, in indefinite contexts (Felser & Arslan, 2019), while heritage speakers of Turkish in the USA were less accurate in their production and comprehension of accusative case and DOM marker *-yI* compared to adult monolingual speakers (Coşkun-Kunduz & Montrul, 2022). In sum, case-marking morphology used by heritage speakers of Turkish may show more variation compared to monolingual speakers, and this may affect the way case-marking cues are employed in predictive processing by heritage speakers.

1.3. Predictive processing in Turkish

A handful of studies have investigated predictive use of verb semantics and case marking in Turkish (Brouwer et al., 2019; Özge et al., 2019; Özkan et al., 2022). In one of the first studies, Brouwer and colleagues (2019) investigated whether Turkish-speaking monolingual adults and 4- and 5-year-old children were able to use verb semantics to predict the upcoming object information in sentences with SVO word order. They presented participants with sentences with either semantically-constraining verbs (e.g. eat) or with neutral verbs (e.g. see), paired with a visual display of two images (e.g. cake vs. bird). They found that while adults fixated on the target image after hearing the verb but before hearing that object information, children in both age groups did not. These results suggested that monolingual Turkish-speaking adults, but not children, were able use semantics of the verb to predict the upcoming noun in the sentence. These findings indicate that Turkish-speaking monolingual children may not rely heavily on word order and verb semantics in predictive processing; instead they may prioritise other cues such as case marking.

Özge et al. (2019) examined children's predictive use of case-marking cues. They investigated whether Turkish-speaking monolingual children and adults were able to use accusative or nominative case marking on the first NP to predict the second NP of the sentence. They found that monolingual children and adults fixated on the agent image more after hearing an accusative case-marked first NP and before hearing the second NP in both verb-medial and verb-final sentences. These findings indicate that monolingual Turkish-speaking children and adults were able to use case-marking cues to predict the thematic role of the upcoming noun with or without the additional help from the verb semantics. Özkan and colleagues (2022) conducted a follow-up study with 4–8 year olds focusing on verb-final sentences only. They also examined the role of verbal and cognitive skills on prediction skills. In addition to replicating Özge et al.'s (2019) results, they found that a larger early productive vocabulary, better language production skills, and higher working memory capacity (i.e. episodic buffer) facilitated monolingual children's prediction abilities.

1.4. Current study

Past research thus has demonstrated that case-marking cues play a prominent role in incremental interpretation of argument structures in Turkish. They are considered reliable cues and may be used to predict upcoming information during online language comprehension by monolingual child and adult speakers of Turkish. Their predictive use is modulated by various individual-level factors such as better language skills and higher cognitive abilities. However, it remains unknown whether these early-acquired, transparent and frequent cues can be used predictively by bilingual speakers of Turkish, specifically when their other language does not support these cues. Therefore, in the current study, we examine prediction skills of Turkish heritage speakers. More specifically, we focus on case-marking cues in Turkish using a visual world eye-tracking paradigm (following Özge et al., 2019) to investigate (1) to what extent the case-marking cues in verb-medial and verb-final sentences can be used predictively by heritage speakers compared to monolingual speakers, and (2) to what extent spoken and written language experience in both languages modulate prediction skills of heritage speakers.

With respect to our first research question, we hypothesised that Turkish heritage speakers would not use case-marking cues predictively to the same extent as monolingual speakers since it has been found that not all morphosyntactic cues were used predictively by heritage speakers and that heritage speakers might be slower than monolingual speakers to generate predictions (e.g. Sekerina, 2015; Fuchs, 2021). This may be for two reasons, which are not mutually exclusive. First, their reduced experience in Turkish might cause them to weight the reliability of case-marking cues differently compared to monolingual speakers. Relatedly, their reduced experience in Turkish might also cause processing in Turkish to be cognitively more demanding, limiting the availability of cognitive resources to generate morphosyntactic predictions. Second, given that Dutch marks case information only pronominally, cross-linguistic influence from this language might affect how efficiently case-marking cues are used in predictive processing (Kaan & Grüter, 2021). We also hypothesised that heritage speakers would show better prediction skills in the verb-medial sentences than verb-final sentences since predictive cues from different domains might be used in combination, which might increase the likelihood of generating predictions (e.g. Henry et al., 2022). With respect to our second research question, we hypothesised that both spoken and written language experience of heritage speakers would play a role in their predictive processing skills (Parshina et al., 2022). Enhanced experience in spoken language activities in Turkish as well as increased experience in written language activities in Turkish as well as Dutch might facilitate prediction skills of heritage speakers.

2. Methodology

2.1. Participants

Twenty-four adult monolingual speakers and 26 adult heritage speakers of Turkish participated in this study. One participant in the heritage group was excluded due to technical problems. The monolingual Turkish-speaking adults (M_{AGE} = 27.04, SD_{AGE} = 6.14, *Range* = 18–41, 17 females) were tested in Turkey, and recruited through the personal network of the first author. They all spoke Turkish as their first and primary language, and had minimal contact with a second language on a daily basis. The majority of monolingual (79%) and heritage speakers (80%) either had completed or had been attending higher education at the time of testing. The heritage speakers (M_{AGE} = 26.72, SD_{AGE} = 5.22, *Range* = 19–39, 19 females) were tested in the Netherlands. The selection criteria for heritage speakers[2] were that (1) they should be exposed to both Turkish and Dutch before the age of 4;0, (2) they should not be exposed to a third language in early childhood (e.g. Arabic, Kurdish, English, German etc.), (3) they should not have lived in a country where a third language was the majority language, (4) they should not have moved back to Turkey at any point in their lives, and (5) they should have weekly contact with both Turkish and Dutch at the time of the testing.

The heritage speakers were born in the Netherlands, except for three who were born in Turkey and moved to the Netherlands within the first year of their lives. The parents of the participants were born in Turkey, except for one mother who was born in the Netherlands to Turkish-speaking parents who had immigrated to the Netherlands. The mean age of immigration to the

Netherlands for the parents was 16.17 years (*SD* = 5.11, *Range* = 4–25) for the mothers and 19.08 years (*SD* = 5.55, *Range* = 2–30) for the fathers. All heritage speakers were exposed to Turkish by birth and Dutch before the age of 4;0 (*M* = 2.44, *SD* = 1.64, *Range* = 0–4). They were also exposed to English at school at age 10. Many of the participants (*n* = 17) reported that they were currently using English in their everyday lives to some extent.

All heritage speakers filled out a language environment questionnaire, which was adapted from an existing questionnaire about their family background, current weekly language exposure and use, literacy activities, and cumulative language input (van Dijk, 2021, based on Bilingual Language Experience Calculator, Unsworth, 2013; Language Experience and Proficiency Calculator, Marian et al., 2007; Language History Questionnaire, Li et al., 2014). To estimate their current language exposure, language use and literacy activities in a regular week, the participants were asked to state in total how many hours per week they spent speaking, listening, reading and writing in different contexts (e.g. school, work, with family, with friends, etc.) and divide these hours into percentages for different languages. Current language exposure and use were calculated by dividing the number of hours spent for listening and speaking in one language by the total number of hours of listening and speaking, respectively. Literacy activities were based on the total number of hours spent in reading and writing, and calculated in the same way. To estimate their cumulative language input, the participants were asked to state how much they were exposed to their languages in different periods of their lives (e.g. between the ages of 0-2;0, 2;0-4;0 etc.) in percentages. Using these percentages, we calculated how many years in a given period corresponded to Turkish and Dutch input. The total number of years of Turkish and Dutch was then divided by the total number of years. Table 1 provides the detailed background information of the participants.

As seen in Table 1, heritage speakers were exposed to Dutch (51%) more than Turkish (37%), and they used Dutch (57%) more than Turkish (37%). They also engaged in literacy activities in Dutch (64%) more often than Turkish (14%). Nevertheless, the average cumulative language input throughout their lives was similar in Dutch (46%) and Turkish (46%).

Table 1. Overview of background information of monolingual and heritage speakers.

Monolingual speakers (N = 24)			
	M	SD	Range
Age (years)	27.04	6.14	18–41
Heritage speakers (N = 25)			
	M	SD	Range
Age (years)	26.72	5.22	19–39
Age of first exposure to Dutch (years)	2.44	1.64	0–4
Length of exposure to Dutch (years)	24.28	4.96	17–35
Current exposure to Turkish (listening) (%)	36.85	15.86	11.11–67.82
Current exposure to Dutch (listening) (%)	51.08	14.54	16.79–85.08
Current use of Turkish (speaking) (%)	37.24	14.75	7.32–65.33
Current use of Dutch (speaking) (%)	57.17	13.60	34.67–92.68
Current literacy activities in Turkish (reading & writing) (%)	14.44	15.02	0–50
Current literacy activities in Dutch (reading & writing) (%)	64.09	21.38	12.59–100
Cumulative input in Turkish (%)	46.43	13.40	30.30–77.88
Cumulative input in Dutch (%)	46.32	10.47	22.12–62.69

Note: The current exposure, use and literacy activities are based on 24 instead of 25 participants, since one participant did not fill out the relevant section of the questionnaire.

