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The interplay between syntactic and morphological comprehension in heritage contexts: The case of relative clauses in heritage Syrian Arabic

Evangelia Daskalaki¹ , Adriana Soto-Corominas², Aisha Barisé³, Johanne Paradis¹ , Xi Chen⁴ and Alexandra Gottardo⁵ 

¹University of Alberta, Edmonton, Alberta T6G 2E7, Canada, ²Universitat Internacional de Catalunya, Barcelona, Spain, ³McGill University, Montreal, Canada, ⁴University of Toronto, Toronto, Canada and ⁵Wilfrid Laurier University, Waterloo, Canada

Corresponding author: Evangelia Daskalaki; Email: daskalak@ualberta.ca

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Abstract

Previous studies show that even though monolingual children find subject relatives easier than object relatives, their comprehension of object relatives can be facilitated by morphological cues. Given that in heritage contexts functional morphology is a vulnerable domain, a question that needs to be addressed is whether bilingual children, who are heritage speakers of their L1, will also be able to use morphological cues to comprehend complex syntax. To contribute to this line of research, we focused on monolingual ($N = 18$; Mean Age: 11.43) and bilingual/first generation ($N = 108$; Mean Age: 11.98), Syrian Arabic-speaking children in Canada, and examined their ability to use gender morphology in their comprehension of relative clauses, while taking into consideration cognitive, environmental, and age-related variables. To this end, we used two offline sentence-picture matching tasks targeting relative clauses and gender (as encoded in SV agreement and object clitics). Results showed that, like monolingual children, first-generation, Arabic-speaking children living in Canada used morphological cues to comprehend complex syntax in their L1. Furthermore, even though there was an association between comprehension of gender agreement and comprehension of relative clauses, performance in gender agreement was higher than performance in relative clauses, suggesting that challenges with complex syntactic structures are not necessarily an epiphenomenon of a morphological deficit.

Keywords: attrition; gender agreement; heritage language acquisition; morphological cues; Syrian Arabic relative clauses

Introduction

A large number of studies have examined monolingual children's comprehension of complex syntactic structures, such as interrogatives and relative clauses. These studies have shown that even though monolingual children find object relatives/interrogatives more challenging than subject relatives/interrogatives, their performance improves in the presence of morphological cues. These include case (Guasti *et al.*, 2007; Roesch & Chondrogianni, 2015) as well as subject-verb agreement with respect to gender or number (Belletti *et al.*, 2012). Given that in heritage contexts functional morphology is a vulnerable domain (Montrul, 2018; Slabakova, 2019), a question that needs to be addressed is whether bilingual children who are heritage speakers of their L1 also rely on morphological cues to comprehend complex syntax. Very few studies have addressed this question, but those that have done so suggest that heritage children's reliance on morphology may be delayed (Reyes & Hernández, 2006) and contingent on their knowledge of the relevant morphological category (Chondrogianni & Schwartz, 2020).

To contribute to this line of research, we will focus on monolingual ($N = 18$; Mean Age: 11.43) and bilingual/first-generation, Syrian Arabic-speaking children in Canada ($N = 108$; Mean Age: 11.98; Mean English AoA: 7.55), and we will examine their ability to use gender morphology (as encoded in subject-verb agreement and object resumptive clitics) in their comprehension of relative clauses. Furthermore, we will examine whether there is an association between bilingual children's comprehension of complex syntax (relative clauses) and their comprehension of morphology (gender), while taking into consideration cognitive, environmental, and age-related variables. Results will be of both an empirical and theoretical significance. In addition to enhancing our understanding of the strategies used by bilingual children to comprehend complex syntactic structures, they will contribute to the discussion about the interplay between morphological and syntactic comprehension, and the extent to which challenges with complex syntax are an epiphenomenon of a morphological deficit.

The role of morphological cues in monolingual L1 acquisition of relative clauses

Research on the monolingual L1 acquisition of relative clauses has shown that, at least in languages with head-initial relative clauses, children find subject relatives (1) easier to comprehend than object relatives (2) (for Greek, see Guasti *et al.*, 2007, for Italian see Arosio *et al.*, 2009; Arosio *et al.*, 2010; Belletti *et al.*, 2012; for Hebrew, see Arnon, 2005; Friedmann *et al.*, 2009; Belletti *et al.*, 2012; for Persian, see Rahmany *et al.*, 2011).

- (1) The girl that greeted the grandmother.
- (2) The girl that the grandmother greeted.

According to the Canonicity Hypothesis, the observed subject-object asymmetry could be attributed to the fact that children tend to assign thematic roles and grammatical relations following a canonical (SVO) word order pattern (Friedmann & Novogrodsky, 2004; Philip *et al.*, 2001; for an overview of the different accounts, see Lau & Tanaka, 2021). This strategy leads to the correct interpretation in the case

of subject relatives, because the first DP (the head of the relative clause) is indeed the subject of the verb of the relative clause. In the case of object relatives, though, it leads to a misanalysis, since the first DP (the head of the relative clause) is actually the object. Significantly for our purposes, the rate of misanalyses decreases in the presence of morphological cues indicating who is doing what to whom, such as case (Guasti et al., 2007) and subject-verb agreement (for gender, see Arnon, 2010; Belletti et al., 2012; for number, see Adani et al., 2010). As an example, we may consider Belletti et al.'s (2012) comprehension study of relative clauses in Hebrew, a language where verbs agree with the subject in gender. The authors found that even though young monolingual children (3;9-5;5) were more accurate with subject than with object relatives, they performed better in object relatives where the two DPs encoded a different gender (3) than in object relatives where they encoded the same gender (4).

- (3) Tare li et ha-yalda she-ha-rofe mecayer.
 show to-me ACC the-girl(fem) that-the-doctor(masc) draws-masc
 "Show me the girl that the (male) doctor draws."
- (4) Tare li et ha-yalda she-ha-isha mecayeret.
 show to-me ACC the-girl(fem) that-the-woman(fem) draws-fem
 "Show me the girl that the woman draws."

Note that in (3), subject-verb agreement morphology (instantiated as a suffix on the verb) unambiguously identifies one of the two DPs (the male doctor) as the subject. In (4), on the other hand, subject-verb agreement morphology is uninformative in that it is in principle compatible with either of the two DPs. The fact that monolingual children are more successful with examples like (3) shows that from very early on, they may benefit from agreement cues that unambiguously identify the subject of the sentence.

The role of morphological cues in heritage language acquisition of relative clauses

Studies with child heritage speakers (HSs, henceforth) also report a subject-object asymmetry (for Levantine Arabic, see Albirini, 2018; for Mandarin, see Jia & Paradis, 2020; for Turkish, see Coşkun Kunduz & Montrul, 2022; for Russian, see Polinsky, 2011). It remains unexamined, though, whether heritage children's comprehension of object relatives is facilitated by morphology.

Why would we expect child HSs to be less attentive to morphological cues? Because inflectional morphology, in general, and agreement morphology, in particular, is vulnerable, when acquired under reduced input conditions and under the influence of another language (for Arabic, see Albirini et al., 2011; for Russian, see Polinsky, 2006; for Inuittitut, see Sherkina-Lieber et al., 2011; for Spanish, see Anderson, 1999). If agreement morphology is attrited or not fully developed, it is reasonable to hypothesize that it might not be as useful a cue for the comprehension of complex syntax. As an example, we may consider Reyes and Hernández's (2006) comprehension study. The authors focused on Spanish, a language that encodes subject-verb agreement

in number, and tested child HSS' comprehension of non-canonical word orders with (5) and without (6) number mismatches.

