Prediction in bilingual children: The missing piece of the puzzle

Figen Karaca[1], Susanne Brouwer[1], Sharon Unsworth[1], and Falk Huettig[1,2]

[1]Centre for Language Studies, Radboud University, Nijmegen, the Netherlands

[2]Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands

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Abstract

A wealth of studies has shown that more proficient monolingual speakers are better at predicting upcoming information during language comprehension. Similarly, prediction skills of adult second language (L2) speakers in their L2 have also been argued to be modulated by their L2 proficiency. How exactly language proficiency and prediction are linked, however, is yet to be systematically investigated. One group of language users which has the potential to provide invaluable insights into this link is bilingual children. In this paper, we compare bilingual children's prediction skills with those of monolingual children and adult L2 speakers, and show how investigating bilingual children's prediction skills may contribute to our understanding of how predictive processing works.

Keywords: bilingual children, prediction, cross-linguistic influence, language proficiency

What is prediction?

One of the most fascinating characteristics of language comprehension is how efficient and effortless it is in spite of the fast and incremental nature of spoken language. Listeners actively process the rapid speech signals as they unfold by not only incrementally analyzing incoming input but also by generating predictions about the upcoming information. In other words, they successfully pre-activate specific linguistic input before it is encountered (e.g., Altmann & Mirkovic, 2009; Dell & Chang, 2014; Federmeier, 2007; Ferreira & Chantavarin, 2018; Gibson et al., 2013; Hale, 2001; Hickok, 2012; Huettig 2015; Kuperberg & Jaeger, 2016; Levy, 2008; Norris et al., 2016; Pickering & Gambi, 2018; Pickering & Garrod, 2013; van Petten & Luka, 2012). It is worth noting that there is no consensus on the definition of *prediction* in language. Some argue for differentiating between facilitation and prediction in that the former means faster and easier processing of a word, whereas the latter requires pre-activation of the linguistic representation of a specific word. In this paper, we will include studies that differentiate facilitation from prediction as well as those that do not. We believe that in almost all cases facilitation of a word is a consequence of pre-activation (e.g., through priming) and thus part of predictive processing. We define prediction here as the pre-

activation of linguistic representations before incoming bottom-up input has had a chance to activate them (Huettig, 2015).

Information from various levels of representation including but not limited to morphosyntax, semantics, and discourse might serve as a reliable cue in predicting the meaning of the upcoming signal. For instance, Altmann and Kamide (1999), in their seminal work, argued that monolingual adult speakers use the semantic restrictions of verbs to predict upcoming information. Using a visual world paradigm (VWP; Cooper, 1974; Tanenhaus et al., 1995), they presented participants with sentences that contained a semantically restraining verb such as *The boy will eat the cake*, or a neutral verb such as *The boy will move the cake* in a visual context of a toy train set, a toy car, a balloon, and a birthday cake. In this context, only the cake was edible while all objects could be moved by the agent. The analyses of the eye-movements revealed that having heard the verb *eat*, the participants looked at the only edible object more often before encountering the word *cake*. Based on these anticipatory eye movements, it was clear that the listeners were able to make predictions about the upcoming information in a sentence based on the cues at their disposal, in this case verb semantics.

How are prediction and proficiency related?

Studies conducted so far have robustly suggested that not only monolingual adults but also monolingual children successfully engage in predictive language processing (e.g., Brouwer, Sprenger, Unsworth, 2017; Brouwer et al., 2019; Havron et al., 2019; Lew-Williams & Fernald, 2007; Mani & Huettig, 2012; Özge et al., 2019). Prediction skills of monolingual adults and children have been argued to be modulated by their language proficiency, variously measured using target-like production of certain linguistic structures, vocabulary knowledge, and reading skills (e.g., Borovsky et al., 2012; Brouwer, Sprenger, & Unsworth, 2017; Gambi et al., 2020; Huettig & Brouwer, 2015; Mani et al., 2016; Mani & Huettig, 2012, 2014; Rommers et al., 2015). This link between language proficiency and prediction may be bidirectional, in that not only people improve in prediction as they become more proficient language users, but also prediction ability may support linguistic development through facilitating processing of linguistic input in childhood (e.g., Gambi et al., 2020; Gambi, this volume). In other words, prediction may directly or indirectly facilitate language learning (though it may not be necessary for learning, see Huettig & Mani, 2016; see also Hopp, this volume).

The importance placed on prediction in relation to cognition and language learning has led to extensive research on second language (L2) users' engagement in prediction. Given that L2 acquisition is characterized

by considerable individual variation, it is not surprising that studies in L2 predictive processing have yielded mixed results. Some studies provided evidence for successful prediction effects to a similar extent as monolingual speakers (e.g., Dijkgraaf et al., 2017; Ito et al., 2018), whereas other studies demonstrated smaller or delayed effects and in some cases no effect of prediction (e.g., Hopp, 2015; Mitsugi & MacWhinney, 2016). The studies reporting little to no prediction effects mostly investigated predictive use of (morpho)syntactic cues such as case and gender marking, which is difficult to master even for monolingual speakers, depending on the transparency of the cues. Adult L2 speakers' ability to use such cues predictively has been shown to be modulated by their L2 proficiency (e.g., Dussias et al., 2013; Hopp, 2013; Hopp & Lemmerth, 2018; but cf. Hopp 2015; Ito et al., 2018; Dijkgraaf et al., 2017) and the presence of the same cues in their L1 (e.g., Dussias et al., 2013; Foucart et al., 2014; see also Foucart, this volume).

