Syntactic error processing in bilingualism: an analysis of the Optional Infinitive stage in child language acquisition

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ABSTRACT

The English language acquisition process includes a stage in which children optionally replace finite verbs with corresponding nonfinite forms. During this "Optional Infinitive" (OI) stage between the ages of two and four, children sometimes produce correct verb forms but often omit the past tense *–ed* ending, present tense third person singular *-s* ending, and auxiliary verbs. Children showing normal language development cease to produce OI errors after age four, but mature English speakers continue to show difficulty in processing these forms even as adults, reacting more slowly to OI errors than to non-developmental errors in grammaticality judgment tasks (Kovelman et al., under review).

I present a study investigating the influence of the developmental OI stage in L1 language acquisition on adult language processing. Because Mandarin Chinese does not exhibit an OI stage, I extend Kovelman et al. (under review)'s auditory grammaticality judgment task to compare differences in reaction time and accuracy for OI and non-developmental errors in native Chinese speakers who learned English after age 5 to the behavioral measures of monolingual English speakers, with a pilot investigation of native Spanish speakers. Results indicate that the different language groups show the same relative difficulty with OI errors in English, suggesting a fundamental difference in the processing of these and non-developmental errors in the adult grammar regardless of the occurrence of the developmental stage.

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1. Introduction

The English language acquisition process includes a stage in which children produce nonfinite forms in place of some finite verbs. Termed the Optional Infinitive (OI) stage by Wexler (1994 and following), this period lasts until the age of four and is characterized in English by the omission of past tense *–ed* endings, present tense third person singular *-s* endings and auxiliary verbs. These nonfinite forms coexist with correctly inflected forms; adult inflection is therefore possible, but no more acceptable than nonfinite forms. This phenomenon is characterized by three important observations: (1) children with normal language development gradually cease to produce OI forms by the age of four (Wexler 1994 and following), (2) OI stage tense-marking error patterns do not appear in acquisition taking place after age five (Prévost & White 2000; Ionin & Wexler 2002; Haznedar 2003), and (3) mature English speakers continue to show difficulty in processing OI errors even as adults (Kovelman et al., under review).

Finding an explanation for the Optional Infinitive that suitably accounts for these facts presents an opportunity to characterize the child language acquisition process as a whole, and the way that patterns in child grammar are related to the adult grammars they approximate and eventually become. Many questions surrounding this issue center on the notion of parameter-setting: language acquisition, in this view, is a process of using available input to narrow down the correct set of parameters that describe the language of exposure (Legate & Yang 2007). In some views phrase structure is fully articulated but hampered by a computational or derivational deficit (Wexler 1994 and following; Phillips 1996); others dispute this in saying that Universal Grammar is underspecified in the child grammar (Rizzi 1994) or even that abstract notions of phrase structure are not available until much later on. For those theories, then, the development of child language centers primarily on imitation of the input (cf. Tomasello 2000; Croker, Pine, & Gobet 2000). Still others locate the underlying cause of the Optional Infinitive in the pragmatic or discourse interface with the syntactic system (Avrutin 1999; Pratt & Grinstead 2007, 2008).

These competing ideas may be clarified by the observation noted above that L2 learners whose exposure begins later do not exhibit the patterns of a productive OI stage, though they do show issues with verbal morphology (Ionin & Wexler 2002). Instead, their impairment appears more morphological in nature (Prévost & White 2000). Wexler (2002) takes this as compelling evidence that the Optional Infinitive does not represent a learnability problem, but a genetic constraint on *child* language acquisition. That is, this pattern of optional inflection reflects not a limitation of the input (a problem that would seemingly be common to both L1 and L2 learners) but a constraint on the developing brain as the processor matures. He therefore proposes a syntactic explanation relating to phrasal structure-building, in which the *Unique Checking Constraint* (UCC) restricts feature-checking operations in such a way that tense and agreement projections are optionally omitted (Wexler 1998). The UCC is able to explain the fact that OI errors cease to be produced after age four because it theoretically applies only to the immature language processor, except in cases of overall systemic delays (e.g. Specific Language Impairment (SLI)).

Kovelman et al. (under review) are responsible for the observation that adult English-speakers still show difficulty in processing OI errors even though they do not produce them. They integrate this with the implications of Wexler's UCC by proposing that the UCC in fact persists after age four and licenses competing representations that the adult processor must suppress. This suppression manifests as slower reaction times in grammaticality judgment tasks, as compared to subject-verb agreement errors that do not have corresponding developmental stages.

The idea of processing difficulty corresponding to errors produced in a developmental stage poses an interesting question in view of the experimental data showing that L2 learners do not exhibit the developmental stage in question (Ionin & Wexler 2002). The cause of adult processing slowdowns is proposed by Kovelman et al. (under review) to be a competing representation licensed by the UCC that must be suppressed before the adult form wins out. If the UCC does not appear to have influenced the trajectory of language development and an OI stage was not observed, in the case of L2 English speakers, does that imply that it is not present as a constraint, perhaps because that constraint is linked to cognitive development and not language development? If it is not present as a constraint on the earliest grammatical representations of L2 speakers, should it therefore be considered not to exist in the adult grammars of these speakers? In that case they should not show processing slowdowns for English OI errors as adults if they are not exposed to English before age four.