- (5) a. El perro los caballos está correteando.
 the dog the horses is chasing
 b. El perro los caballos están correteando.
 the dog the horses are chasing
- (6) El perro el caballo está correteando.
 the dog the horse is chasing

They found, indeed, that child HSs started making consistent use of number cues later than their monolingual peers, around the age of 11. The authors attributed the delay to bilingualism. Specifically, they hypothesized that the processing of subject-verb agreement (a cue that it is taxing on working memory since it is encoded on two constituents) might be even more demanding for bilingual children, who have to process two linguistic systems. In addition to the role of bilingualism, though, the authors acknowledged the need to examine the association between child HSS' sensitivity to agreement cues and their overall language proficiency, language practices, and AoA of their second language.

In what follows, we will extend this line of research to a new population (Syrian Arabic-speaking children who are first-generation immigrants in Canada). Before turning to the details of our study design, we will briefly discuss how gender (as encoded in subject-verb agreement and object clitics) relates to the disambiguation of relative clauses in Syrian Arabic.

Syrian Arabic morphosyntax

Syrian Arabic is a spoken variety that belongs to the Levantine geographical/linguistic group of Arabic varieties (Aoun *et al.*, 2010). Like other Arabic varieties, it is a null-subject language, with an elaborate paradigm of subject-verb agreement (in person, number, and gender) and a relatively free word order (predominantly SVO and VSO) (Brustad, 2000). In this regard, it differs from English, a language with a relatively rigid SVO word order and a comparatively poor paradigm of subject-verb agreement.

Relative clauses and gender in Syrian Arabic

Similarly to English, restrictive relative clauses in Syrian Arabic are head initial and are introduced by a complementizer (*yali* "that"). This is illustrated below with subject (7) and object relatives (8) (Brustad, 2000: 89–91). The two types of relative clauses follow different relativization strategies. Subject relatives, on the one hand, employ the gap strategy, which means that no subject resumptive clitic is required at the relativization site. Object relatives, on the other hand, typically employ the resumptive strategy, which means that the antecedent is co-indexed with an object resumptive clitic (for Syrian Arabic, see Soto-Corominas *et al.*, 2021; for Lebanese Arabic, see Aoun *et al.*, 2010; Albirini, 2018). The latter is realized as a suffix on the

verb and inflects for person, number, and gender. For instance, it is realized as -o “3SgM” in the case of a singular masculine antecedent (8a) and as -a “3SgF” in the case of a singular feminine antecedent (8b).

- (7) el-walad yali yi-lha? ez-zalame
 Det-boy.M that 3-chase Det-man.M
 “The boy who chases the man.”
- (8) a. el-walad yali yi-lh?-o ez-zalame
 Det-boy.M that 3-chase-3SgM Det-man.M
 “The boy that the man chases.”
 b. el-bint yali ti-lh?-a el-mara
 Det-girl.F that 3-chase-3SgF Det-woman.F
 “The girl that the woman chases.”

Because both subject and object relative clauses display the same linear word order (DP-yali-Verb-DP), disambiguation relies solely on morphological devices. In the case of matching relatives (i.e., in the case of relative clauses, where both DPs encode the same number and gender) the presence vs. absence of the object resumptive clitic appears to be the sole differentiating cue (compare (7) with (8a)).

In the case of mismatching relatives (i.e., in the case of relative clauses, where the two DPs differ in gender and/or in number), though, the resumptive/gap cue is further enhanced by agreement morphology. For instance, in (9), which is an example of an OR, the singular feminine subject-verb agreement morphology (instantiated as a verbal prefix) identifies the second DP (*el-bint* “the girl”) as the subject. In addition, the singular masculine agreement morphology on the object clitic identifies the first DP (*el-walad* “the boy”) as the object.

- (9) el-walad yali t-lh?-o el-bint
 Det-boy.M that 3SgF-chase-3SgM Det-girl.F
 “The boy that the girl chases.”

It follows from the above description that Syrian Arabic and English use different devices to disambiguate subject from object relatives. English, on the one hand, as is evident by the English translations, relies primarily on word order: SRs surface in a DP_{Subj}-that-V-DP_{Obj} word order, whereas ORs surface in a DP_{Obj}-that-DP_{Subj}-V word order. Syrian Arabic, on the other hand, relies solely on the presence/absence of the resumptive clitic enhanced by agreement morphology.

The acquisition of relative clauses and gender in (Syrian) Arabic

Despite the relevance of (gender) agreement morphology for the disambiguation of Arabic relative clauses, the acquisition of relativization and agreement are most commonly studied independently from one another. Very few studies have tested the acquisition of both phenomena by the same group of participants and, to our knowledge, no study has examined the association between the two.

Studies with young monolingual children, in particular, report that verbal agreement with singular, masculine subjects is mastered earlier than verbal

agreement with singular, feminine subjects (Aljenaie, 2010), and that subject relatives are mastered earlier than object relatives (Botwinik *et al.*, 2015). In addition, subject-verb agreement appears to be mastered earlier than relativization. For instance, the monolingual group in Albirini (2018), which consisted of children who were on average 5;06 years old, was at ceiling with the production of subject-verb agreement (100% accuracy, independently of the gender/number of the subject) but not with the comprehension of relative clauses (SR: 98.33%; OR: 75%).

Turning to studies focusing on HS who are second-generation immigrants in the United States, Albirini (2018), in the aforementioned study, compared his monolingual group with two groups of child HSs: an early L2 exposure (EE) group (Mean AoA of English: 1;09) and a late L2 exposure (LE) group (Mean AoA of English: 4;01). The author found that even though the monolingual group outperformed the heritage groups, the heritage groups displayed response patterns that are similar to those reported for younger monolinguals: They performed better with singular, masculine agreement (LE: 93.33%; EE: 76%) rather than with singular, feminine agreement (LE: 70%; EE: 46%). Accordingly, they performed better with subject relatives (LE: 93%; EE: 90%) rather than with object relatives (LE: 51.67%; EE: 40%). Significantly for our purposes, child HSs were challenged not only by relativization but also by agreement morphology.

Similarly to child HSs, adult HSs in the United States are less accurate than adult monolinguals in both agreement and relativization, a fact suggesting that challenges with these domains may persist to adulthood (Albirini *et al.*, 2013; Albirini & Benmamoun, 2014). As far as error patterns are concerned, the trend is the same: Adult HSs are more successful matching verbs with singular, masculine nouns rather than with singular, feminine nouns (Albirini *et al.*, 2013), and with subject relatives rather than with object relatives (Albirini & Benmamoun, 2014).

In sum, existing studies have shown that second-generation HSs of Arabic in the United States (both children and adults) are often challenged by relative clauses and agreement morphology. In the present study, we will extend this line of research by examining whether this is also the case with first-generation immigrant children with an older AoA of English, and, if yes, whether there is an association between morphological and syntactic comprehension. In addition, to better understand the morphology–syntax interplay, we will control for factors that have been independently shown to affect the comprehension of HL morphosyntax. These include current amount of HL use/activities (Daskalaki *et al.*, 2019; Paradis *et al.*, 2021), HL schooling/literacy (Bayram *et al.*, 2017; Soto-Corominas *et al.*, 2021), L2 AoA (Albirini, 2018; Paradis *et al.*, 2021; Soto-Corominas *et al.*, 2021), and cognitive abilities (Paradis *et al.*, 2021; Soto-Corominas *et al.*, 2021).