Overall, then, increased language proficiency as measured by vocabulary size, reading skills, and target-like production of certain structures, has been shown to facilitate prediction skills of not only monolingual speakers but also adult L2 speakers. In the case of the latter group, L1-L2 similarity also plays a role.

Not only linguistic but also cognitive skills play a role in predictive processing. This is because language processing and more general

cognitive processing are closely intertwined. Studies suggest, for instance, that age-related cognitive changes result in decreased prediction in language processing (e.g., Federmeier & Kutas, 2005), and higher working memory capacity in increased prediction in language processing (Huettig & Janse, 2016; Ito et al., 2018). This suggests that language proficiency and the availability of more general cognitive resources both determine prediction in language processing and one should not be considered without the other.

What we know so far about predictive processing in relation to language proficiency and cognitive skills has been shaped around data provided by monolingual speakers (e.g., Huettig & Janse, 2016; Mani & Huettig, 2012, 2014) and by adult L2 speakers (e.g., Dussias et al., 2013; Hopp, 2013; Hopp & Lemmerth, 2018). One group that has been neglected so far but may contribute to our understanding of prediction in general is bilingual children. Within the framework of this chapter, we define bilingual children as children who were exposed to two languages before the age of four (e.g., Genesee et al., 2004; McLaughlin, 1978; Unsworth, 2013a), and who are exposed to and use both their languages in their daily lives, that is, what are commonly referred to as simultaneous or early sequential bilinguals.

Investigating bilingual children's prediction skills may help us better understand the way predictive processing works. More specifically,

this line of investigation may be informative in two different ways: due to both similarities to and differences from a) monolingual children and b) adult L2 speakers. First, on average, bilingual children are similar to monolingual children in their trajectory of developing cognitive skills but different in that they are acquiring more than one language. Being exposed to two languages in their daily lives causes significant variation in the language environments of bilingual children both between bilingual children and as a group in comparison to monolingual children. As a result, even though most bilingual children's language development is within normal range in one of their language and sometimes in both, their language proficiencies show significant variation. The extent of this variation is what sets bilingual children apart from their monolingual peers, who also vary but likely to a lesser extent, and it may enable researchers to investigate the role of language proficiency in predictive processing more comprehensively.

The second way in which investigating bilingual children's prediction skills may inform our understanding of predictive processing is in comparison with adult L2 speakers. Bilingual children are similar to adult L2 speakers in that they have two languages but they differ as to whether these languages develop sequentially or simultaneously. Adult L2 speakers have an already entrenched L1 system when they start to learn an L2. Furthermore, they often learn their L2 in classroom environments,

which limits their experiences with the target language significantly. Because they are more dominant and proficient in their L1, they often exhibit unidirectional cross-linguistic influence, that is from L1 to L2. In contrast, bilingual children's two languages develop more or less in parallel and their relative proficiency in the two languages varies considerably: they may be more or less equally proficient in both languages or more proficient in either of their languages. Such varied relative proficiencies and potential effects of bidirectional cross-linguistic influence offer a good place to start exploring the mediating role of language proficiency in prediction skills in one language, and the interaction of prediction skills in two languages in a developing mind.

In sum, these differences show us that including bilingual children into prediction research might provide new insights into prediction that neither monolingual children nor adult L2 speakers offer. This paper will argue that given the similarities and differences between bilingual and monolingual children as well as bilingual children and adult L2 speakers, studies with bilingual children have the potential to provide a relevant test case to investigate (1) the role of language proficiency in prediction due to the significant amount of variation that is observed in bilingual children in comparison to monolingual children and adult L2 speakers, and (2) the role of cross-linguistic influence in predictive processing in the absence of a fully-acquired L1. The following sections will review the studies with

monolingual children and adult L2 speakers, and show how examining bilingual children's prediction skills could contribute to predictive processing research. We will also show how studies with bilingual children may inform (L2) predictive processing accounts, concluding with suggestions for future research.

What do we know about prediction skills in monolingual children?

Children's predictive language processing skills have predominantly been investigated in monolingual populations. A growing number of studies suggests that monolingual children can exploit cues from various sources such as verb semantics (e.g., Borovsky et al., 2012; Brouwer et al., 2019; Gambi et al., 2018; Mani & Huettig, 2012; Mani et al., 2016) and morphosyntax (e.g., Brouwer, Sprenger, & Unsworth, 2017; Lew-Williams & Fernald, 2007; Lukyanenko & Fisher, 2016; Melançon & Shi, 2015; van Heugten & Shi, 2009) in order to generate predictions about the upcoming information. However, the way in which the prediction system of monolingual children develops is to a certain extent language-specific, in that not all languages have the same predictive cues. Their performance, moreover, is modulated by their language proficiency as measured with vocabulary knowledge and target-like production of certain structures.