Crucially, however, the UCC applies cross-linguistically. These L2 speakers had no exposure to English at the time that the UCC was theoretically in place. But if they were learning, for example, Spanish, which has its own manifestations of the Optional Infinitive and is certainly constrained by the UCC (Pratt & Grinstead 2007, 2008), then the UCC was still influential in the development of (one of) their grammar(s). The UCC therefore continues to compete with adult constraints, and indeed Spanish-speaking adults react more slowly to Spanish OI errors (Arredondo, Satterfield, & Kovelman 2012). The larger question then arises whether the language processor comprises one instrument with a dual language capacity, or whether a bilingual speaker has two separate sets of syntax to implement. Are there global grammatical constraints, as Wexler (1994 and following) and Kovelman et al. (under review) are proposing, that could apply cross-linguistically as mechanisms in common within a single speaker even if that speaker maintains two separate sets of parameters for those two languages? If so, we would expect that a Spanish speaker whose exposure to English began after age four would still show difficulty processing English OI errors as an adult. This would imply that the UCC is licensing competing representations in English even though the speaker's language development process did not include a stage during which the UCC was a dominant constraint on their English. This is even clearer in Mandarin Chinese, which lacks the overt verbal morphology that would allow patterns of tense omission to be evident. Mandarin speakers who are also late learners of English therefore did not produce OI errors in either of their languages, and we might expect that if the UCC is indeed the cause of adult processing slowdowns, Mandarin speakers should not exhibit them at all, although the possibility exists that the OI stage happens covertly for them and that they therefore would show effects of the UCC as English-speaking adults. The UCC aside, the more basic issue remains as to whether the *production* of these types of errors in the child stage is related to the adult processing patterns.

This paper will consider the various implications of these questions with a grammaticality judgment task replicating and extending the paradigm of Kovelman et al. (under review) in fluent adult English-speakers whose L1 is Chinese or Spanish, and whose exposure to English did not begin until after the conclusion of the productive OI stage at age four, using a reaction time measure. I will first present a theoretical background for the OI stage, including competing explanations as to why it happens, and its cross-linguistic manifestations, intersections with bilingualism, and relationship with the adult grammar. I will then describe my experimental design and explain my results, and finally will present an analysis of the viability of and alternatives to Wexler (1994 and following)'s UCC proposal in the context of my findings, arguing that input-driven processing models for the Optional Infinitive stage may present equally compelling accounts of the phenomena under consideration.

2. Background: the Optional Infinitive Across Languages and Across the Life Span

In this section I will outline the dominant theories explaining the occurrence of the Optional Infinitive stage in child language development, considering syntactic, computational, and pragmatic perspectives. I will then give a cross-linguistic account of the Optional Infinitive stage and explain how it intersects with bilingualism and L2 acquisition. Finally I will consider the relevance of the Optional Infinitive beyond its typical developmental stage, in syntactic error processing patterns in adults.

2.1 Explaining the Optional Infinitive: Competing Theories in the Literature

Though Wexler has dominated theoretical discussions of the Optional Infinitive since the first papers published in the early 1990's, several other theories have been proposed in opposition to Wexler's *Unique Checking Constraint*. These include Rizzi (1994)'s syntactic truncation model, pragmatic accounts introduced by Avrutin (1999) and advanced by Pratt & Grinstead (2007, 2008), computational learnability theories as proposed by Croker, Pine, & Gobet (2000), and Legate & Yang's (2007) morphosyntactic parameter-setting model. Each focuses on a different potential point of departure from the target language in the developmental process and explains how deficits in that area, whether syntactic, pragmatic, computational, or morphological, might explain patterns of tense acquisition in young children. In Section 2.1 I will describe and compare the structures and implications of these different theories.

2.1.1. Syntactic Explanations

Proposals for a syntactic explanation of the Optional Infinitive generally rest on the idea of underdevelopment or under-specification of the child's phrase structure and the derivational process by which it is manipulated. One option is truncation, articulated by Rizzi (1994) as the stripping off of external clausal layers. This is in contrast to the idea on which Wexler (1994 and following)'s theories rest, that children have full knowledge of phrase structure and syntactic parameters from the earliest stages of language acquisition, and that the Optional Infinitive stems from a constraint on feature-checking operations.