Present study

The aim of the present study is to examine the interplay between syntactic and morphological comprehension in monolingual and heritage language acquisition and development. Specifically, we will focus on two groups of Syrian Arabic-speaking children: a monolingual group, residing in Syria, and a bilingual group, who are first-generation immigrants in Canada. Using an offline sentence-picture matching task, we will test: their comprehension of gender morphology (in subject-

verb agreement and object clitics), their comprehension of relative clauses, and the interplay between the two. The inclusion of the monolingual group will enable us to determine if the monolingual–bilingual differences that are well-reported for second-generation child HSs are also attested in the case of first-generation children with an older AoA. The subsequent focus on the bilingual group will enable us to examine linguistic and extra-linguistic sources of variability in bilingual children's syntactic comprehension. Our research questions are the following:

1. How do monolingual and bilingual/immigrant children compare in their comprehension of gender morphology in Syrian Arabic?
2. How do monolingual and bilingual/immigrant children compare in their comprehension of relative clauses in Syrian Arabic? Do both groups attend to gender cues?
3. How does knowledge of gender morphology affect bilingual/immigrant children's comprehension of relative clauses? Is the effect of morphological knowledge significant, even when we take into consideration cognitive, environmental (length of schooling in the HL, amount of current HL use, frequency of current HL listening/speaking activities), and age-related variables (AoA)?

With respect to the first two questions, we expect that the bilingual group may show lower accuracy rates due to limited Arabic language use and/or due to exposure to English, a language that uses primarily word order rather than agreement to encode grammatical relations. At the same time, though, we expect that both groups will find feminine gender morphology more challenging than masculine gender morphology and object relatives more challenging than subject relatives (in line with results reported for monolingual and child HSs with an earlier AoA; Albirini, 2018). Significantly, given the focus of our study, we expect that if they attend to gender cues, then they will perform better in relative clauses with gender mismatches than in relative clauses without mismatches. With respect to our third research question, we predict that if children's ability to attend to gender cues is contingent on their knowledge of gender, then there should be an association between gender comprehension and relative clause comprehension. In addition to gender comprehension, which is the predictor of primary interest in the present study, extra-linguistic variables are also taken into consideration. Based on prior research, we expect superior non-verbal cognitive abilities to be associated with stronger morphosyntactic abilities (Paradis et al., 2021; Soto-Corominas et al., 2021). We also expect a positive effect of current amount of Syrian Arabic use at home (e.g., Daskalaki et al., 2019; Jia & Paradis, 2020), frequency of listening/speaking activities in Syrian Arabic (e.g., Jia & Paradis, 2015), and length of Arabic schooling before migration (e.g., Soto-Corominas et al., 2021; Torregrossa et al., 2023). Finally, we expect older AoA to be associated with superior performance, since children that were exposed to English later in life had more time to solidify their knowledge of Syrian Arabic in a predominantly monolingual context (Montrul, 2008).

Methods

Participants

To answer our research questions, we collected data from a Bilingual and a Monolingual group of Syrian Arabic-speaking children. The *Bilingual group* (N = 108) comprised Syrian children who resettled in Canada between years 2015 and 2018 (with the vast majority of them arriving in 2016 and 2017). As such, at the time of testing, these children were bilingual in Syrian Arabic and English, and they had a mean length of exposure to English of 4.6 years (range = 3–5.83; SD = 0.71). The *Monolingual group* (N = 18) comprised children born and raised in Syria who were living in Syria at the time of testing. They belonged to a group of families that were relocated to Damascus due to the war in 2013, and they were not fluent in any other language other than Syrian Arabic and Modern Standard Arabic.

Materials

Participants completed two offline sentence-picture matching tasks to assess their knowledge of morphology and syntax. Both tasks involved the same three protagonists (a female cat, a male monkey, and a male rabbit) carrying out the same range of activities (hugging, pushing, chasing, drawing, carrying, and touching). The morphology task always preceded the syntax task and the two were separated by a five-minute break. Items for the two tasks were always administered in order (i.e., without randomized presentation). Prior to starting the morphology task, there was a training session in which participants were familiarized with the protagonists. The experimenter indicated, on the response sheet, whether the participant's response was correct or not at the time of testing.

Sentence-picture matching task: morphology

This task focused on two different domains: gender encoded on verbs (in the context of subject-verb agreement) and gender encoded on object clitics. In the case of subject-verb agreement, children were shown pairs of pictures presented on the same slide of a power point presentation. The pictures depicted either a female cat or a male monkey performing the same action (e.g., hugging) on the same animal (a rabbit) (Figure 1). For each picture pair, children heard an audio-recorded sentence involving a verb with either masculine (strictly speaking unmarked for gender morphology) (e.g., *yi-d^fum el-ʔarnab* “(he) hugs the rabbit”) or feminine morphology (e.g., *t-ʔbot^f el-ʔarnab* “(she) hugs the rabbit”). Their task was to choose the picture that matched the sentence they heard.

In the case of gender encoded on object clitics, the two pictures depicted the same animal (the rabbit) performing the same action (e.g., hugging) either on a male monkey or on a female cat (Figure 2). For each picture pair, children heard an audio-recorded sentence involving a clitic of either masculine (e.g., *el-ʔarnab d^fam-o* “the rabbit hugged him”) or feminine morphology (e.g., *el-ʔarnab d^fam-a* “the rabbit hugged her”) and their task was to point to the picture that matched the sentence they heard.

There were a total of 27 picture pairs accompanied by 27 audio-recorded items (3 practice items and 24 experimental items). Of the 24 experimental items,

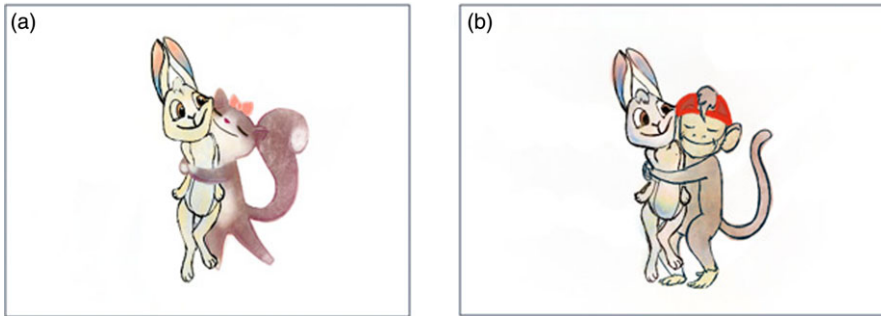


Figure 1. Sample picture pair used to target gender morphology on verbal agreement.

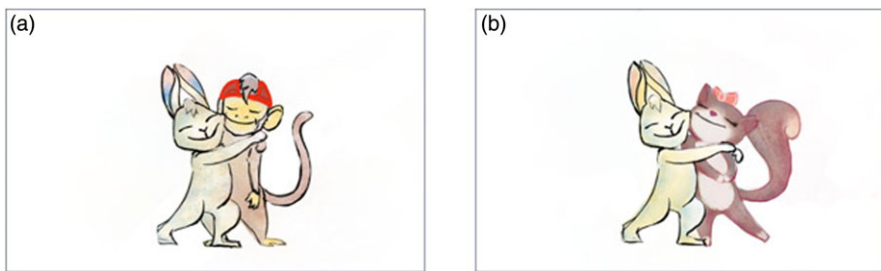


Figure 2. Sample picture pair used to target gender morphology on object clitic.

12 targeted gender morphology on subject-verb agreement and 12 targeted gender morphology on object clitics. Sample items are provided in Table 1.

Sentence-picture matching task: syntax

This task targeted the syntax of relativization and was similar to tasks developed for the comprehension of relative clauses in other languages (for Lebanese Arabic, see Albirini, 2018; for Hebrew, see Friedmann et al., 2009; for Russian, see Polinsky, 2011). Children were shown again picture pairs presented on the same slide of a power point presentation. Each picture pair depicted the same two animals in reversible actions, as in Figure 3. Each picture pair was accompanied by an audio-recorded relative clause that matched one of the two pictures (e.g., *el-ʔarnab yali yi-dʔum-o el-ʔrd* “the rabbit that the monkey hugs”). The children’s task, then, was to choose the picture that matched the sentence they heard.