Previous work has shown that children may rely on different cues in predictive processing depending on the language they speak. For some languages monolingual children can use a cue predictively at a very young age, whereas in some other languages predictive use of the same cue may be delayed. For instance, monolingual German-speaking children as young as 2-year-old can predict upcoming information when presented with sentences containing semantically restricting or neutral verbs (e.g., *eat* vs. *see*) accompanied by two familiar images (e.g., cake and bird) (Mani & Huettig, 2012). Similarly, monolingual English-speaking children were also able to combine such semantic cues with structural relations (e.g., argument structure) to guide their predictions around the age of four (Gambi et al., 2016). In contrast, 4-to-5-year-old monolingual Turkish-speaking children were not able to use verb semantics predictively unlike their Dutch-speaking peers (Brouwer et al., 2019). Furthermore, when the word order and verb semantics were the only cues at their disposal (i.e., in the absence of any case-marking cues), Turkish monolingual children showed uncertainty in figuring out the argument structure around the ages of one to three (Candan et al., 2012). One possibility explaining these results is that children speaking a head-final language might prioritize early-arriving cues (e.g., case-marking) over late-arriving cues (e.g., verb semantics) (Choi & Trueswell, 2010), or that in such languages morphosyntactic cues bear more predictive power.

In line with such suggestions, it has been observed that Turkish-speaking monolingual children can successfully exploit case-marking cues for predictive processing. Özge and colleagues (2019) investigated whether 4-to-5-year-old Turkish-speaking monolingual children can use accusative or nominative case-marking on the first noun phrase (NP) to predict the second NP in the sentence, where the former marks the direct object while the latter the subject. They presented children with sentences in which the first NP was either in nominative (i.e., the subject) or accusative (i.e., the direct object) case. Accompanying such sentences, a visual context with three related images was presented. 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 results showed that in verb-final sentences, after hearing the sentence initial accusative-marked NP, children fixated more on the plausible agent prior to hearing the verb and the second NP. These findings clearly demonstrated that children were sensitive to case-marking information, and further used that cue to predict the thematic role of the upcoming noun. Taken together, it appears to be the case that the strategies monolingual children employ in predictive processing depend heavily on the language they speak.

In addition to verb semantics and case-marking, monolingual children have also been found to exploit gender-marking cues predictively.

In one of the key studies, Lew-Williams and Fernald (2007) examined whether 3-year-old monolingual Spanish-speaking children were able to benefit from gender-marking on articles in predicting the upcoming noun, using a looking-while-listening task. The results revealed that children identified the target image faster when the gender of the target and the distractor image were different, thus informative about the referent of the upcoming noun. These findings suggested that gender cues facilitated language processing in Spanish-speaking monolingual children. This facilitation effect showed that children were able to make predictions about the upcoming nouns based on gender cues on the preceding articles in Spanish which has a transparent gender-marking system. In contrast, 2-year-old Dutch-speaking monolingual children were found to experience difficulties with processing such cues, in that they could use the common gender-marked article *de* predictively, but not the neuter gender-marked *het* (Johnson, 2005). As they get older and become more adult-like in production of gender-marking in Dutch, they do however start to use both gender cues predictively (Brouwer, Sprenger, & Unsworth, 2017; cf. Kochari & Flecken, 2019). Observing the differences between the Spanish- and Dutch-speaking children, it is conceivable that the nature of the gender-marking system in different languages (transparent versus opaque) affects whether and, if so, how such information can be processed predictively in different languages (though further research is needed to

replicate these differences between Spanish- and Dutch-speaking children).

In sum, the available research demonstrates that monolingual children can predict upcoming information in a sentence using a diverse number of cues including verb semantics, case- and gender-marking. The way in which their prediction skills develop and their level of sensitivity towards different predictive cues appear to depend (at least partly) on the characteristics of the language in question.

Not only language-level but individual-level factors such as the proficiency of the monolingual children play a role in the development of prediction skills. Language proficiency may be indexed by receptive and/or productive vocabulary size and target-like production of certain linguistic structures, and it is closely related to the children's language environment. Accumulating empirical evidence strongly suggests an association between vocabulary knowledge and predictive processing of verb semantics in monolingual children (Borovsky et al., 2012; Gambi et al., 2020; Mani & Huettig, 2012; Mani et al., 2016; cf. Gambi et al., 2016). For example, Borovsky and colleagues (2012) reported that 3-to-10-year-old monolingual children and adults with higher receptive vocabulary skills were faster in prediction. Furthermore, Mani and Huettig (2012) argued that the number of words that 2-year-old monolingual children were able to not only understand but also produce correlated

positively with their prediction skills. Similar effects of production abilities were also attested in Brouwer, Sprenger, and Unsworth (2017), where monolingual Dutch-speaking children with target-like production of gender agreement were able to use gender cues predictively, whereas those with non-target-like production were only able to use the same cues facilitatively. That is, target-like production might have triggered successful online comprehension in the form of prediction. Taken together, the available research suggests that the language proficiency of monolingual children, as measured by their vocabulary knowledge and target-like production performance, is associated with their prediction skills.