2.2. Materials

2.2.1. Processing speed tasks

To check whether the cognitive skills of monolingual and heritage speakers were similar, we used two pencil-and-paper subtests from Wechsler Adult Intelligence Test (WAIS-IV; Wechsler, 2008), namely symbol coding and symbol search to measure their processing speeds. In the symbol-coding test the participants are presented with a key that pairs numbers from 1 to 9 with 9 different geometrical symbols, along with a table on which each digit is presented multiple times in a random order with a blank box underneath. In the symbol search test, they are presented with two target symbols on the left side of each row, along with an array of 5 symbols on the right. The participants were asked to code as many symbols as possible in 90 s in the symbol coding task, and to search for as many target symbols as possible in 90 s in the symbol search task.

The processing speed in these tasks was measured by calculating how much time the participants spent to code or search for one symbol. In other words, the total time of 90 s was divided by the total number of symbols a participant coded for (Huettig & Janse, 2016) or searched for. In both tasks, lower scores indicate faster processing speed.

2.2.2. Language proficiency task

To measure participants' Turkish proficiency, we used two C-tests (Karayayla, 2018). C-test is a fill-the-blanks test generally considered to be an indicator of overall language proficiency (Schmid, 2004). In this task, the second half of every second word was deleted, with the first and last sentence of the paragraph kept intact. The participants had to complete the words. There were 40 items in total.

The answers were coded as accurate if they included a correct and complete word or an acceptable variant in the context of the sentence, without penalising for any spelling errors. The total number of accurate responses was used as the proficiency score.

2.2.3. Eye-tracking experiment

The visual world eye-tracking experiment was adapted from Özge et al.'s (2019) study. It consisted of a set of auditory stimuli in which the case marking on the first noun phrase (NP) (accusative vs. nominative, within-subjects) and the position of the verb in the sentence (sentence medial vs. sentence final, within-subjects) were manipulated in a 2×2 design, with eight items per condition. Two separate eye-tracking blocks were created for verb-final and verb-medial sentences. They were presented separately to isolate the effects of the case-marking cues when presented alone (i.e. verb-final sentences) and in combination with verb semantics (i.e. verb-medial sentences), as well as to closely follow the experimental set-up of Özge et al. (2019).

The auditory stimuli were recorded by a female native speaker of Turkish in a sound-proof room using Audacity© (16 bits, 22050Hz). The experimental stimuli were transitive sentences with two overt arguments. The first noun was always preceded by an adjective such as *hızlı* "speedy", and followed by the time adverbial *birazdan* "soon". The second noun was always preceded by the modifier *şuradaki* "the one over there". The verb was placed in the sentence-final position in sentences (1) and (2), and in sentence-medial position in sentences (3) and (4) as shown in Table 2. The case-marking on the first noun was manipulated to be either accusative as in (1) and (3) or nominative as in (2) and (4), resulting in either object-initial or subject-initial sentences.

There were 32 experimental items (eight for each condition), created with the following verbs: *tekmele-* "kick", *yut-* "swallow", *kucakla-* "hug", *ısır-* "bite", *yala-* "lick", *yakala-* "catch", *gıdıkla-* "tickle", *sakla-* "hide", *kurtar-* "save", *kovala-* "chase", *öp-* "kiss", *ye-* "eat" and *bul-* "find", the last three of which were used twice. Ten filler items were created in addition to the filler sentences used in Özge et al. (2019), an example of which is given below in sentence (5). The filler items were included in the experiment to prevent the participants from noticing the experimental manipulation. A complete list of items can be found here: https://osf.io/uk94s/?view_only=f297563ae308481d9039b0c97baa73ee.

(5) Yorgun doktorun uçağı birazdan kalkacak.
Tired doctor-GEN plane-POSS.3SG soon take-off-FUT
"The tired doctor's plane will soon take off".

Following Özge et al. (2019), the verb-final sentences were edited in Praat (Boersma & Weenink, 2017) to have the following structure: 200 ms silence + adjective + the first noun + 300 ms silence + adverb + 200 ms silence + modifier + the second noun + verb + 1500 ms silence at the end of the sentence. Similarly, verb-medial sentences were also edited to have the following structure: 200 ms silence + adjective + the first noun + 300 ms silence + adverb + verb + modifier + the second noun + 1500 ms silence at the end of the sentence.

Accompanying each sentence, a visual display with three coloured and thematically related images was presented on the screen (see the osf folder for a sample visual display: https://osf.io/uk94s/?view_only=f297563ae308481d9039sb0c97baa73ee). These images represented the first NP (e.g. rabbit), a plausible patient in a context where the first NP is the agent (e.g. carrot), and a plausible agent in a context where the first NP is the patient (e.g. fox). The potential patient and agent images corresponded to the referents of the second NP in subject-initial sentences (i.e. SVO and SOV) and object-initial sentences (i.e. OVS and OSV), respectively. The images representing the agent, patient, and the first NP appeared on the lower middle, upper right and upper left positions of the screen equally often.

Table 2. Overview of the manipulations of the experimental sentences.

#	Case Marking	Verb Position	Word Order	Sentence
1	Accusative	Final	OSV	Hızlı tavşan**ı** birazdan şuradaki tilki∅ **yiyecek** Speedy rabbit**ACC** soon there fox**NOM** **eat** *"The fox over there will soon eat the speedy rabbit"*
2	Nominative	Final	SOV	Hızlı tavşan∅ birazdan şuradaki havuc**u** **yiyecek** Speedy rabbit**NOM** soon there carrot**ACC** **eat**. *"Speedy rabbit will soon eat the carrot over there"*
3	Accusative	Medial	OVS	Hızlı tavşan**ı** birazdan **yiyecek** şuradaki tilki∅ Speedy rabbit**ACC** soon **eat** there fox**NOM** *"The fox over there will soon eat the speedy rabbit"*
4	Nominative	Medial	SVO	Hızlı tavşan∅ birazdan **yiyecek** şuradaki havuc**u** Speedy rabbit**NOM** soon **eat** there carrot**ACC** *"Speedy rabbit will soon eat the carrot over there"*

2.3. Procedure

All experimental sessions took place in a quiet room at either the first author's or the participants' homes/workplaces or in a lab space at Radboud University.[3] The participants completed 5 tasks in total that took approximately 75 min for the monolingual speakers and 90 min for the heritage speakers. The order of the tasks were (1) first eye-tracking block (either verb-final or verb-medial), (2) a story narration task in Turkish (not reported on in this paper), (3) symbol search and symbol coding tests, (4) second eye-tracking block (either verb-medial or verb-final), and (5) two Turkish C-tests. The heritage group completed the language environment questionnaire at the end of the session. All participants signed a written consent form at the beginning of the session, and received a gift card (€10) for participating. Ethical approval was granted by the Ethics Assessment Committee Humanities of Radboud University (EACH number 2020-8963).

Four experimental lists were created; two with verb-final and two with verb-medial block. In each list, there were eight critical items per condition. If a participant listened to a critical item in the accusative condition in the verb-medial block (e.g. sentence 3 in Table 2), then they listened to it in the nominative condition in the verb-final block (e.g. sentence 2 in Table 2). The presentation order of verb-medial and verb-final blocks was counterbalanced.

The eye-tracking experiment was presented using OpenSesame software (Mathôt et al., 2012). The participants were seated in front of a Tobii 120 or Tobii x3-120 eye-tracker (sampling rate 120 Hz for both), approximately 65 cm away from the screen. Prior to the experiment, a 5 point calibration was performed, and repeated if necessary. The presentation of each trial was gaze-contingent, in that the participants were required to look at the cross in the centre of the screen for the next trial to be presented (i.e. drift-correct). After the drift-correct, a blue fixation dot appeared in the middle of the screen for 500 ms, followed by the presentation of the visual display of three images. After a preview time of 2000 ms, the auditory stimulus was presented. Following the auditory stimulus, an animation was presented in 15 trials and for the remaining 11 trials, the participants were informed that there was no animation. Participants were instructed to listen to the sentences carefully while looking at the images on the screen. If there was an animation, they were asked to watch carefully and to state whether the event depicted in the animation matched the event described in the sentence by saying Yes or No. An eye-tracking block took approximately 12 min to complete, including calibration and two practice trials at the beginning.