The task consisted of a total of 50 picture pairs accompanied by 50 audio-recorded items (2 practice items, 12 fillers, and 36 experimental items). Of the 36 experimental items, 18 targeted subject relatives and 18 targeted object relatives. Finally, each relative type consisted of both matching relatives (that is of relative clauses in which the two animals encoded the same gender) and mismatching relatives (that is of relative clauses in which the two animals encoded different gender). Specifically, there were 6 matching relatives (male–male) and 12 mismatching relatives (6 male–female and 6 female–male). Sample items per relative type are provided in Table 2.

Table 1. Sample items used in the morphology task

Conditions	Examples		
Subject-verb agreement condition: masculine (6 items)	yi-d ^ʕ um 3-hug “(He) hugs the rabbit.”	el-ʔarnab the-rabbit	
Subject-verb agreement condition: feminine (6 items)	t-d ^ʕ um 3F-hug “(She) hugs the rabbit”	el-ʔarnab the-rabbit	
Object-clitic agreement condition: masculine (6 items)	el-ʔarnab rabbit hugged him.”	d ^ʕ am-o hugged-him	the “The rabbit
Object-clitic agreement condition: feminine (6 items)	el-ʔarnab the rabbit	d ^ʕ am-a hugged-her	

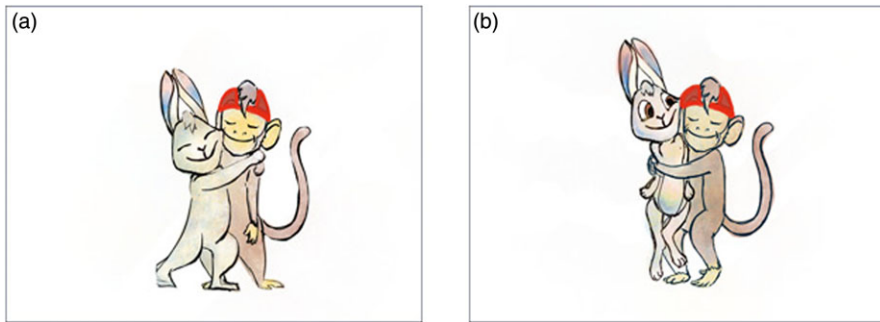


Figure 3. Sample picture pair used in the syntax task.

Alberta language environment questionnaire-4 (ALEQ-4; Paradis *et al.*, 2020)

To collect background information about our participants, we used ALEQ-4, a parental questionnaire. Besides general demographic information (e.g., age, AoA, length of exposure to English, length of formal schooling in Arabic), we obtained information on the Arabic/English relative language use in the home, as well as on Arabic-speaking and listening activities. More specifically, parents were asked to use a 1–5 scale to indicate the relative language use between each relative and the child (1 = mainly or only Arabic, 2 = usually Arabic/English sometimes, 3 = Arabic and English, 4 = usually English/Arabic sometimes, 5 = mainly or only English). For this study, we use the variable “language use with siblings,” which is a number between 1 and 5 indicating the relative use of the two languages between the participant and their siblings. An in-depth study on input/output between the participant and their relatives in the bilingual sample showed that there was little variability when it came to language use between participants and their parents, with most participants scoring a 1 (Authors, Submitted). As such, this variable would not have been informative enough for any statistical analysis. In addition, it was found that language use did not differ between younger vs. older siblings, thus allowing us to combine this information into the variable “language use with siblings.” We also

Table 2. Sample items used in the relative clause tasks

Conditions	Examples
Subject relative condition: masculine–masculine (6 items)	El-ʔarnab yali yi-d ^ʕ um el-ʔrd the-rabbit that 3-hug the-monkey “The rabbit that hugs the monkey”
Subject relative condition: masculine–feminine (6 items)	El-ʔarnab yali yi-d ^ʕ um el-ʔit ^ʕ a the-rabbit that 3-hug the-cat “The rabbit that hugs the cat”
Subject relative condition: feminine–masculine (6 items)	El-ʔit ^ʕ a yali ti-d ^ʕ um el-ʔarnab the-cat that 3F-hug the-rabbit “The cat that hugs the rabbit”
Object relative condition: masculine–masculine (6 items)	el-ʔarnab yali yi-d ^ʕ um-o el-ʔrd the rabbit.M that 3-hug-him the-monkey.M “The rabbit that the monkey hugs.”
Object relative condition: masculine–feminine (6 items)	El-ʔit ^ʕ a yali yi-d ^ʕ um-a el-ʔarnab the-cat that 3-hug-her the-rabbit “The cat that the rabbit hugs (her).”
Object relative condition: feminine–masculine (6 items)	El-ʔarnab yali t-d ^ʕ um-o el-ʔit ^ʕ a the-rabbit that 3F-hug-him the-cat “The rabbit that the cat hugs (him).”

employed ALEQ-4 to obtain information on the frequency of Arabic-speaking and listening activities. This information was obtained using an ordinal scale (1 = 0–1 hours, 2 = 1–5 hours, 3 = 5–10 hours, 4 = 10–20 hours, 5 = 20+ hours). These types of activities did not include casual conversations among the members of the household and instead referred to activities such as engaging with storytelling, poetry, watching TV or videos, and videochatting.

Non-verbal analytical skills test

In order to assess non-verbal analytical skills in the bilingual group, we used the Kaufman Brief Intelligence Test-2 (Kaufman & Kaufman, 2004). Specifically, participants completed the Matrices subtests, which asks them to choose a picture of an array in order to complete a matrix. Even though this test was standardized on a population that was not our target one, we used the standard score in the analysis below because this test relies on minimal verbal instructions. To ensure that the possible bias introduced by the use of standardized scores did not compromise the findings of the model used in this study, we fit the same model with the raw test score, and results did not meaningfully change. Therefore, we present the model with standard scores below.

Procedures

Ethics

The protocols for this study were revised and approved by the ethics board [redacted university name] (protocols number Pro00099235 and Pro00077538). Since all participants were minors when they were tested, their parents provided written consent for participating in the study. In addition, participants themselves provided oral assent.

Recruitment

Participants in the bilingual group were part of an ongoing longitudinal study with Syrian children in Canada. At the time of testing, the children were participating in the third wave of data collection. Monolingual participants were recruited via word-of-mouth. All participants included in this sample were typically developing and, according to parental report, had not received a diagnosis of language disorder and did not have a history of language difficulties/delays.

Testing

All participants were tested online, via Zoom, by a research assistant who was a native speaker of Arabic. Participants were asked to put on headphones and to be in a quiet room at the time of testing. The research assistant used the function “Share screen” to display the power point presentation and to share the respective audio file. If participants claimed not having heard an item of the morphology or syntax task, it was replayed once more for them, though this occurred rarely. All the tasks were administered in the same session. For monolingual children, this session lasted around 30 minutes approximately, whereas for bilinguals, these tests were part of a larger battery of tests that lasted around 45–50 minutes. Parents were administered the ALEQ-4 questionnaire either through Zoom or over the phone.

Data analysis

Data analysis was performed in R (R Core Team, 2020). Visualizations were performed using the *ggplot2* package (Wickham, 2016). In order to answer research questions 1–3, regression analyses were performed using the *lme4* package (version 1.1-26; Bates et al., 2015). Model diagnostics were run using the *DHARMA* package (version 0.3.3.0; Hartig, 2020). More specifically, the regression models were all binomial generalized linear mixed-effects models that modeled the likelihood of a target response (1) or not (0) as a function of a set of predictors. For the three regression models presented below, we began with a maximally specified random-effects structure that had to be pared down to convergence issues. In the end, all models included a random intercept for Participant and one for Item. As for the main effects (predictors), we initially began with a model that included all the interactions and predictors of interest. We then proceeded with backwards selection, eliminating one by one an interaction term or predictor that was not significant, until we obtained an optimal model. All categorical predictors were sum-coded in order to facilitate the interpretation of the main effects in the presence of interactions. Numerical predictors were scaled and centered to prevent any issues derived from the use of different scales. Model comparisons were performed using likelihood ratio tests.