In line with these studies, Mani et al. (2016) suggested that it is not only language proficiency but also language experience which affects monolingual children's prediction skills. More specifically, these authors found that children with a larger productive vocabulary were better in predicting the words that were strongly (e.g., *book*) or weakly associated (e.g., *letter*) with the verb (e.g., *read*) compared to an unassociated word (e.g., *cheese*). However, a significant correlation between prediction skills and productive vocabulary disappeared in trials in which weakly and strongly associated objects were presented together in the visual context (e.g., *the boy reads the book* vs. *the letter*). In such cases, prediction performance was modulated by the relative associative strength of the

words in relation to a specific verb based on past experiences. In other words, the prediction skills of monolingual children appear to be influenced by their language experience (Foucart, 2015; Mani & Huettig, 2014). The role of language experience may be more apparent in languages with relatively more opaque systems (e.g., gender marking in Dutch) since mastery and predictive use of opaque structures require substantial linguistic input (Unsworth, 2013b).

Overall, it has been suggested that larger receptive and productive vocabulary size and target-like production abilities (i.e., higher language proficiency) may make monolingual children better predictors. More and diverse language experience of monolingual children benefits their proficiency in language, facilitating their prediction skills.

The variation observed among monolingual children highlights the complexity of prediction and significance of language proficiency, necessitating more comprehensive research into how exactly proficiency modulates prediction skills. However, there is only so much variation among monolingual children in terms of language proficiency and experience that will allow researchers to properly investigate the role of such factors in prediction. Bilingual children, however, are likely to show comparatively more variation in their linguistic skills and language environments, and therefore offer an interesting test case. Assuming that all typically developing children have similar cognitive resources available

during language comprehension, and that bilingual children (as a group) show more variation in their language experience and proficiency when compared to monolingual children, bilingual children's prediction skills will offer invaluable insights into the exact role of these factors in predictive processing.

Not only differences in proficiency but also language-specific properties of bilingual children's other language may affect predictive processing. The next section reveals that, based on what we know about adult L2 speakers, there are reasons to believe this might be the case.

What do we know about prediction skills in adult L2 speakers?

The research on adult L2 speakers' prediction skills so far has yielded mixed findings. Some studies provided evidence for successful prediction effects to a similar extent as monolingual speakers (e.g., Dijkgraaf et al., 2017), whereas other studies demonstrated smaller or delayed and in some cases no effect of prediction (e.g., Hopp, 2015; Mitsugi & MacWhinney, 2016). There are a multitude of interrelated factors that modulate L2 predictive processing of which cross-linguistic influence and L2 proficiency have been shown to be of major impact.

One of the factors involved in adult L2 prediction abilities is the interaction between the two languages of bilinguals. Due to the non-selective nature of bilingual language processing, linguistic input from one language co-activates both languages. In the course of language processing, two concomitantly active languages interact with each other, not only at the lexical but also at the syntactic level (e.g., Kootstra & Doedens, 2016). For instance, studies have shown that bilingual speakers recognize and produce cognate words faster than non-cognates (see Lijewska, 2020, for a detailed overview), and that their choice of syntactic structures and processing strategies are under the influence of the other language (see van Gompel & Arai, 2018). Co-activation of languages might slow down or facilitate predictive processing, as successful prediction requires attention and sensitivity towards a variety of language-specific cues.

For instance, Martin and colleagues (2013) investigated whether highly proficient Spanish-English adult L2 speakers engaged in prediction while reading highly constrained sentences in which the final noun (expected versus unexpected and starting with a vowel versus consonant) and the preceding article (*a* versus *an*) were manipulated (e.g*., Since it is raining, it is better to go out with an umbrella/ a raincoat*). They employed an ERP paradigm in which the lexical prediction effect was indexed by the N400 effect elicited by the unexpected article. The results

revealed a greater N400 effect only in the monolingual group. The lack of such an effect in L2 speakers was interpreted as a failure to predict the target noun. One important confound that was overlooked in relation to these results was the difference in the article systems of the two languages. Even though both Spanish and English have articles, their selection in Spanish is not driven by phonological properties of the following noun. It is, then, possible that the L2 speakers might still be able to predict the following noun, but failed to show the prediction effect on the article in English. It is also important to note that the prediction effect that was found in the monolingual group in Martin et al. (2013) was not replicated in later studies (e.g., Nieuwland et al., 2018).