2.4. Data preparation and analysis

Given the sampling rate of the eye-trackers, participants' eye gaze was sampled 120 times per second, corresponding to approximately every 8 ms. After fixations that were invalid or outside the screen dimensions were removed, gaze location of the participants were automatically coded to be on the screen left, screen right and screen bottom images. In order to calculate our binary dependent variable, agent preference, the fixations to the first NP image were removed from the dataset. There was a considerable number of fixations to the first NP throughout the trials in the verb-final and the verb-medial sentences by both the monolinguals (43% in the verb-final sentences and 44% in the verb-medial sentences) and the heritage speakers (48% in the verb-final sentences and 51% in the verb-medial sentences), but the distribution did not differ across blocks or across monolinguals and heritage speakers. The figures of the proportion of fixations to all three images can be found in Figures S1 and S2 in the supplementary materials. After excluding the looks to the first NP, the looks to the agent and patient images were coded as 1 and 0, respectively. The time in each trial was synchronised at the second NP onset, making this the new zero point, as it marked the end of the predictive time window. The predictive time windows in both verb-final and verb-medial sentences started with the onset of the adverb (after the first NP + 300 ms) and ended with the onset of the second NP. The predictive time window included the adverb region, 200 ms silence, and modifier region in the verb-final sentences, and adverb, verb, and modifier regions in the verb-medial sentences. We did not offset the predictive time window by 200 ms because we were interested in purely predictive looks, and wanted to avoid any integration effects at a phonological level.

As we were interested in potential prediction effects, we carried out our statistical analyses on the eye-gaze data in the predictive time window only. We fitted generalised linear mixed effects models to the binary dependent variable, agent preference, in R using *lme4* package (Bates et al., 2015). To test for prediction effects and whether these differed per group, we included the interaction between *Condition* (case marking on the first NP: nominative/accusative), *Time* (continuous, in the predictive time window) and *Group* (monolingual/bilingual). The binary variables *Condition* and *Group* were contrast-coded: nominative and monolingual were coded as −0.5 and accusative and heritage as +0.5. The continuous variable *Time* was centred around the mean and scaled.

As we were also interested in the effect of spoken and written language experience (i.e. exposure, use and literacy activities in both languages) on heritage speakers' prediction abilities, we conducted separate analyses for this group including each measure (centred and scaled) in interaction with *Condition* and *Time*.

We backward fitted the random effect structures in our models, starting with the most complex structure (Barr et al., 2013). The likelihood of the simpler model was compared against the more complex one using Akaike Information Criterion (AIC). Trial order and presentation order of the verb-final and verb-medial blocks were added to the model in interaction with condition, as control variables, and only kept in the model when they improved the model fit. All supplementary materials, final models and the data that support the findings of this study are openly available in https://osf.io/uk94s/?view_only=f297563ae308481d9039b0c97baa73ee.

3. Results

3.1. Processing speed, language proficiency and experience measures

An independent t-test conducted on the symbol coding scores showed that the heritage speakers was significantly faster ($M = 1.47$, $SD = 0.20$) than the monolingual speakers ($M = 1.63$, $SD = 0.26$, $t = 2.31$, $p = .026$). However, a Wilcoxon rank sum test conducted on the symbol search scores showed no difference between the heritage ($M = 2.95$, $SD = 0.54$) and the monolingual group ($M = 3.16$, $SD = 0.47$, $W = 221$, $p = .114$). An independent t-test conducted on the C-test scores showed that the monolingual group ($M = 33.08$, $SD = 4.39$) had significantly higher accuracy than the heritage group ($M = 26.92$, $SD = 7.44$, $t = 3.55$, $p = .001$). The heritage speakers' patterns of language use ($r(22) = -0.77$, $p < .001$) and exposure ($r(22) = -0.71$, $p < .001$) in Turkish and Dutch were negatively correlated, while their literacy activities in two languages were not correlated ($r(22) = -0.07$, $p = 0.73$). Furthermore, language use and exposure were positively correlated both in Turkish ($r(22) = 0.88$, $p < .001$) and in Dutch ($r(22) = 0.82$, $p < .001$). In Turkish, language exposure and use correlated positively with literacy activities ($r(22) = 0.62$, $p = 0.001$; $r(22) = 0.54$, $p = 0.006$), and the same held for Dutch ($r(22) = 0.45$, $p = 0.028$; $r(22) = 0.41$, $p = 0.047$).

3.2. Eye gaze data

The results for the two eye-tracking blocks are presented below separately.

3.2.1. Verb-final block

Figure 1 shows the time course of agent preference for monolingual and heritage speakers. In the monolingual group, the preference to look at the agent image increased in the accusative condition (i.e. when the first NP bears an accusative case), as the sentence unfolded. After the onset of the second NP, the agent preference steadily increased in the accusative condition, while decreasing in the nominative condition. Between the onset of the adverb and onset of the second NP, i.e. predictive time window, they started to show greater agent preference in accusative condition compared to nominative condition, suggesting a pattern in line with prediction behaviour. The heritage speakers showed a preference for the agent image in

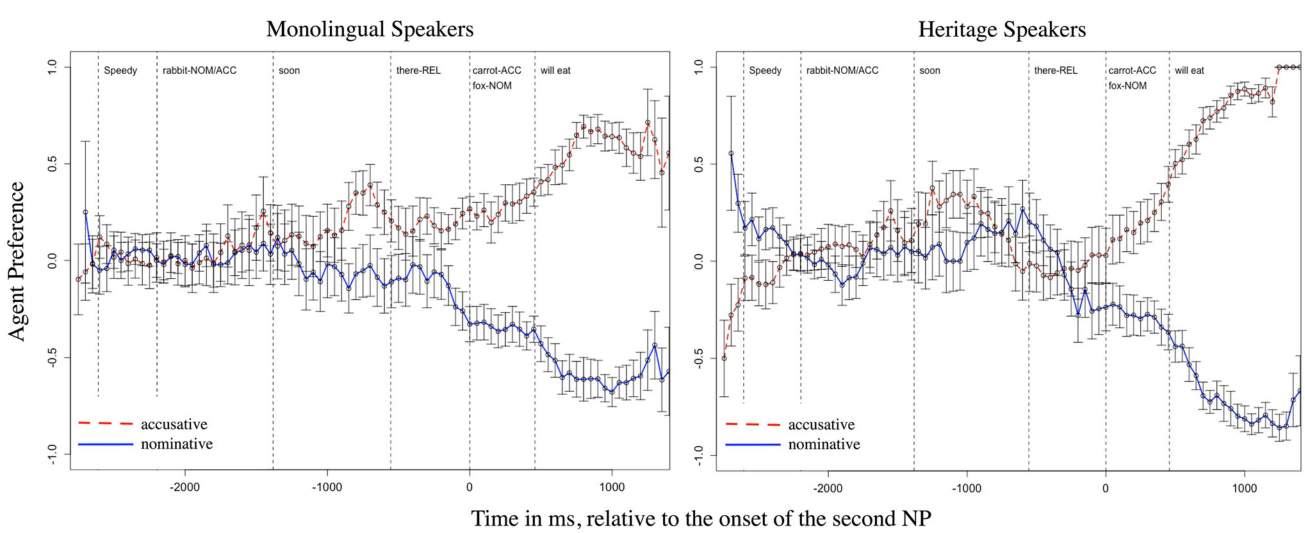

Figure 1. Agent preference for monolingual speakers (left panel) and heritage speakers (right panel) in the verb-final block.

Table 3. Summary of the fixed effects from the generalised linear mixed effects regression model with the interaction between Time, Condition, and Group in the verb-final block.

	Estimate	SE	z-value	*p*-value
Intercept	−0.142	0.214	−0.664	0.507
Condition	1.592	0.423	3.769	<.001
Time	−0.134	0.011	−11.813	<.001
Group	−0.021	0.288	−0.075	0.940
condition*time	0.035	0.023	1.560	0.119
condition*group	−0.526	0.559	−0.941	0.347
time*group	−0.160	0.023	−7.078	<.001
conditionnom:trial	0.058	0.016	3.570	<.001
conditionacc:trial	−0.010	0.016	−0.626	0.531
condition*time*group	−0.451	0.045	−9.955	<.001

agent_preference ~ condition * time * group + condition: trial order + (1 + condition|participant) + (1 + group|item)

the adverb region, which switched to the patient image in the modifier region in both accusative and nominative condition. They showed virtually no preference for the agent image in the accusative condition immediately before the second NP, and agent preference only began to increase with the onset of the second NP. Therefore, the eye gaze patterns suggest a prediction effect for the monolingual speakers, but not for the heritage speakers.

Table 3 summarises the best-fitting model for the agent preference data in the predictive time window. The model showed that the interaction of Condition and Time was not significant, while the interaction of Condition, Time and Group was significant, suggesting that the prediction effect manifested itself differently in the monolingual and heritage group. In order to further investigate this effect, we performed separate analyses for two groups.