Results

Participant characteristics

A total of 108 bilinguals (60 females) and 18 monolinguals (11 females) participated in this study. All participants were born in Syria and were exposed to Syrian Arabic

Table 3. Participant characteristics for the bilingual group

	Mean	SD	Min	Max
Age in years	11.99	1.92	8.58	16.08
AoA English in years	7.55	1.96	3.92	11.67
Exposure to English (in months)	53.11	7.14	30	65
Length of Arabic formal instruction (in months)	16.12	18.30	0	70
Arabic/English use among siblings (1–5 scale)	2.45	1.30	1	5
Arabic-speaking/listening activities (1–5 scale)	2.69	1.36	1	5

since birth. Participant characteristics for the bilingual group appear in Table 3. The group was just under 12 years of age on average, which was very close to the monolingual control group ($M = 11.43$, $SD = 2.37$). The difference in age was not statistically significant, $t(20.873) = 0.943$, $p = .356$. Bilingual participants had been exposed to English for about 4.5 years on average. After this prolonged exposure, there was variation in the relative amount of Arabic/English use among siblings in the sample. While the average was 2.45 (i.e., almost the middle of the 1–5), some participants used only Arabic, and some used only English.

Comprehension of gender morphology

Accuracy results for gender morphology in clitics and verbal agreement appear in Figure 4. As shown in this visualization, both groups were mostly at ceiling with regard to verbal agreement and clitics with masculine gender. On the other hand, more variation was observed regarding accuracy with feminine clitics.

The initial model to address our second research question included a fixed-effects structure with a triple interaction between Group (Bilingual vs. Monolingual), Gender domain (Clitic vs. Verbal agreement), and Gender (Masculine vs. Feminine). However, the optimal model was one where accuracy in the two gender domains was predicted by Group, Gender domain, Gender, and the interaction between Gender domain and Gender. The main results of the model are the following: overall, monolinguals were more accurate than bilinguals (est. = 0.835, SE = 0.413, z -value = 2.021, $p = .043$), and both groups performed worse with gender encoded in object clitics rather than in subject-verb agreement (est. = 1.293, SE = 0.330, z -value = 3.912, $p < .001$). Even though there was not a main effect for Gender, there was a significant interaction between Gender domain (subject-verb agreement and object clitics) and Gender (feminine and masculine), in that the masculine–feminine asymmetry was significantly more pronounced in the domain of object clitics than in subject-verb agreement (est. = 2.476, SE = 0.661, z -value = 3.746, $p < .001$), as shown in Figure 5. This was expected since accuracy with verbal agreement was mostly at ceiling, whereas that was not the case for feminine clitics.

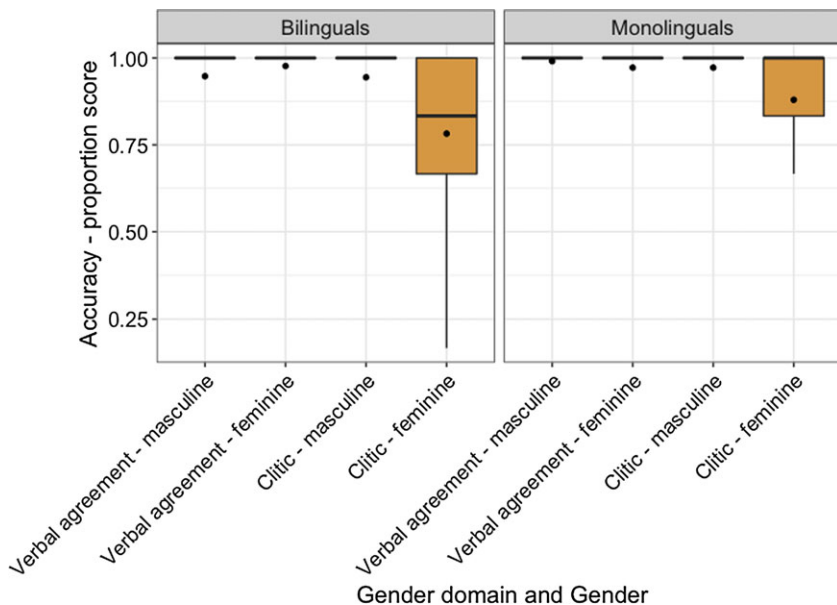


Figure 4. Accuracy as a proportion score (0–1) on verbal agreement (masculine and feminine) and clitics (masculine and feminine) according to group. Points in the boxplot indicate group means.

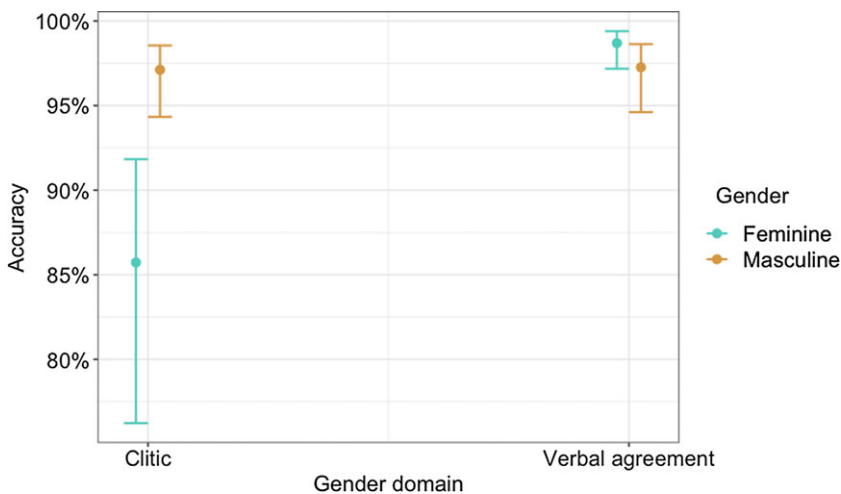


Figure 5. Predicted values given the interaction between Gender domain (Clitic vs. Verbal agreement) and Gender (Masculine vs. Feminine) in the model predicting accuracy with gender morphology according to the participant group, gender domain, gender, and the interaction between gender domain and gender.

Comprehension of relative clauses

Addressing question 2, we sought to determine how monolingual and bilingual children compared in their comprehension of relative clauses, and how the structure of clause (subject vs. object relatives) and the presence or absence of gender cues (mismatching vs. matching) may modulate that knowledge.

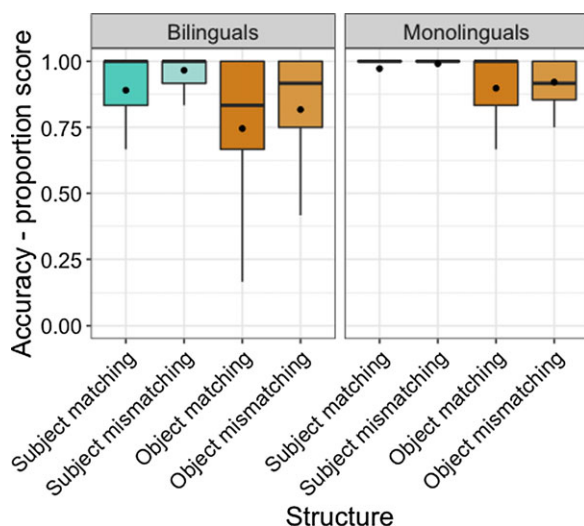


Figure 6. Accuracy as a proportion score (0–1) on subject relatives (matching and mismatching) and object relatives (matching and mismatching) according to the group.