Using a similar paradigm, Foucart and colleagues (2014) reported N400 effects elicited by the article that matched the gender of the unexpected noun in both monolinguals as well as French-Spanish adult L2 speakers. The authors argued that their contradictory findings resulted from cross-linguistic similarities and differences as the L2 speakers in their study were able to use a morphosyntactic cue (i.e., gender-marking on the article) that was readily available in both languages. Similar facilitative effects of cross-linguistic similarity in the gender system were also reported in Dussias et al. (2013) with regard to Italian-Spanish adult bilinguals. It should however be noted that all the critical nouns in Foucart et al. (2014) were carefully selected so that they bore the same gender in

both languages. Therefore, it is hard to identify the exact source of the observed prediction effect: Is it the presence of a gender system in both languages, or the gender overlap between lexical items and their translation equivalents?

The role of gender overlap was investigated in a recent study with Russian-German adult L2 speakers (Hopp & Lemmerth, 2018). Both Russian and German are gender-marking languages. Importantly, the nouns in both languages may bear the same or different genders, and both languages mark gender agreement on adjectives, whereas only German does so on articles. The findings of this study showed that adult L2 speakers of German with high-intermediate level of proficiency were able to use gender-marking on adjectives predictively regardless of whether the target noun bore the same gender in both languages. However, they showed predictive use of gender-marking on articles only when genders of the target noun overlapped in the two languages. These findings suggested that gender overlap benefitted adult L2 speakers specifically when gender was marked syntactically different in L1 and L2.

In addition to gender-marking cues, the predictive use of another morphosyntactic cue, namely case-marking, has also been examined in adult L2 speakers. Using a VWP similar to Kamide et al. (2003) where case-marking cues and verb semantics carried predictive information about the second NP, Hopp (2015) tested monolingual German speakers

and English-German adult L2 speakers. He found that monolingual speakers fixated on the target image before the onset of the second NP in both SVO and OVS sentences, suggesting that they were able to integrate information from case-marking and verb semantics. In contrast, adult L2 speakers fixated on the patient image regardless of the case-marking on the first NP. This finding suggested that L2 speakers were not able to employ case-marking cues predictively, instead they relied only on verb semantics. Corroborating these findings, English-Japanese L2 speakers were also shown to be unable to generate predictions based on case-marking cues (Mitsugi & MacWhinney, 2016).

Compared to morphosyntactic cues, verb semantics appears to be less susceptible to cross-linguistic differences, most likely due to its reliance on general world-knowledge. For example, Dijkgraaf and colleagues (2017, 2019) reported successful prediction effects in Dutch-English L2 speakers. Some aspects of verb semantics, however, are more language-specific. For instance, German and Dutch encode specific positional information in placement verbs (i.e., *zetten* for standing objects, and *leggen* for lying objects in Dutch). It has been suggested that this language-specific information was used predictively by monolingual Dutch-speaking adults and by German-Dutch L2 speakers. In contrast, L2 speakers whose L1 did not specify such information such as French and English, were found to not use the same cue predictively (van Bergen &

Flecken, 2017). The similarity between Dutch and German in encoding the position of the object in placement verbs was argued to facilitate predictive processing. These findings indicate that not even the cues from verb semantics are immune to cross-linguistic influence.

In sum, cross-linguistic similarities and differences play a key role for adult L2 speakers when it comes to using cues from morphosyntax or verb semantics predictively. Due to the co-activation of both languages, predictive processing in the L2 might be affected by the presence of conflicting cues, or it may be facilitated by the similarities in the processing strategies.

Similar to monolingual children, individual-level factors such as language proficiency, language experience and cognitive skills, also play a significant role in predictive processing in adult L2 speakers. One obvious and important determinant of L2 predictive processing is L2 proficiency (e.g., Dussias et al., 2013; Hopp & Lemmerth, 2018; cf. Hopp 2015). For instance, Hopp and Lemmerth (2018) found that unlike high-intermediate Russian-German adult L2 speakers, advanced L2 speakers were able to use gender cues predictively regardless of gender overlap or differences in the syntactic realization of gender between the two languages. Moreover, Hopp (2013) found that English-German adult L2 speakers who assigned correct gender on nouns in a production task were able to use gender cues predictively, whereas the ones with less target-like gender assignment

were not able to do so. These findings underscore that L2 proficiency significantly modulates predictive processing. Relatedly, Foucart (2015) pointed out that increased L2 experience may help adult L2 speakers, such that increased familiarity with L2 structures and co-occurrences may benefit predictive processing. Lastly, predictive processing in L2 was argued to depend on the availability of cognitive resources and skills of listeners (Ito et al., 2018).