In the monolingual group, the main effect of Condition ($\beta = 1.94$, $SE = 0.53$, $z = 3.64$, $p < .001$) as well as the interaction between Condition and Time ($\beta = 0.26$, $SE = 0.03$, $z = 8.67$, $p < .001$) was significant, with a positive estimate. In the bilingual group, the main effect of Condition ($\beta = 0.41$, $SE = 0.46$, $z = 0.89$, $p = 0.372$) was not significant. The interaction between Condition and Time ($\beta = -0.19$, $SE = 0.03$, $z = -5.61$, $p < .001$) was significant, with a negative estimate. Figure 2 shows that the monolingual group's preference for the agent increased in the predictive time window when the first NP was marked with accusative case, and decreased when it was marked with a nominative case, suggesting a prediction effect in the expected direction. No such pattern was present in the heritage speakers' looking preferences in the predictive time window. Their preference for the agent was not modulated by the case-marking of the first NP, suggesting no predictive pattern. Overall, monolingual speakers, but not heritage speakers, showed greater agent preference in the accusative condition compared to the nominative condition in the course of the predictive time window. These results point to a prediction effect based on case-marking cues in the monolingual group, but not in the heritage group. Since no prediction effect was found in the heritage group, the effect of spoken and written language experience measures was not examined.

3.2.2. Verb-medial block

The time course of agent preference is shown in Figure 3 for monolingual and heritage speakers. In the monolingual group, agent preference increased in the accusative condition and decreased in the nominative condition, starting in the adverb region. The steady increase in the agent preference differences between accusative and nominative condition in the predictive time window (i.e. between the onset of the adverb and onset of the second NP) pointed to a predictive pattern in the monolingual group. Similarly in the heritage group, the agent preference increased in the accusative condition and decreased in the nominative condition, starting in the verb region. Through the course of the predictive time window, the agent preference differences between the two conditions increased steadily, suggesting a predictive pattern for the heritage speakers, as well.

Table 4 shows the summary of the best-fitting model for the agent preference data in the predictive time window. As can be seen, the interaction of Condition and Time was significant, suggesting that the agent preference did change in the course of the predictive time

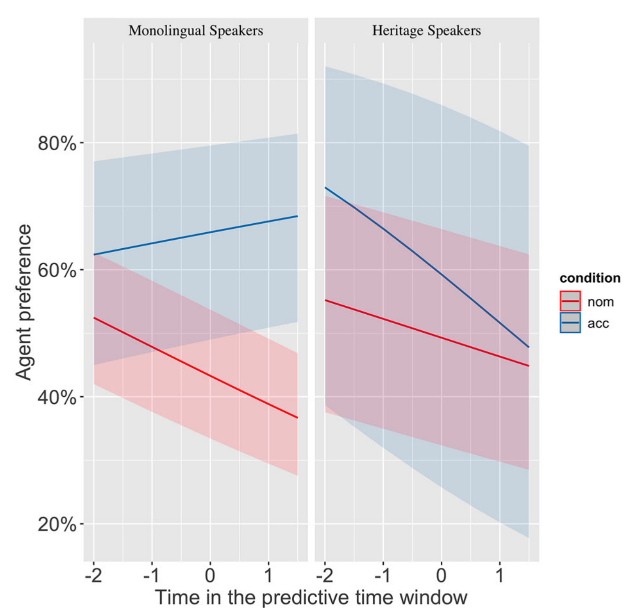

Figure 2. Agent preference in the accusative (blue line) and the nominative (red line) condition over time based on the model calculations in the verb-final block for monolingual speakers (in the left panel) and heritage speakers (in the right panel).

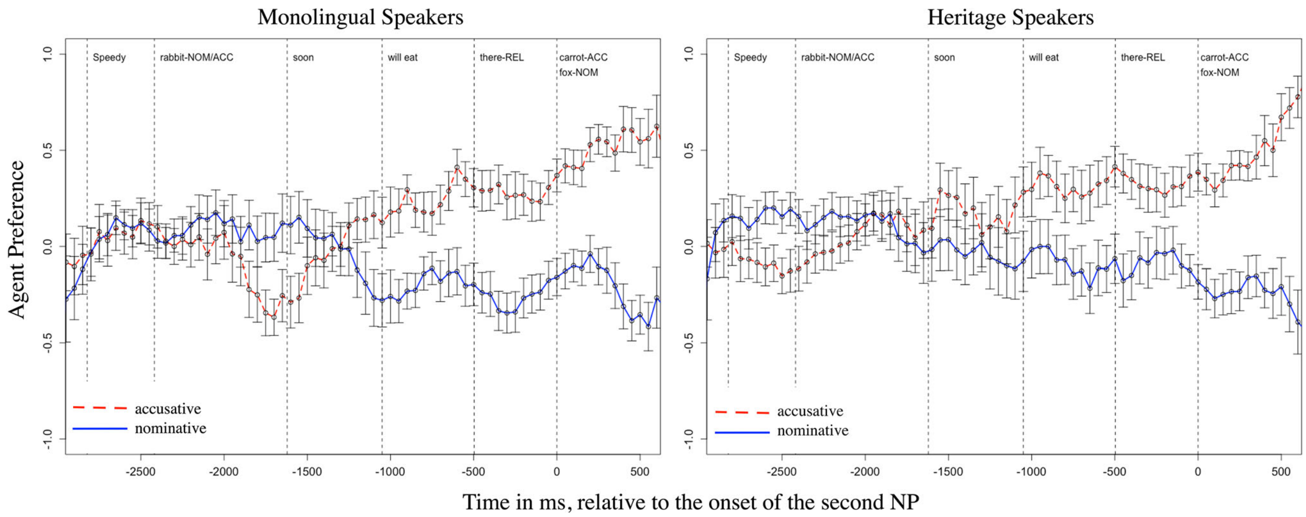

Figure 3. Agent preference for monolingual speakers (left panel) and heritage speakers (right panel) in the verb-medial block.

window in the accusative and nominative condition across monolingual and bilingual groups. The interaction of Condition, Time and Group was also significant, indicating that the prediction effect was different for the monolingual and the heritage groups. In order to further investigate this effect, we performed separate analyses for both groups.

In the monolingual group, the effect of Condition was significant ($\beta = 1.06$, $SE = 0.38$, $z = 2.80$, $p = 0.005$), suggesting that agent preference was different in the two conditions. The interaction of Condition by Time was also significant ($\beta = 0.42$, $SE = 0.02$, $z = 17.25$, $p < .001$), meaning that the agent preference changed based on condition in the course of the predictive time window. In the heritage group, the effect of Condition on agent preference was also significant ($\beta = 1.01$, $SE = 0.43$, $z = 2.35$, $p = 0.019$), suggesting that agent preference was different in the accusative and nominative condition. The interaction effect of Condition and Time was also significant ($\beta = 0.12$, $SE = 0.03$, $z = 3.88$, $p < .001$). The significant interaction of Time and Condition in both groups suggested that agent preference increased in the accusative condition and decreased in the nominative condition over the course of the predictive time window, as visualised in Figure 4. This difference between conditions over time points to a prediction effect in both groups, though it seems to be smaller in magnitude in the heritage group compared to the monolingual group.

Since a significant prediction effect was found in the heritage group, the effect of spoken and written language experience measures in both Turkish and Dutch was further examined in the verb-medial block. As we were interested in six different measures, we

Table 4. Summary of the fixed effects from the generalised linear mixed effects regression model with the interaction between Time, Condition, and Group in the verb-medial block.

	Estimate	SE	z-value	*p*-value
Intercept	0.279	0.143	1.951	0.051
Condition	0.994	0.298	3.337	<.001
Time	0.011	0.010	1.126	0.260
Group	0.514	0.242	2.127	0.033
condition * time	0.268	0.019	13.927	<.001
condition * group	−0.096	0.512	−0.188	0.851
time * group	−0.042	0.019	−2.183	0.029
condition * time * group	−0.302	0.038	−7.841	<.001

agent_preference ~ condition * time * group + (1 + condition|participant) + (1 + group|item)

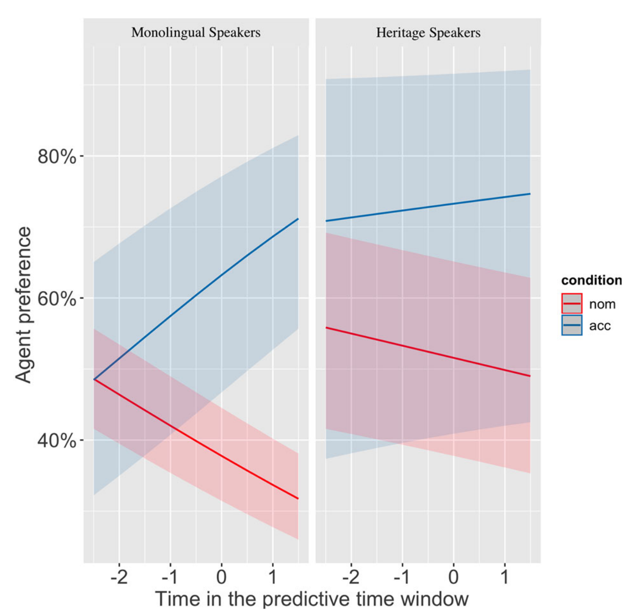

Figure 4. Agent preference in the accusative (blue line) and the nominative (red line) condition over time based on the model calculations in the verb-medial block for monolingual speakers (in the left panel) and heritage speakers (in the right panel).