The two groups had a ceiling or near to ceiling performance with SRs ($M_{bilingual} = 0.928$, $SD_{bilingual} = 0.126$; $M_{monolingual} = 0.981$, $SD_{monolingual} = 0.049$). With ORs, on the other hand, they displayed a higher degree of variability ($M_{bilingual} = 0.781$, $SD_{bilingual} = 0.264$; $M_{monolingual} = 0.910$, $SD_{monolingual} = 0.117$). Descriptive results breaking down SRs and ORs into matching and mismatching sentences are shown in Figure 6. The initial model investigating performance in this task included a three-way interaction between Group (Bilingual vs. Monolingual), Gender cues (Matching vs. Mismatching), and Structure (Subject vs. Object). As discussed in the *Data analysis* section, we only discuss the optimal model in the text, and we include its full output in the [Appendix](#). The optimal model included Group, Relative type, Gender cues, as well as an interaction between Relative type and Gender cues. This model found that, overall, the monolingual group outperformed the bilingual group (est. = 1.152, SE = 0.399, $z = 2.887$, $p = .004$), that both groups performed worse in object relatives than in subject relatives (est. = -1.722 , SE = 0.225, $z = -7.658$, $p < .001$), and that they performed better on relative clauses with gender mismatches rather than in relative clauses without gender mismatches (est. = 0.983, SE = 0.224, $z = 4.395$, $p < .001$). Furthermore, there was a significant interaction between Structure (subject vs. object relative) and Gender cues (est. = 0.920, SE = 0.446, $z = 2.060$, $p = .039$), in that the advantage of gender mismatches was more pronounced in the case of subject relatives (rather than in the case of object relatives) (Figure 7).

Individual differences in the comprehension of relative clauses

For our third research question, we focused on the Bilingual group and asked whether knowledge of gender morphology as encoded on clitics affects the comprehension of object relative clauses. Subject relatives and subject-verb

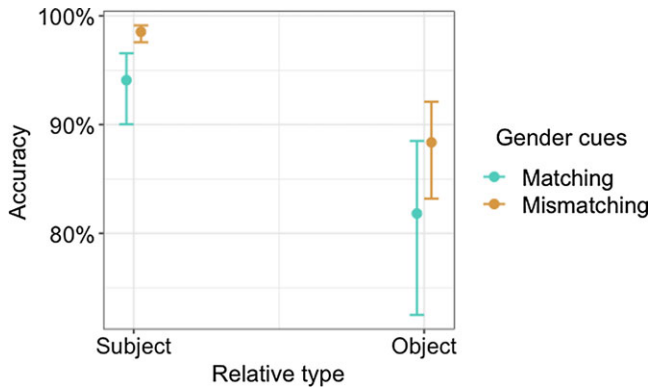


Figure 7. Predicted values given the interaction between Gender cues (Matching vs. Mismatching) and Relative type (Subject vs. Object) in the model predicting performance with relative clauses according to the participant group, relative clause type, presence or absence of gender cues, and the interaction between relative type and gender cues.

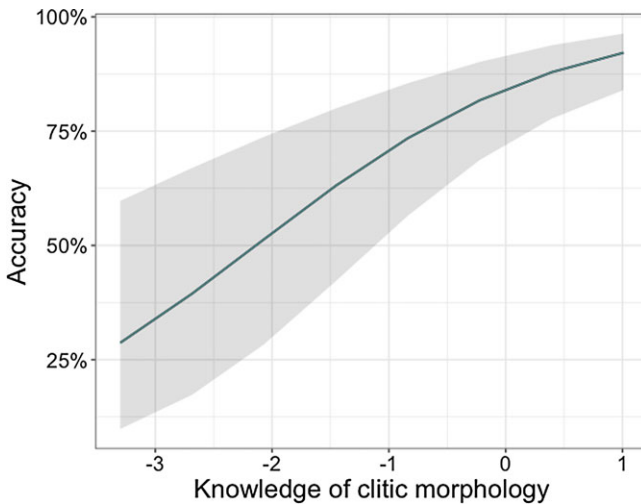


Figure 8. Predicted values of the effect of knowledge of clitic morphology in the model predicting accuracy with object relatives.

agreement were set aside due to ceiling performance. As such, the model included the predictors of Gender cues (Matching vs. Mismatching) and Knowledge of gender morphology in clitics. To test for the effect of potentially interfering factors, we added as fixed predictors: English AoA, Amount of current HL use with siblings, Length of Arabic formal instruction, Frequency of Arabic-speaking/listening activities, and Cognitive abilities. Finally, we had an interaction between Gender cues and all other fixed effects.

The final model included Gender cues, Knowledge of gender morphology, AoA, Frequency of Arabic-speaking/listening activities, Cognitive abilities, and the interaction between Gender cues and AoA. The main findings were the following:

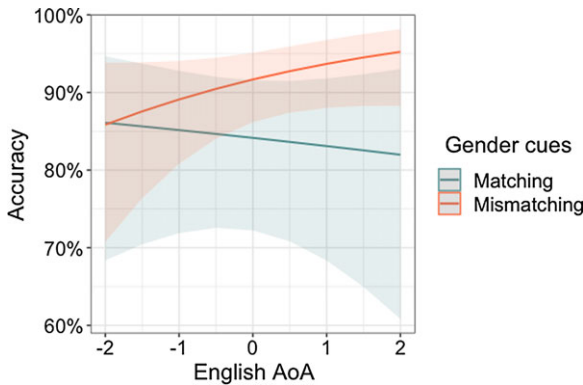


Figure 9. Predicted values given the interaction between Gender cues (Matching vs. Mismatching) and English AoA in the model predicting accuracy with object relatives.

having more knowledge of gender morphology on clitics predicted higher accuracy on relative clauses (est. = 0.783, SE = 0.174, z -value = 4.499, $p < .001$) (Figure 8), as did having higher cognitive abilities (est. = 0.411, SE = 0.181, z -value = 2.273, $p = .023$). There was also a positive association between higher frequency of Arabic-speaking/listening abilities and accuracy with object relatives (est. = 0.482, SE = 0.176, z -value = 2.747, $p = .006$). Finally, the interaction between Gender cues and AoA (est. = 0.375, SE = 0.148, z -value = 2.540, $p = .011$) appears visualized in Figure 9. It is interpreted in the following way: whereas English AoA does not appear to make a difference in the interpretation of object relatives without gender cues, having an older AoA predicts a higher likelihood of correctly interpreting sentences with gender cues.

Discussion

This study examined the interplay between morphological and syntactic comprehension among monolingual children, who were speakers of Syrian Arabic residing in Syria, and Syrian Arabic-English bilingual children, who were first-generation immigrants in Canada. More specifically, we asked: (i) how monolingual and bilingual children comprehended gender morphology as encoded on subject-verb agreement and on object clitics; (ii) how they comprehended relative clauses; and (iii) whether there was an association between morphological (gender) and syntactic (relative clauses) comprehension, when environmental, cognitive, and age-related variables were taken into consideration.