In short, then, it is evident that prediction skills of L2 speakers show substantial variation and the ability to generate predictions is modulated by not only language-level (i.e., cross-linguistic influence) but also individual-level factors (e.g., L2 proficiency, language experience and cognitive skills). However, our knowledge and assumptions about how prediction occurs in one language in the presence of another language are based almost exclusively on data provided by adult L2 speakers. Even though adult L2 speakers have the advantage of cognitive maturity, they have acquired their L2 with an entrenched L1 system and often have relatively limited L2 experience. They are typically dominant and more proficient in their L1, which makes unidirectional cross-linguistic influence likely when it comes to predictive processing. In contrast, bilingual children acquire two languages in parallel. Their language experiences and relative proficiencies in two languages vary significantly, making bidirectional crosslinguistic influence also a more plausible option

in their case. Because bilingual children's relative language proficiency varies significantly, they are more likely to spread across the full 'continuum of bilingualism' (Luk & Bialystok, 2013). More widely distributed positions of bilingual children on this continuum may enable researchers to examine the effects of proficiency in prediction in more detail. Therefore, investigating bilingual children's prediction skills might offer a new perspective in prediction research in terms of the role of language proficiency and crosslinguistic influence.

What do we (not) know about bilingual children?

Despite the wealth of studies with monolingual children and adult L2 speakers, research on bilingual children's prediction skills is newly emerging and rather scarce (Brouwer, Özkan, & Küntay, 2017; Lemmerth & Hopp, 2019; Meir et al., 2020). Nevertheless, the research that has been done has yielded interesting and promising findings.

In one of the first prediction studies with bilingual children, Brouwer, Özkan and Küntay (2017) investigated whether 4-5-year-old bilingual children with heterogeneous L1 backgrounds could use verb semantics cues predictively compared to monolingual Dutch-speaking children. In a VWP similar to the one used in Mani and Huettig (2012),

they presented children with sentences containing a semantically constraining (e.g., *eat*) or neutral (e.g., *see*) verb, accompanied by two pictures (e.g., cake and tree). The results showed that bilingual children were able to make predictions about upcoming information on the basis of verb semantics in Dutch similar to their monolingual peers. In fact, the 4-year-old bilingual children outperformed their monolingual peers. These findings suggested that bilingual children were in principle able to use verb-semantics predictively to the same extent as their monolingual peers, if not better.

Two more recent studies have examined bilingual children's prediction skills using morphosyntactic cues. Lemmerth and Hopp (2019), for example, investigated whether 7-to-9-year-old Russian-German simultaneous bilingual children and bilingual children with an age of onset between one to three years were able to use gender-marking cues predictively, by adapting Hopp and Lemmerth's (2018) VWP experiment for children. The analyses of the reaction times revealed no qualitative differences between prediction skills of monolingual and simultaneous bilingual children, though the latter group was slower overall. However, bilingual children who were exposed to German between the ages of one to three launched earlier looks to the target picture only when the target noun bore the same gender in the two languages. These results demonstrated a predictive processing effect that was modulated by the

lexical gender-congruency between languages. This effect indicated that linguistic input co-activated both of the languages these bilingual children were acquiring. The authors argued that hearing a gender-marked article in one language activated all nouns bearing the same gender across languages. As a result, the nouns sharing the same gender with their translation equivalents benefitted from this non-selective co-activation and were thus more easily predicted. This study therefore suggested that lexical gender overlap may aid predictive use of gender cues for bilingual children who were exposed to German between the ages of one to three, whereas the gender-incongruent nouns may suffer from competition effects.

The second study investigating predictive processing in bilingual children focussed on case-marking cues. Meir and colleagues (2020) examined whether 4-to-8-year-old Russian-Hebrew bilingual children were able to employ case-marking cues in predictive processing, in comparison to monolingual Russian- and Hebrew-speaking children. In a VWP, monolingual Russian-speaking children looked at the plausible agent (e.g., fox) as soon as they heard the accusative-marked NP (e.g., bunny), whereas their Hebrew-speaking peers failed to do so. Bilingual children also used accusative case on the first NP to predict the upcoming agent in Russian, though more slowly than their monolingual peers. Interestingly, they also employed the same cue predictively in Hebrew,

after hearing the verb. These results showed that bilingual Russian-Hebrew-speaking children were able to exploit a cue that cannot be used predictively by their monolingual Hebrew-speaking peers. These findings suggested that interaction between case-marking cues from both languages affected predictive processing in bilingual children. The predictive power of a relatively less reliable cue in one language (i.e., Hebrew) was boosted by the presence of the same, but stronger, cue in the other language (i.e., Russian), which is in line with offline studies showing cross-linguistic influence in the form of acceleration relative to monolingual peers (e.g., Meroni et al., 2017).

Overall, the limited number of studies available on bilingual children's prediction skills show mixed findings. In some cases, bilingual children outperformed their monolingual peers (Brouwer, Özkan, & Küntay, 2017; Meir et al., 2020), whereas in other cases their performance aligned with or showed a different pattern from monolingual children (Lemmerth & Hopp, 2019). Such findings highlight that there is so much variation to explore in the case of bilingual children, and that their developing skills may change our assumptions about predictive processing. For instance, knowing another language may not necessarily impede prediction skills, not even in the use of case marking cues predictively. In short, the available findings of the limited studies with bilingual children show that there is still so much that we do not know,

and what we do know is not completely clear, and yet bilingual children could offer a new perspective into predictive processing.