Table 5. Summary output of the main interaction terms of interest from different generalised linear mixed effects regression models in the heritage group.

Model #	Fixed effects	Estimate	SE	z-value	*p*-value	adjusted *p*-value
1	condition * time * Turkish use	0.072	0.028	2.575	0.010	0.020
2	condition * time * Dutch use	−0.048	0.028	−1.716	0.086	0.103
3	condition * time * Turkish exposure	0.081	0.029	2.805	0.005	0.015
4	condition * time * Dutch exposure	−0.037	0.028	−1.339	0.181	0.181
5	condition * time * Turkish literacy	0.069	0.029	2.370	0.018	0.027
6	condition * time * Dutch literacy	0.115	0.029	3.978	<.001	<.001

Note: The models are based on 24 instead of 25 participants, since one participant did not fill out the relevant section of the questionnaire.

corrected the significance threshold for multiple comparisons in our analyses using the Benjamini-Hochberg procedure (Benjamini & Hochberg, 1995). Table 5 summarises the main interaction effects of the models.

Based on the outputs of the model 2 and model 4 in Table 5, the effect of the heritage speakers' current language use and exposure in Dutch did not significantly modulate their prediction skills. In contrast, the results of model 1 and 3 show that Turkish language use and exposure significantly modulated their prediction skills. As can be seen in the upper panel of Figure 5, as heritage speakers' current exposure to Turkish increased, the difference between their agent preference in accusative and nominative condition also increased over the course of the predictive time window. When their exposure to Turkish was below average, the heritage speakers preferred to look at the agent image more in both conditions. When their current exposure to Turkish increased to average or above average levels, a prediction effect emerged. A similar facilitatory pattern was also found for current Turkish use and Turkish literacy activities, which was expected given the positive correlation between current use and exposure and literacy activities in Turkish. Lastly, literacy activities in Dutch were also found to modulate prediction skills, as visualised in the lower panel of Figure 5: literacy activities in Dutch had a positive effect on prediction skills of heritage speakers in Turkish. The comparable effects of literacy activities in Turkish and Dutch on prediction skills in Turkish suggest an overall facilitatory effect of literacy across two languages.

4. Discussion

This study investigated whether case-marking cues can be used predictively in verb-final and verb-medial sentences by heritage speakers of Turkish and Turkish monolingual speakers, and to what extent language experience in both languages modulates prediction skills of heritage speakers.

The time course of predictive processing in the two groups showed great differences in the use of case-marking cues in prediction: while monolingual speakers were able to generate predictions regardless of the position of the verb in the sentences, replicating Özge

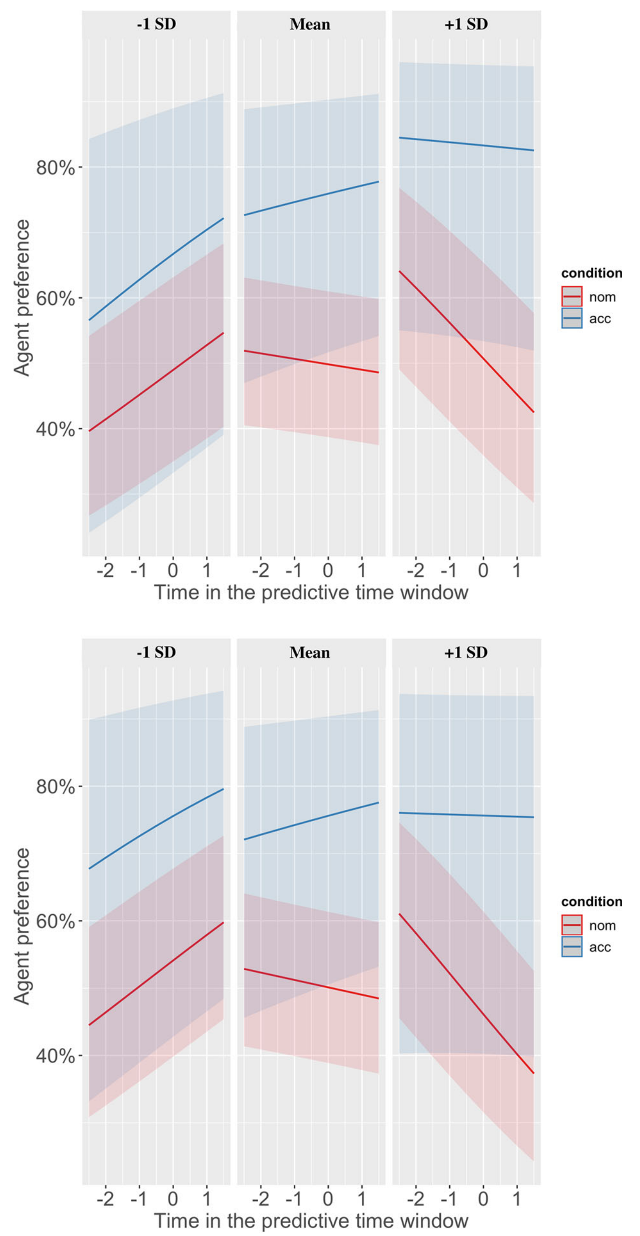

Figure 5. The effect of current exposure to Turkish (upper panel) and current literacy activities in Dutch (lower panel) on prediction skills of heritage speakers.

et al.'s (2019) study, heritage speakers, as a group, were only able to use case-marking cues predictively when these were supported with verb semantics. These findings thus confirm our hypotheses that heritage speakers do not use case-marking cues predictively to the same extent as monolingual speakers, and that heritage speakers show better prediction skills in verb-medial sentences compared to verb-final sentences. The crucial difference between verb-final and verb-medial sentences is that in the former only case-marking cues can be used predictively whereas in the latter both case-marking and semantic information of the verb could be used for prediction. It is important to note that in our design, it was not possible for our participants to use verb-semantic information on its own to predict the targets. Our data do not allow us to separate effects of case marking and verb semantics in both participant groups in the verb-medial sentences (though visual inspection of the graphs suggests that prediction effects start a little before verb onset and hence may have been driven (partly) by case-marking cues). We believe that the following interpretation however is most parsimonious: monolingual participants used both case-marking and verb semantics for prediction in the verb-medial sentences (as they also predicted in verb-final sentences when case-marking was the only predictable cue available). Heritage speakers on the other hand needed the additional information of verb semantics to scaffold the use of morphosyntactic cues for prediction.

We believe that there are two possible reasons for the heritage speakers' inability to generate predictions, as a group, in the verb-final sentences. First, the predictive time window was on average 240 ms shorter in the verb-final sentences compared to verb-medial sentences, meaning that they had more time to generate predictions in the verb-medial sentences. However, since no clear agent preference was found even towards the end of the predictive time window in verb-final sentences in the accusative condition, it seems unlikely that a prediction effect would have been observed with more time.

The second and we believe far more likely explanation is related to how reliable predictive cues are (Macwhinney, 2012; Kaan & Grüter, 2021). Our overall results strongly suggest that morphosyntactic predictive cues on their own are not considered to be fully reliable by heritage speakers. There are also hints for a slightly bigger prediction effect in our data when both cues were available for prediction (in the verb-medial sentences compared to the verb-final sentences) in the monolingual group although no statistical comparisons could be made due to the different durations of the predictive time windows. These results are consistent with previous research that reported benefits of having access to additional cues (e.g. prosody) on predictive processing of case-marking cues in L2 adults and monolingual speakers (e.g. Grüter et al., 2020; Henry et al., 2017, 2022). This study extends the key role of additive cues in predictive processing to the heritage speakers. The findings suggest that cue additivity plays a role in both monolingual and bilingual speakers' predictive processing but perhaps more so in bilinguals since their ability to generate predictions was dependent on the scaffolding from another cue (i.e. verb semantics or prosody).

Though only in verb-medial sentences, Turkish heritage speakers were able to use case-marking cues predictively. This finding is in line with previous studies with heritage speakers that reported morphosyntactic prediction effects based on gender-marking cues (Sekerina, 2015; Fuchs, 2021, 2022), while contradicting the findings of the studies with adult L2 speakers. For instance, Hopp (2015) reported that even the advanced English-German L2 speakers were unable to generate predictions about the thematic role of the second NP when they had access to both case-marking on the first NP and verb semantics unlike monolingual German-speaking adults. Nevertheless, the heritage speakers in our study were able to integrate case-marking and verb-semantics cues to generate predictions similar to Turkish- and German-speaking monolingual adults. The difference in prediction skills between the Turkish heritage speakers and English-German L2 speakers may be explained by heritage speakers' early and naturalistic exposure to informative cues in childhood. However, in order to account for the cross-linguistic differences in the reliability of case-marking cues in Turkish and German, future studies should ideally directly compare predictive use of case-marking cues in Turkish heritage speakers with German heritage speakers and adult L2 speakers of Turkish to tease apart the role of these factors.