Overall, both groups exhibited a ceiling or a near to ceiling performance suggesting that after four years of residency in Canada, first-generation children maintain a good grasp of L1 morphosyntax. In this regard, first-generation children differ from the early exposure group studied in Albirini (2018), who, after the same length of English exposure (approximately four years), displayed a lower performance in both subject-verb agreement (singular-masculine: 76%; singular-feminine: 46%) and relative clauses (subject relatives: 90%; object relatives: 40%). The discrepancy could be attributed to differences in AoA. Whereas the children studied in the present study were exposed to English when they were on average

seven and a half years old, the children studied in Albirini's study (2018) were exposed to English when they were on average one and a half. As a result, they had a much more limited amount of time to solidify their knowledge of Syrian Arabic morphosyntax (on the role of AoA for L1 maintenance, see Montrul, 2008). A further consideration concerns the country of residence before the onset of bilingualism. The children studied in the present study were born and raised in Syria, which suggests that they used Syrian Arabic in a predominantly monolingual context not only for a longer period but also in a wider range of sociolinguistic contexts and registers and with a wider range of speakers. Thus, the richness of Syrian Arabic input, in addition to the length of exposure to Syrian Arabic, may have contributed to the better L1 outcomes reported in the present study.

In what follows, we discuss the morphological and the syntactic tasks in more detail. As we will see, despite first-generation children's very high performance, there was still a monolingual–bilingual difference in accuracy rates, suggesting that even first-generation children with a later AoA to the L2 may potentially experience attrition/incomplete acquisition. At the same time, though, there were no monolingual–bilingual differences in response patterns.

Morphological comprehension

The task targeting gender morphology revealed that even though the monolingual group outperformed the bilingual group, both groups displayed similar response patterns (research question 1): Both groups performed better with singular masculine gender rather than with singular feminine gender and with gender as encoded in subject–verb agreement rather than in object clitics.

Participants' higher performance with third person singular masculine is unsurprising given its default status in Arabic. As discussed in our introduction, it is fully mastered earlier than other forms and it is often overextended while the agreement system is still developing (Aljenaie, 2010). What is more, it is commonly overused by child and adult HSs (for Arabic, see Albirini, 2018; Albirini *et al.*, 2013; for Spanish, see Martinez-Nieto & Adelaida Restrepo, 2022; Shin *et al.*, 2019).

Participants' higher performance with gender as encoded in subject–verb agreement (rather than object clitics) indicates that the same category (gender) can show different degrees of resilience depending on the domain. The relative resilience of subject–verb agreement is well reported in the literature—especially in relation to noun–adjective agreement—and has been attributed to considerations of function and frequency: Affixes encoding subject–verb agreement index the subject of the sentence and co-vary with the temporal reference of the clause. Consequently, they are functionally more informative than affixes encoding noun–adjective agreement, a fact that may be related to their relative resilience (Albirini *et al.*, 2013). Considerations of frequency and function may also be implicated in the asymmetry observed in the present study: Differently from subject–verb agreement, object clitics are only compatible with transitive verbs and do not index temporal reference. It may, therefore, be unsurprising that they are less resilient than subject–verb agreement. Note that challenges with gender morphology on object clitics have been reported for HSs of other languages such as Spanish (Martinez-Nieto & Adelaida Restrepo, 2022; Shin *et al.*, 2019) and Greek (Alexiadou *et al.*, 2021).

Syntactic comprehension

Similarly to the task targeting gender morphology, the task targeting relative clauses (research question 2) revealed monolingual–bilingual differences in accuracy but not in response patterns. Specifically, both groups performed better in subject relatives rather than in object relatives (subject advantage), and in relative clauses with gender mismatches rather than in relative clauses without mismatches (mismatching advantage).

As mentioned in our introduction, the subject advantage in the comprehension of relative clauses (and other *wh*-dependencies such as interrogatives) is well-reported for younger monolingual children (e.g., Belletti et al., 2012; Roesch & Chondrogianni, 2015), as well as for heritage children exposed to the majority language in early childhood (before the age of 5) (e.g., Albirini, 2018; Coşkun Kunduz & Montrul, 2022). The present study serves to show that it persists among older monolingual and first-generation children with a later age of acquisition of the L2 (Mean AoA = 7.55). In the context of the Canonicity Hypothesis assumed in our study, these results can be taken to indicate that even older monolingual and first-generation children with a late AoA to English occasionally favor a linear interpretation of sentences. This tendency leads them to the correct interpretation in the case of subject relatives, whereby the first DP that they encounter (i.e., the head/antecedent) is indeed the subject/agent of the verb of the relative clause. By contrast, it leads to a misanalysis in the case of object relatives, whereby the first DP is actually the object/patient of the relative clause.

At the same time, the mismatching advantage shows that first-generation children, on a par with their monolingual peers, benefit from the presence of gender cues disambiguating who is doing what to whom (in line with the monolingual children studied in Belletti et al., 2012). This is despite their four-year long exposure to English, a language that uses primarily word order (rather than agreement) to encode grammatical relations.

Finally, the interaction between relative clause type and gender mismatches suggests that children (monolingual and bilingual, alike) are more likely to use gender cues in subject relatives rather than in object relatives (in contrast with results reported in Belletti et al., 2012 for Hebrew relative clauses). Why would gender cues be more helpful in the case of SRs? Recall from our introduction that in Syrian Arabic, both SRs and ORs display the same linear order (DP yali V DP) and disambiguation lies solely in gender morphology. Crucially, whereas in the case of SRs, gender morphology identifies the *preverbal DP as the subject*, in the case of ORs, gender morphology identifies the *preverbal DP as the object*. It may, therefore, be that gender cues are easier to attend to when they align with word order cues (as the case is with SRs) rather than when they compete with word order cues (as the case is with ORs).

The association between syntactic and morphological comprehension

Our last research question focused on the bilingual group and examined the association between syntactic and morphological comprehension in Syrian Arabic, while including environmental, cognitive, and age-related variables as co-variates.

Relative clauses and subject-verb agreement

Because of bilingual children's ceiling performance in the domain of subject-verb agreement, we were unable to test the association, if any, between comprehension of gender morphology as encoded in subject-verb agreement and comprehension of relative clauses. At the same time, bilingual children's ceiling performance in subject-verb agreement is interesting in its own right, as it shows that their variable performance with relative clauses does not necessarily indicate a morphological deficit. Rather, it could be that the ability to attend to subject-verb agreement is compromised when the latter is used in non-canonical word orders. Interestingly, a similar conclusion is supported by studies focusing on case and word order in heritage Greek (Chondrogianni & Schwartz, 2020) and heritage Korean (Kim et al., 2018). Both studies report higher performance in the task targeting case morphology than in the task targeting comprehension of non-canonical word orders. The observed asymmetry could be taken to indicate that children's ability to use case cues is compromised when the latter ones are embedded in non-canonical word orders.

Relative clauses and object clitics agreement

In the domain of object clitics, bilingual children showed a higher degree of variability, a fact that allowed us to test the syntax-morphology association. We found, indeed, that children with higher performance with object clitics also had a higher performance with object relatives, suggesting that morphological comprehension strengthens syntactic comprehension. This is in line with Chondrogianni & Schwartz (2020) who also found an association between knowledge of case morphology and comprehension of non-canonical word orders in heritage Greek (even though, as mentioned above, overall children did better in the task targeting case).

The effect of the co-variates

Sources of individual differences were not the focus of the present study. Nevertheless, cognitive, environmental, and age-related variables were included as co-variates, based on existing studies showing that they may affect the acquisition/development of HL syntax.

Of the variables that we tested, length of Arabic schooling did not have a significant effect (contra Soto-Corominas et al., 2021). The null results could be due to the fact that object relative clauses in Modern Standard Arabic, which is the language of formal instruction, have different properties than object relative clauses in Syrian Arabic (notably relative clauses in Modern Standard Arabic rely on word order, case, and agreement to indicate who is doing what to whom, and they do not have obligatory object clitics). Accordingly, there was no effect for language use in the home with siblings, possibly because object relative clauses are uncommon in daily sibling communication.