How can research with bilingual children inform L2 predictive processing accounts?

Based on the results of earlier studies reporting limited effects of prediction even for highly proficient adult L2 speakers, Grüter and colleagues proposed that L2 speakers have a reduced ability to generate expectations about the upcoming information because they exhaust almost all of their processing resources on integrating the incoming information (Grüter et al., 2014; Grüter et al., 2017; for a similar explanation also see Pickering & Gambi, 2018). In more recent work, Grüter et al. (2018) refined this hypothesis by stating that the differences between L1 and L2 processing were more likely to be gradual, rather than categorical. L2 speakers may weigh cues (semantic versus form-class) differently than L1 users. In contrast, Kaan (2014) assumes no qualitative differences between L1 and L2 predictive processing mechanisms, but rather highlights the potential role of mediating factors which are yet to be systematically investigated, even in monolingual populations (Huettig, 2015). More specifically, she argues that the mechanisms involved in L1 and L2

predictive processing are fundamentally the same, and that similar mediating factors and individual differences could be responsible for the observed differences between L1 and L2 speakers as well as among L1 speakers. These mediating factors include frequency information about the likelihood of occurrences of words and of structures in a specific context, the quality of lexical representations as well motivation, emotional state and cognitive resources. Whilst there are clear differences between the RAGE Hypothesis and Kaan's (2014) account in terms of the underlying reasons behind the observed differences between the two groups, the two accounts essentially make the same prediction when it comes to L2 speakers, namely that more proficient L2 speakers will be more likely to engage in predictive processing.

These two accounts, as well as the available evidence from monolingual children and adult L2 speakers, suggest that language proficiency may modulate predictive processing in L1 and L2. We argue that the exact role of language proficiency may be better understood when investigated in bilingual children. We hypothesize that, as for monolingual children and adult L2 speakers, the language proficiency of bilingual children influences their prediction skills in the language in question. Less proficient listeners might need to allocate more cognitive resources during language processing, leaving limited resources to generate predictions. That means that depending on their proficiency in that language, bilingual

children may or may not engage in predictive processing to the same extent as their monolingual peers. Not only differences in proficiency but also language-specific properties of bilingual children's other language may affect predictive processing. We furthermore hypothesize that cross-linguistic influence might take place at the level of prediction since bilingual children's two languages could employ similar as well as different predictive strategies. In the remainder of this paper, we will discuss how exactly research into bilingual children's prediction skills may help us better understand the relationship between prediction and proficiency.

Even though language acquisition proceeds in similar ways in monolingual and bilingual children, there are important differences between the language environments of monolingual and bilingual children. More specifically, there are factors influencing the quantity and quality of language exposure children receive which may differ across bilingual and monolingual contexts. To varying degrees, these factors modulate how proficient bilingual children are in two languages. This means that if proficiency is central to (developing) prediction skills, then the quantity and quality of exposure in bilingual children's two languages should also be related to their prediction skills.

Input quantity has been previously argued to affect bilingual children's language outcomes (see Paradis, 2011; Unsworth, 2016, for an

overview) as well as their processing skills (Sorace, 2005). For instance, cumulative length of exposure has been reported to modulate the production of gender agreement in Dutch (Unsworth, 2013b), and the comprehension of wh-questions disambiguated by case-marking cues in German, depending on the position and number of such cues available in the sentence (Roesch & Chondrogianni, 2016). In a study on bilingual Spanish-English toddlers, Hurtado et al. (2014) observed a complex relationship between amount of exposure, processing speed and vocabulary size. They argued that children who had comparatively larger vocabulary sizes in one language were able to process words in that language more quickly (as measured by mean RTs in one language divided by the mean RTs in the other language), and the relative speed of processing words in one language was tied to relative experience in that language. In other words, relatively more exposure in one language increases bilingual children's experience and practice in that language, which promotes their language processing skills. According to the authors, children with increased processing speed may take better advantage of the linguistic input that they receive, which subsequently helps them learn new vocabulary faster in that language. In turn, the larger vocabulary size in one language makes language processing easier and faster for children in that language. Given the available evidence relating language exposure to language proficiency and processing, we expect that amount of

exposure will also be positively related to bilingual children's predictive processing skills.

In addition to quantity of input, the quality of input may also play a role in bilingual children's prediction skills. The quality of input encompasses various factors including the number of input providers in the language environment and their nativelikeness, as well as the richness of input (e.g., language activities such as reading) (Paradis, 2011). For instance, Hoff et al. (2020) found that lexical and grammatical features of the child-directed speech provided by native speakers and proficient non-native speakers significantly differed from that of non-native speakers with limited proficiency. In other words, proficiency of non-native speakers modulated the richness of the input that children received. Relatedly, Unsworth et al. (2019) found that receptive vocabulary and morphosyntactic skills of 3-year-old bilingual children with heterogenous L1 backgrounds were modulated by the degree of nativelikeness of the input providers. The authors argued that morphosyntactically complex and lexically diverse input provided by more proficient non-native speakers helped bilingual children's language outcomes. With respect to prediction skills, we can derive the following hypotheses from these findings. The more bilingual children are exposed to consistent and rich linguistic input due to the high proficiency level of input providers, the more likely that they will be able to notice and derive correct structures from the input.