The findings of this study support Kaan and Grüter's (2021) utility account, which proposes that predictive processing in both L1 and L2 may be better explained when the utility of predictions is taken into consideration. On this account, listeners weight the cost and benefit of generating predictions to optimise their language processing. The outcome of this cost–benefit analysis hence may not be the same for L1 and L2 speakers because the reliability of the predictive cues might be different for bilingual speakers based on their language experiences, cross-linguistic influence and context of L2 acquisition. Therefore, what seems to be a more efficient language processing strategy for monolingual speakers may not be so for L2 speakers, and the path to maximal processing efficiency may vary in different contexts (Grüter et al., 2020). Accordingly, in the current study, adult heritage speakers may have weighted predictions based solely on case-marking cues to be too costly, but support from another cue (e.g. verb semantics) may have tipped the scale in favour of generating predictions using case-marking cues. Thus, it is conceivable that having access to additional cues such as verb semantics compensates for the potential effects of (1) increased processing demands due to two simultaneously active languages, (2) cross-linguistic influence from Dutch, a language that marks case information only pronominally, and lastly (3) reduced language experience in Turkish, a language with transparent and reliable case-marking cues. Though the present findings fit well with utility accounts such as the one proposed by Kaan and Grüter (2021), it is apparent that considerable further work is needed to explore the potential mechanisms of such a cost and benefit analysis.

The present findings showing that heritage speakers' prediction skills were modulated by their spoken and written language experience support the view that *language experience* is an important factor in predictive language processing. Participants' spoken language experience in Turkish, i.e. their patterns of language exposure and use, benefitted their prediction skills. In other words, the more heritage speakers were exposed to and used Turkish in their everyday life, the better their prediction skills were in the verb-medial sentences.

Regarding the effect of the spoken language exposure, it is conceivable that more exposure to Turkish, operationalised as everyday listening activities, was associated with better prediction skills in this study because of the spoken nature of the stimuli used. More experience with listening activities in Turkish in everyday life may lead to faster and more efficient processing of spoken language, leaving more cognitive resources to generate predictions. Everyday spoken language exposure may also sharpen the probabilistic knowledge of listeners (Ito & Sakai, 2021; Kuperberg & Jaeger, 2016), such that when everyday language exposure is reduced, listeners may have fewer opportunities to update their probabilistic knowledge and consequently they may assess generating predictions to be costly.

The observed effects of spoken language use, operationalised as everyday speaking activities, are also informative for evaluating potential links between language production and prediction. Prediction-by-production models of predictive language processing propose that predictions are formed (entirely or partly) using language production mechanisms (e.g. Ito & Pickering, 2021; Mani & Huettig, 2012; Pickering & Gambi, 2018). When heritage speakers engage more in spoken language production activities in their everyday life, they may be better able to employ cues that involve the later stages of production (i.e. syntactic information) to generate predictions in Turkish.

Written language experience both in Turkish and in Dutch, operationalised as everyday reading and writing activities, was also found to facilitate predictive processing (in line with e.g. Favier et al., 2021; Huettig & Brouwer, 2015; Mani & Huettig, 2014; Mishra et al., 2012). This suggests that reading and writing activities of adult heritage speakers may have affected their predictive processing skills through primary and secondary influences of reading behaviour (see Huettig & Pickering, 2019 for a detailed discussion). Regarding the primary influences, written language experiences in both languages may have trained their prediction mechanisms by providing opportunities to practise with written language decoding as well as by exposing them to written words that are more form-invariant compared to spoken words. Given that some representations are shared between the two modalities, these experiences may also transfer to prediction in spoken language. It is, then, conceivable that written language experiences not only in Turkish but also in Dutch language facilitated the predictive processing skills in Turkish. Additionally, being exposed to book language, which is lexically and syntactically more diverse, may lead to more well-developed vocabulary and verbal working memory (Huettig & Pickering, 2019; Smalle et al., 2019).

Given the mediating role of language experience in this study and the similarities and differences observed in the prediction skills of adult heritage speakers, adult L2 speakers, child heritage speakers as well as monolingual speakers, one should critically reflect on the validity of treating these populations as categorically different (e.g. Grüter, 2023). There is emerging consensus in the field that bilingualism should be viewed as a continuum (e.g. Luk & Bialystok, 2013; Wiese et al., 2022). Focusing on the role of individual differences such as language experience (e.g. Dussias, 2023; Grüter, 2023) as one of the variables contributing to the placement of individuals along such a continuum would enable future research with opportunities to gain a comprehensive understanding of predictive processing.

5. Conclusion

Our results showed that heritage speakers are able to use morphosyntactic cues when they are scaffolded by verb semantics. Their experience with spoken and written language in the heritage language as well as the written language in the majority language improves their prediction skills in the heritage language. These findings underscore the prominent role of language experience in predictive processing and also support the argument that written language has a direct and enhancing effect on spoken predictive processing skills (Pickering & Huettig, 2019). Furthermore, the effect of written language experience is not limited to the language in which these activities are performed (e.g. Parshina et al., 2022), indicating that engaging in literacy activities trains core aspects of predictive processing that are shared across two languages.

Notes

1. Even though many studies still use the term monolingual speakers, this group usually consists of university students who have been exposed to one or more foreign languages at schools. While we acknowledge that these presumed monolinguals may not be "true" monolinguals after all, we continue to refer to them as monolinguals for consistency of the comparisons we will make across studies.
2. In this study, we preferred to refer to our bilingual group as "heritage speakers" even though some prior studies with heritage speakers covered a broader range of age of arrival or age of onset to the majority language than our study in which we strictly set the cut-off point at 4 years in terms of age of onset. We chose this terminology following the definition provided in the introduction since we focused on the heritage language skills of the bilingual group. However, we acknowledge that other studies may prefer and use "early bilinguals" to refer to the same group.
3. Data collection took place between 2020 and 2021 during the COVID19 pandemic. Therefore, testing participants in a lab environment was not always possible.

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Data availability statement

The data that support the findings of this study as well as analysis scripts are openly available at OSF: https://osf.io/uk94s/?view_only=f297563ae308481d9039b0c97baa73ee.

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References

Altmann, G. T. M., & Kamide, Y. (1999). Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition*, *73*(3), 247–264. https://doi.org/10.1016/S0010-0277(99)00059-1

Altmann, G. T. M., & Mirković, J. (2009). Incrementality and prediction in human sentence processing. *Cognitive Science*, *33*(4), 583–609. https://doi.org/10.1111/j.1551-6709.2009.01022.x

Barr, D., Levy, R., Scheepers, C., & Tily, H. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, *68*(3), 255–278. https://doi.org/10.1016/j.jml.2012.11.001

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lm4. *Journal of Statistical Software*, *67*(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Bates, E., & MacWhinney, B. (1989). Functionalism and the competition model. In B. MacWhinney & E. Bates (Eds.), *The cross-linguistic study of sentence processing* (pp. 3–76). Cambridge University Press.

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society: Series B (Methodological)*, *57*(1), 289–300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x

Benmamoun, E., Montrul, S., & Polinsky, M. (2013). Heritage languages and their speakers: Opportunities and challenges for linguistics. *Theoretical Linguistics*, *39*(3–4), 129–181. https://doi.org/10.1515/tl-2013-0009

Boersma, P., & Weenink, D. (2017). Praat: Doing phonetics by computer [Computer program]. Version 6.0.29, retrieved from https://www.praat.org

Borovsky, A., Elman, J. L., & Fernald, A. (2012). Knowing a lot for one's age: Vocabulary skill and not age is associated with anticipatory incremental sentence interpretation in children and adults. *Journal of Experimental Child Psychology*, *112*(4), 417–436. https://doi.org/10.1016/j.jecp.2012.01.005

Brouwer, S., Özkan, D., & Küntay, A. C. (2019). Verb-based prediction during language processing: The case of Dutch and Turkish. *Journal of Child Language*, *46*(1), 80–97. https://doi.org/10.1017/S0305000918000375

Brouwer, S., Sprenger, S., & Unsworth, S. (2017). Processing grammatical gender in Dutch: Evidence from eye movements. *Journal of Experimental Child Psychology*, *159*, 50–65. https://doi.org/10.1016/j.jecp.2017.01.007

Çakıcı, R. (2005). Automatic induction of a CCG grammar for Turkish. In *Proceedings of the ACL Student Research*

Workshop (pp. 73–78). Association for Computational Linguistics.