By contrast, there was a positive effect of non-verbal cognitive abilities (in line with Soto-Corominas et al., 2021 and Paradis et al., 2021) and a positive effect of frequency of oral activities in Arabic, showing that concurrent language practices matter not only for second-generation heritage children with an early exposure to

the L2 (e.g., Daskalaki et al., 2019; Daskalaki et al., 2022) but also for first-generation immigrant children who immigrated to the host country at an older age (e.g., Paradis et al., 2021). Turning to the effect of AoA, there was a positive interaction between older AoA and the presence of gender mismatches. In other words, an older AoA was associated with a better performance in ORs *with* gender mismatches but not in ORs *without* gender mismatches. This may be related to the fact that ORs without gender mismatches are later acquired even by monolingual children (see, for instance, Belletti et al., 2012, for Hebrew). As hypothesized by Tsimpli (2014), later acquired phenomena are more likely to be sensitive to input rather than to the AoA of the societal L2.

Study limitations and future directions

It is important to acknowledge the limitations of our study. In order to keep testing time with children located in Syria to a minimum, we did not collect information on maternal education or on non-verbal IQ. It is, therefore, possible that there are differences between the bilingual and the monolingual group that we were unable to control for. Second, we need to keep in mind that our conclusions are based solely on comprehension tasks. Given that differential patterns are usually manifested earlier in production than in comprehension (e.g., Perez-Cortes et al., 2019), it is possible that we would have seen a higher rate of variability in a narrative or a sentence completion task. Finally, a longitudinal study design following the children's language development from the point of resettlement to the present (similar to Paradis et al., 2021; Authors, submitted) would have enabled us to determine if the observed variability with gender morphology and syntax diminishes (protracted acquisition), increases (attrition), or does not change significantly over time (incomplete acquisition/divergent attainment).

Conclusions

To conclude, bilingual children had a very high performance in both relative clauses (ranging from 74% in matching ORs to 96% in mismatching SRs) and gender agreement (ranging from 78% +in feminine object clitics to 97% in feminine subject-verb agreement). This result shows that after a residency of four years and a half in Canada, Syrian Arabic-speaking children, with a later AoA of English ($M = 7.5$ years), maintain a very good grasp of their L1 morphosyntax, at least as far as comprehension is concerned. At the same time, they differ significantly from their monolingual peers, suggesting that the monolingual–bilingual differences that are well-reported for the case of second-generation children, born and raised in the host country, may eventually obtain even in the case of children with an older AoA of the L2.

Turning to the interplay between morphology and syntax, our results support three main conclusions. First, bilingual children performed better in relative clauses with gender mismatches than in relative clauses without mismatches, suggesting that, like their monolingual peers, they attend to and benefit from morphological cues to comprehend ORs. Second, there was an association between morphological and syntactic comprehension, suggesting that morphological knowledge may enhance/compromise children's ability to comprehend ORs. Third, despite this

association, there was an asymmetry between morphology and syntax: comprehension of agreement in simple clauses (gender agreement on verbs: 95.5%; gender agreement on clitics: 86%) was, at least descriptively, higher than comprehension of object relatives with gender mismatches (ORs: 81%).

These results are of theoretical relevance as they support the view that challenges with ORs, and more generally challenges with non-canonical word orders, are not *necessarily* an epiphenomenon of a morphological deficit. Rather, it may be that bilingual children are less likely to attend to morphological cues when the latter ones are in “conflict” with word order cues. Difficulties attending to morphological cues in these contexts could be due to processing limitations and/or exposure to a societal language that relies primarily on word order to indicate who is doing what to whom (see Kim *et al.*, 2018, for similar conclusions). Implications for HL instruction may also be considered. Specifically, our results may be taken to support explicit instruction of morphological categories such as agreement not only in isolation but also in the context of both canonical and non-canonical word orders (a suggestion originally made by Slabakova (2014) for L2).

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Replication package. Replication data and materials for this article can be found at <https://osf.io/ufm5t/>.

Competing interests. The authors declare that they do not have competing interests that could have appeared to influence the work reported in this paper.

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Appendices

Table A1. Estimates for the fixed effects of the model predicting accuracy in the two gender domains as predicted by Group (Bilingual vs. Monolingual), Gender domain (Clitic vs. Verbal agreement), Gender (Masculine vs. Feminine), and the interaction between Gender domain and Gender. The three categorical predictors were sum-coded: “Bilinguals” (from the predictor Group), “Clitic” (from the predictor Gender domain), and “Masculine” (from the predictor Gender) were coded as -0.5 and their alternative was coded as 0.5 . As such, estimates are the difference between the two levels of each predictor. The Intercept corresponds to the global grand mean. Model run on 3024 observations (126 participants, 24 items). C index of concordance = .90. No violations observed in the residuals

	Estimate	Std. Error	z value	$Pr(> z)$
(Intercept)	3.718	0.272	13.673	<.001***
Group	0.835	0.413	2.021	.043*
Gender domain	1.293	0.330	3.912	<.001***
Gender	-0.486	0.330	-1.472	.141
Gender domain:Gender	2.476	0.661	3.746	<.001***

Table A2. Random effects of the model predicting accuracy in the two gender domains as predicted by Group, Gender domain, Gender, and the interaction between Gender domain and Gender

Groups	Variance	Std. Dev
Participant	1.289	1.355
Item	0.434	0.659

Table A3. Estimates for the fixed effects of the model predicting accuracy with relative clauses according to Group (Bilinguals vs. Monolinguals), Structure (Subject vs. Object), presence or absence of Gender cues (Matching vs. Mismatching), and the interaction of Structure and Gender cues. The three categorical predictors were sum-coded: “Bilinguals” (from the predictor Group), “Subject” (from the predictor Structure), and “Matching” (from the predictor Gender cues) were coded as -0.5 , and their alternative was coded as 0.5 . As such, estimates are the difference between the two levels of each predictor. The Intercept corresponds to the global grand mean. Model run on 4536 observations (126 participants, 36 items). C index of concordance = .87. No violations observed in the residuals

	Estimate	Std. Error	z value	$Pr(> z)$
(Intercept)	3.203	0.228	14.039	<.001***
Group	1.152	0.399	2.887	.004**
Structure	-1.722	0.225	7.658	<.001***
Gender cues	0.983	0.224	4.395	<.001***
Structure: Gender cues	-0.920	0.446	2.060	.039*

Table A4. Random effects of the model predicting accuracy with relative clauses according to the participant group, relative type, presence or absence of gender, and the interaction of relative type and gender cues

Groups	Variance	Std. Dev
Participant	1.690	1.300
Item	0.283	0.532

Table A5. Estimates for the fixed effects of the model predicting accuracy in object relatives by the Bilingual group as predicted by Gender cues (Matching vs. Mismatching), Knowledge of gender morphology on clitics, AoA, Frequency of Arabic speaking/listening activities, Non-verbal analytical skills, and the interaction between Gender cues and AoA. All numerical predictors have been scaled and centered. Gender cues was sum-coded: “Matching” was coded as -0.5 and “Mismatching” as 0.5. Model run on 1926 observations (107 participants, 18 items). C index of concordance = .91. No violations observed in the residuals

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	2.035	0.259	7.853	<.001***
Gender cues	0.729	0.405	1.800	.072.
Knowledge of gender morphology on clitics	0.783	0.174	4.499	<.001***
AoA	0.110	0.183	0.603	.547
Frequency of Arabic speaking/listening activities	0.482	0.176	2.747	.006**
Non-verbal cognitive skills	0.411	0.181	2.273	.023*
Gender cues:AoA	0.375	0.148	2.540	.011*

Table A6. Random effects of the model predicting accuracy in the two gender domains as predicted by Group, Gender domain, Gender, and the interaction between Gender domain and Gender

Groups	Variance	Std. Dev
Participant	2.212	1.487
Item	0.560	0.748

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