Such input is more likely to increase the strength of associations between words and structures for bilingual children, making possible predictive cues more reliable.

Another measure of the input quality is richness of the language environment, which is often indexed by language activities such as reading (Paradis, 2011). Enriching bilingual children's language experience through reading activities may benefit their language outcomes as well as their prediction skills. Such an association between reading skills and prediction has been previously suggested (see Huettig & Pickering, 2019) in relation to prediction skills of monolingual children (Mani & Huettig, 2014) and adults (Kukona et al., 2016), monolingual adults with dyslexia (Huettig & Brouwer, 2015), and low and high literates (Mishra et al., 2012) partly because reading activities are argued to enhance the quality of the linguistic representations, making prediction during language comprehension more viable.

In addition to leading to a better understanding of the relation between proficiency and prediction, bilingual children can also help us further understand the interaction between cross-linguistic influence and language proficiency in prediction. The parallel acquisition of two languages, coupled with varied relative proficiencies in two languages may result in differences in prediction skills of bilingual children compared to adult L2 speakers, which may be informative on how

language proficiency interacts with crosslinguistic influence in predictive processing. For instance, target-like production ability, which is an indicator of language proficiency, has been found to play a role in predictive processing skills of both monolingual children (Brouwer, Sprenger, & Unsworth, 2017) and adult L2 speakers (Hopp, 2013), then it is only logical to expect similar effects in bilingual children. Nonetheless, Meir et al. (2020) found that Russian-Hebrew bilingual children, who were less accurate in production of accusative case morphology both in Russian and in Hebrew, were able to use accusative case-marking on the first NP to predict the upcoming second NP in online language processing. The authors argued that the prediction skills of these bilingual children in Hebrew benefitted from the presence of stronger case marking cues in their other language (i.e., Russian). The effects of non-target like production in this case may have been mitigated by the strong interaction of the same predictive cues in two languages during language processing. In other words, cross-linguistic influence in the form of acceleration took place in predictive language processing. It is important to note here that even though the topic of cross-linguistic influence in bilingual children is well researched (see van Dijk, van Wonderen et al. (under review) for meta-analysis), there is very little research on cross-linguistic influence in real-time language processing (but see van Dijk, Dijkstra, & Unsworth (under review)).

Since the bilingual children in Meir et al. (2020) were able to use case-marking cues predictively, their less target-like performance in production of case marking suggests a production-specific problem. This finding is of relevance for predictive processing accounts which specifically argue for the involvement of the production system in prediction. For instance, Pickering and Gambi (2018) have argued that using production systems is the most effective way of predicting; however, because this route takes time and resources, non-native speakers may use it less, which makes it an optional mechanism for less proficient language users (see also Ito & Pickering, this volume). The findings that showed that bilingual children, who demonstrated a production-specific problem, were able to use case-marking cues in prediction while their monolingual peers were not, may be interpreted to suggest that prediction-by-production is not always the most effective way of predicting.

What we know about bilingual children's prediction skills so far shows that knowing another language is not necessarily a disadvantage in predictive processing. The amount and quality of input that bilingual children receive in each language varies significantly, which in turn is an important factor predicting their relative proficiency in their two languages. The considerable variation observed in bilingual children's relative language proficiency spreads them out more widely on the full continuum of language proficiency. Since they are likely to inhabit more

diverse positions on this continuum with their varying relative proficiencies compared to adult L2 speakers, investigating their prediction skills may help us understand the relation between proficiency and prediction more comprehensively.

What's next?

Bilingual children offer an interesting case to investigate how language proficiency, experience and cognitive skills as well as cross-linguistic influence affect prediction skills, due to their distinct characteristics in comparison to monolingual children and adult L2 speakers, the two groups which have thus far dominated the predictive processing research. Bilingual children's prediction skills should be systematically investigated by taking individual-level and language-level differences into consideration.

In terms of individual-level differences, it is essential to test prediction skills of bilingual children in both languages and to measure their proficiencies in both languages because relative language proficiency may significantly modulate predictive processing skills of bilingual children in each language. By adopting a within-subjects design, the research with bilingual children may further unravel how language

proficiency and experience modulate prediction skills of bilingual children in each language while keeping the cognitive skills constant. It is also important to include different groups of bilingual speakers (i.e., simultaneous, successive and adult L2 speakers) as the amount and timing of exposure to another language may affect how prediction skills develop significantly.

In terms of language-level differences, comparative studies with several groups of bilinguals with different language pairs (e.g., Turkish-Dutch and German-Dutch) will be informative as to the exact nature of cross-linguistic influence in predictive processing (see also van Dijk, van Wonderen et al. (under review) for a similar argument). Therefore, future studies should focus on investigating prediction skills of bilingual children with diverse L1-L2 pairings.

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