Candan, A., Küntay, A. C., Yeh, Y., Cheung, H., Wagner, L., & Naigles, L. R. (2012). Language and age effects in children's processing of word order. *Cognitive Development*, *27*(3), 205–221. https://doi.org/10.1016/j.cogdev.2011.12.001

Coşkun-Kunduz, A., & Montrul, S. (2022). Sources of variability in the acquisition of differential object marking by Turkish heritage language children in the United States. *Bilingualism: Language and Cognition*, *25*(4), 603–616. https://doi.org/10.1017/S1366728921001000

Dell, G. S., & Chang, F. (2014). The P-chain: Relating sentence production and its disorders to comprehension and acquisition. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1634), 20120394. https://doi.org/10.1098/rstb.2012.0394

Demiral, S. B. I., Schlesewsky, M., & Bornkessel-Schlesewsky, I. (2008). On the universality of language comprehension strategies: Evidence from Turkish. *Cognition*, *106*(1), 484–500. https://doi.org/10.1016/j.cognition.2007.01.008

Doğruöz, A. S., & Backus, A. (2009). Innovative constructions in Dutch Turkish: An assessment of ongoing contact-induced change. *Bilingualism: Language and Cognition*, *12*(1), 41–63. https://doi.org/10.1017/S1366728908003441

Dussias, P. E. (2023). Transdisciplinary approaches to understanding variability in bilingual processing and use. In A. Godfroid & H. Hopp (Eds.), *The Routledge handbook of second language acquisition and psycholinguistics* (pp. 268–277). Routledge.

Erguvanlı, E. E. (1984). *The function of word order in Turkish grammar*. University of California Press.

Favier, S., Meyer, A. S., & Huettig, F. (2021). Literacy can enhance syntactic prediction in spoken language processing. *Journal of Experimental Psychology: General*, *150*(10), 2167–2174. https://doi.org/10.1037/xge0001042

Federmeier, K. D. (2007). Thinking ahead: The role and roots of prediction in language comprehension. *Psychophysiology*, *44*(4), 491–505. https://doi.org/10.1111/j.1469-8986.2007.00531.x

Felser, C., & Arslan, S. (2019). Inappropriate choice of definites in Turkish heritage speakers of German. *Heritage Language Journal*, *16*(1), 22–43. https://doi.org/10.46538/hlj.16.1.2

Ferreira, F., & Chantavarin, S. (2018). Integration and prediction in language processing: A synthesis of old and new. *Current Directions in Psychological Science*, *27*(6), 443–448. https://doi.org/10.1177/0963721418794491

Foucart, A. (2015). Prediction is a question of experience. *Linguistic Approaches to Bilingualism, 5*(4), 465–469. https://doi.org/10.1075/lab.5.4.04fou

Foucart, A., Martin, C. D., Moreno, E. M., & Costa, A. (2014). Can bilinguals see it coming? Word anticipation in L2 sentence reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *40*(5), 1461–1469. https://doi.org/10.1037/a0036756

Frenck-Mestre, C., Kim, S. K., Choo, H., Ghio, A., Herschensohn, J., & Koh, S. (2019). Look and listen! The online processing of Korean case by native and non-native speakers. *Language, Cognition and Neuroscience*, *34*(3), 385–404. https://doi.org/10.1080/23273798.2018.1549332

Fuchs, Z. (2021). Facilitative use of grammatical gender in Heritage Spanish. *Linguistic Approaches to Bilingualism*, *12*(6), 845–871. https://doi.org/10.1075/lab.20024.fuc

Fuchs, Z. (2022). Eyetracking evidence for heritage speakers' access to abstract syntactic agreement features in real-time processing. *Frontiers in Psychology*, *13*), https://doi.org/10.3389/fpsyg.2022.960376

Grüter, T. (2023). Synthesis: Psycholinguistics across the lifespan. In A. Godfroid & H. Hopp (Eds.), *The Routledge handbook of second language acquisition and psycholinguistics* (pp. 97–107). Routledge.

Grüter, T., Lau, E., & Ling, W. (2020). How classifiers facilitate predictive processing in L1 and L2 Chinese: The role of semantic and grammatical cues. *Language, Cognition and Neuroscience*, *35*(2), 221–234. https://doi.org/10.1080/23273798.2019.1648840

Hale, J. (2001). A probabilistic early parser as a psycholinguistic model. In *Proceedings of the Second Meeting of North American Chapter of the Association for Computational Linguistics on Technologies* (pp. 159–166).

Henry, N., Hopp, H., & Jackson, C. N. (2017). Cue additivity and adaptivity in predictive processing. *Language, Cognition and Neuroscience*, *32*(10), 1229–1249. https://doi.org/10.1080/23273798.2017.1327080

Henry, N., Hopp, H., & Jackson, C. N. (2022). Cue coalitions and additivity in predictive processing: The interaction between case and prosody in L2 German. *Second Language Research*, *38*(3), 397–422. https://doi.org/10.1177/0267658320963151

Hickok, G. (2012). Computational neuroanatomy of speech production. *Nature Reviews Neuroscience, 13*(2), 135–145. https://doi.org/10.1038/nrn3158

Hopp, H. (2013). Grammatical gender in adult L2 acquisition: Relations between lexical and syntactic variability. *Second Language Research, 29*(1), 33–56. https://doi.org/10.1177/0267658312461803

Hopp, H. (2015). Semantics and morphosyntax in L2 predictive sentence processing. *International Review of Applied Linguistics in Language Teaching*, *53*(3), 277–306. https://doi.org/10.1515/iral-2015-0014

Hopp, H. (2016). Learning (not) to predict: Grammatical gender processing in second language acquisition. *Second Language Research*, *32*(2), 277–307. https://doi.org/10.1177/0267658315624960

Hopp, H., & Lemmerth, N. (2018). Lexical and syntactic congruency in L2 predictive gender processing. *Studies in Second Language Acquisition*, *40*(1), 171–199. https://doi.org/10.1017/S0272263116000437

Huettig, F. (2015). Four central questions about prediction in language processing. *Brain Research*, *1626*, 118–135. https://doi.org/10.1016/j.brainres.2015.02.014

Huettig, F., Audring, J., & Jackendoff, R. (2022). A parallel architecture perspective on pre-activation and prediction in language processing. *Cognition*, *224*, 105050. https://doi.org/10.1016/j.cognition.2022.105050

Huettig, F., & Brouwer, S. (2015). Delayed anticipatory spoken language processing in adults with dyslexia—Evidence from eye-tracking. *Dyslexia*, *21*(2), 97–122. https://doi.org/10.1002/dys.1497

Huettig, F., & Janse, E. (2016). Individual differences in working memory and processing speed predict anticipatory spoken language processing in the visual world. *Language, Cognition and Neuroscience*, *31*(1), 80–93. https://doi.org/10.1080/23273798.2015.1047459

Huettig, F., & Pickering, M. J. (2019). Literacy advantages beyond reading: Prediction of spoken language. *Trends in*

Cognitive Sciences, *23*(6), 464–475. https://doi.org/10.1016/j.tics.2019.03.008

Ito, A., Corley, M., & Pickering, M. J. (2018). A cognitive load delays predictive eye movements similarly during L1 and L2 comprehension. *Bilingualism: Language and Cognition*, *21*(2), 251–264. https://doi.org/10.1017/S1366728917000050

Ito, A., & Pickering, M. J. (2021). Automaticity and prediction in non-native language comprehension. In E. Kaan & T. Grüter (Eds.), *Prediction in second language processing and learning* (pp. 26–46). John Benjamins Publishing Company.

Ito, A., & Sakai, H. (2021). Everyday language exposure shapes prediction of specific words in listening comprehension: A visual world eye-tracking study. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.607474

Kaan, E., & Grüter, T. (2021). Prediction in second language processing and learning: Advances and directions. In E. Kaan & T. Grüter (Eds.), *Prediction in second language processing and learning* (pp. 2–24). John Benjamins Publishing Company.

Karaca, F., Brouwer, S., Unsworth, S., & Huettig, F. (2021). Prediction in bilingual children: The missing piece of the puzzle. In E. Kaan & T. Grüter (Eds.), *Prediction in second language processing and learning* (pp. 116–137). John Benjamins Publishing Company.

Karayayla, T. (2018). *Turkish as an immigrant and heritage language in the UK: Effects of exposure and age at onset of bilingualism on grammatical and lexical development of the first language* [Doctoral dissertation]. University of Essex. http://repository.essex.ac.uk/id/eprint/22392

Ketrez, F. N., & Aksu-Koç, A. (2009). Early nominal morphology in Turkish: Emergence of case and number. In U. Stephany & M. D. Voeikova (Eds.), *Development of nominal inflection in first language acquisition: A cross-linguistic perspective* (pp. 15–48). Mouton De Gruyter.

Kuperberg, G. R., & Jaeger, T. F. (2016). What do we mean by prediction in language comprehension? *Language, Cognition and Neuroscience*, *31*(1), 32–59. https://doi.org/10.1080/23273798.2015.1102299

Levy, R. (2008). Expectation-based syntactic comprehension. *Cognition*, *106*(3), 1126–1177. https://doi.org/10.1016/j.cognition.2007.05.006

Li, P., Zhang, F., Tsai, E., & Puls, B. (2014). Language history questionnaire (LHQ 2.0): A new dynamic web-based research tool. *Bilingualism: Language and Cognition*, *17*(3), 673–680. https://doi.org/10.1017/S1366728913000606

Luk, G., & Bialystok, E. (2013). Bilingualism is not a categorical variable: Interaction between language proficiency and usage. *Journal of Cognitive Psychology*, *25*(5), 605–621. https://doi.org/10.1080/20445911.2013.795574

Macwhinney, B. (2012). The logic of the unified model. In A. Mackey & S. M. Gass (Eds.), *The Routledge handbook of second language acquisition* (pp. 211–227). Routledge.

Mani, N., & Huettig, F. (2012). Prediction during language processing is a piece of cake—But only for skilled producers. *Journal of Experimental Psychology: Human Perception and Performance*, *38*(4), 843–847. https://doi.org/10.1037/a0029284

Mani, N., & Huettig, F. (2014). Word reading skill predicts anticipation of upcoming spoken language input: A study of children developing proficiency in reading. *Journal of Experimental Child Psychology*, *126*, 264–279. https://doi.org/10.1016/j.jecp.2014.05.004

Marian, V., Blumenfeld, H. K., & Kaushanskaya, M. (2007). The language experience and proficiency questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech, Language, and Hearing Research*, *50*(4), 940–967. https://doi.org/10.1044/1092-4388(2007/067)

Martin, C. D., Thierry, G., Kuipers, J. R., Boutonnet, B., Foucart, A., & Costa, A. (2013). Bilinguals reading in their second language do not predict upcoming words as native readers do. *Journal of Memory and Language*, *69*(4), 574–588. https://doi.org/10.1016/j.jml.2013.08.001

Mathôt, S., Schreij, D., & Theeuwes, J. (2012). Opensesame: An open-source, graphical experiment builder for the social sciences. *Behavior Research Methods*, *44*(2), 314–324. https://doi.org/10.3758/s13428-011-0168-7

Meir, N., Parshina, O., & Sekerina, I. A. (2020). The interaction of morphological cues in bilingual sentence processing: An eye-tracking study. In M. M. Brown & A. Kohut (Eds.), *Proceedings of the 44th Annual Boston University Conference on Language Development* (pp. 376–389). Cascadilla Press.

Mishra, R. K., Singh, N., Pandey, A., & Huettig, F. (2012). Spoken language-mediated anticipatory eye movements are modulated by reading ability: Evidence from Indian low and high literates. *Journal of Eye Movement Research*, *5*(1), https://doi.org/10.16910/jemr.5.1.3

Mitsugi, S., & MacWhinney, B. (2016). The use of case marking for predictive processing in second language Japanese. *Bilingualism: Language and Cognition*, *19*(1), 19–35. https://doi.org/10.1017/S1366728914000881

Norris, D., McQueen, J. M., & Cutler, A. (2016). Prediction, Bayesian inference and feedback in speech recognition. *Language, Cognition and Neuroscience*, *31*(1), 4–18. https://doi.org/10.1080/23273798.2015.1081703

Oflazer, K., Say, B., Hakkani-Tür, D. Z., & Tür, G. (2003). Building a Turkish Treebank. In A. Abeille (Ed.), *Treebanks: Building and using parsed corpora* (pp. 261–277). Kluwer.

Özge, D., Küntay, A. C., & Snedeker, J. (2019). Why wait for the verb? Turkish speaking children use case markers for incremental language comprehension. *Cognition*, *183*, 152–180. https://doi.org/10.1016/j.cognition.2018.10.026

Özkan, D., Küntay, A. C., & Brouwer, S. (2022). The role of verbal and working memory skills in Turkish-speaking children's morphosyntactic prediction. *Applied Psycholinguistics*, *43*(6), 1305–1328. https://doi.org/10.1017/S0142716422000388

Parshina, O., Lopukhina, A., & Sekerina, I. A. (2022). Can heritage speakers predict lexical and morphosyntactic information in reading? *Languages*, *7*(1), 60.

Pickering, M. J., & Gambi, C. (2018). Predicting while comprehending language: A theory and review. *Psychological Bulletin*, *144*(10), 1002–1044. https://doi.org/10.1037/bul0000158

Pickering, M. J., & Garrod, S. (2013). An integrated theory of language production and comprehension. *Behavioral and Brain Sciences*, *36*(4), 329–347. https://doi.org/10.1017/S0140525X12001495

Porretta, V., Buchanan, L., & Järvikivi, J. (2020). When processing costs impact predictive processing: The case of foreign-accented speech and accent experience. *Attention, Perception, & Psychophysics*, *82*(4), 1558–1565. https://doi.org/10.3758/s13414-019-01946-7

Sağın-Şimşek, Ç. (2016). Acquisition of canonical and non-canonical word orders in L1 Turkish. In B. Haznedar & F. N.

Ketrez (Eds.), *The acquisition of Turkish in childhood* (pp. 79–98). John Benjamins.

Şahin, H. (2015). *Cross-linguistic influences: Dutch in contact with Papiamento and Turkish* [Doctoral dissertation]. Radboud University Nijmegen. https://hdl.handle.net/2066/143608

Schlenter, J., & Felser, C. (2021). Second language prediction ability across linguistic domains: Evidence from German. In E. Kaan & T. Grüter (Eds.), *Prediction in second language processing and learning* (pp. 48–68). John Benjamins Publishing Company.

Schmid, M. S. (2004). A new blueprint for language attrition research. In M. S. Schmid, B. Köpke, M. Keijzer, & L. Weilemar (Eds.), *First language attrition interdisciplinary perspectives on methodological issues* (pp. 349–364). John Benjamins.

Schwartz, B. (2004). Why child L2 acquisition?. In J. Van Kampen & S. Baauw (Eds.), *Proceedings of generative approaches to language acquisition* (pp. 47–66). LOT Occasional Series.

Sekerina, I. A. (2015). Predictions, fast and slow. *Linguistic Approaches to Bilingualism*, *5*(4), 532–536. https://doi.org/10.1075/lab.5.4.16sek

Sevinç, Y. (2012). *Lexical and structural changes in Turkish spoken in The Netherlands. Linguistic and social factors in Turkish-Dutch contact* [MA thesis]. Radboud University Nijmegen. https://doi.org/10.13140/RG.2.2.21338.36802

Slobin, D. I., & Bever, T. G. (1982). Children use canonical sentence schemas: A crosslinguistic study of word order and inflections. *Cognition*, *12*(3), 229–265. https://doi.org/10.1016/0010-0277(82)90033-6

Smalle, E. H. M., Szmalec, A., Bogaerts, L., Page, M. P. A., Narang, V., Misra, D., Araújo, S., Lohagun, N., Khan, O., Singh, A., Mishra, R. K., & Huettig, F. (2019). Literacy improves short-term serial recall of spoken verbal but not visuospatial items—Evidence from illiterate and literate adults. *Cognition*, *185*, 144–150. https://doi.org/10.1016/j.cognition.2019.01.012

Unsworth, S. (2005). *Child L2, adult L2, child L1 differences and similarities. A study on the acquisition of object scrambling in Dutch*. Doctoral dissertation. Utrecht Institute of Linguistics OTS, LOT, Netherlands Graduate School of Linguistics.

Unsworth, S. (2013). Assessing age of onset effects in (early) child L2 acquisition. *Language Acquisition*, *20*(2), 74–92. https://doi.org/10.1080/10489223.2013.766739

van Bergen, G., & Flecken, M. (2017). Putting things in new places: Linguistic experience modulates the predictive power of placement verb semantics. *Journal of Memory and Language*, *92*, 26–42. https://doi.org/10.1016/j.jml.2016.05.003

van Dijk, C.. (2021). *Cross-linguistic influence during real-time sentence processing in bilingual children and adults* [Doctoral dissertation]. Radboud University Nijmegen. https://hdl.handle.net/2066/237146

van Petten, C., & Luka, B. J. (2012). Prediction during language comprehension: Benefits, costs, and ERP components. *International Journal of Psychophysiology*, *83*(2), 176–190. https://doi.org/10.1016/j.ijpsycho.2011.09.015

Wechsler, D. (2008). *Wechsler adult intelligence scale-fourth edition (WAIS-IV)*. https://psycnet.apa.org/doi/10.1037t15169-000

Wiese, H., Alexiadou, A., Allen, S., Bunk, O., Gagarina, N., Iefremenko, K., Martynova, M., Pashkova, T., Rizou, V., Schroeder, C., Shadrova, A., Szucsich, L., Tracy, R., Tsehaye, W., Zerbian, S., & Zuban, Y. (2022). Heritage speakers as part of the native language continuum. *Frontiers in Psychology*, *12*, 717–973. https://doi.org/10.3389/fpsyg.2021.717973