2.1.1.1. The Truncation Hypothesis

Rizzi (1994), in introducing his Truncation Hypothesis, provides a useful outline of the ways in which current perspectives on child language acquisition may fundamentally differ. Assuming full adult Universal Grammar, he gives the following possibilities:

> Early systems are full-fledged possible natural languages, differing from target systems only as a function of parameter fixation; in some cases, a parameter may be preset on some initial value and then reset on the basis of experience (alternatively, it may be the case that initially both values of a parameter are entertained, but then one is selected on the basis of experience). In addition, there may be performance filters (e.g. working-memory limitations) which may affect early production by triggering systematic omissions of certain classes of elements which are nevertheless present in the mental representation (Rizzi 1994, p.373).

He specifically differentiates the ideas of underspecification and parametric variation, adding the following slight variation to the possibilities above, which he attributes to Borer and Wexler (1987): "A slightly underspecified UG constrains the early systems, where underspecification does not mean just that some parameters are not fixed initially; rather, it means that some principles or properties are not operative initially, but are triggered, or mature later in the mind," (Rizzi 1994, p.374). This view is what governs his proposal for the Optional Infinitive, advocating for the idea that some aspects of language acquisition are not attributable to parametric variation, as parameter-setting takes place, but to the fact that some very local but crucial principles of UG are not fully specified. His view is different from that of Wexler and those following because he locates the cause of the Optional Infinitive in the (underdeveloped) phrase structure itself, and not in an incorrectly set parameter, or in the derivation.

Rizzi notes that root infinitives (his term for OI's) do not occur in *wh*-questions, which suggests that root infinitive forms may not be full CP's and therefore lack a spec,CP landing site for *wh*-elements to raise to. In Rizzi's proposal this is because phrase structure in the child grammar does not require that CP be its root. Root infinitives occur when the most external clause is anything lower than TP, which in English would mean a bare VP. In languages with a more morphologically specified infinitive (e.g. *–er*), the highest clause of a root infinitive is the maximal projection of its head morpheme, and in these languages the infinitival inflection must then be something higher than V. The lack of a T node explains why tense-less representations are licensed by the child grammar: in the mature system C cannot appear in the absence of T, which means that T is obligatory when C is present, but in the child grammar the requirement that CP be the root of the phrase is not yet in place, with the result that when C is absent, there is nothing requiring the presence of the T node. In this way truncation of phrase structure above VP explains not only the occurrence of root infinitive structures but also their optionality.

2.1.1.2. Very Early Parameter Setting

Wexler takes a different view. One of the crucial underlying ideas in Wexler (1998) is that the previously standard holding in language acquisition that genetically encoded grammatical properties emerge early and experience-dependent grammatical properties emerge late should be reconsidered. Wexler challenges not the idea that learning takes time but that many of the patterns children show in language acquisition are attributable to the slow development of these important, usually parametric, properties of language. He considers fundamental structure to be largely intact from a young age, with the causes of deviation from the target language originating elsewhere.

His proposal in opposition to the "late learning/early emergence" hypothesis is that language acquisition is characterized by the principle of *Very Early Parameter Setting* (VEPS):

> (1) Basic parameters of verb movement, e.g. V to I, V to I to C, are correctly set at the earliest observed stages, thus in the OI stage they're correctly set. Parameters that are set at the earliest observed stage (i.e. at beginning of production of multiple word combinations, around 1;6) include:
>
> a. Word order, e.g. VO versus OV (e.g. Swedish vs. German)
> b. V to I or not (e.g. French versus English)
> c. V2 or not (e.g. German versus French or English)
> d. Null subject or not (e.g. Italian versus English or French)
>
> (Wexler 1998, p.29)

Wexler (1998) explains that the null subject parameter, though seemingly unrelated, is in fact correctly set along with the verb parameters, but null subject usage remains high in OI constructions because PRO is licensed by the non-finite verb. VEPS is made alongside another generalization called VEKI, *Very Early Knowledge of Inflection*, which similarly specifies that from the time of the two-word stage the child knows the grammatical and phonological properties of inflection in their language, making very few mistakes in the use of agreement morphemes.

Wexler (1998) cites a variety of evidence for VEPS, including that the word order parameter is observable in the contrast between Japanese and English, where even in the early stages Wexler (1998) says children place verbs in the final position in Japanese, the SOV language, but in SVO order in English. Wexler (1998) cites Pierce (1989, 1992) as showing that in young French-speaking and English-speaking children, the placement of negation provides evidence that the verb-raising parameter has been correctly set (as in (1b)): in French, negative *pas* always follows the finite verb and precedes the non-finite verb, and in English, finite main verbs always follow negation. Finally the V2 parameter (1c) is evident in early German (Poeppel & Wexler 1993), in which two-year-olds correctly place finite verbs in V2 position and nonfinite verbs in final position.

Though VEPS in its definition makes claims only about the period from 18 months onward, it is important to note that this is only because 18 months is the point at which utterances in which evidence of parameter setting would be observable begin to be produced. Wexler (1998) emphasizes that these linguistic properties may be in place even earlier. VEPS is also claimed to discredit the idea of *negative evidence* as a driving force in language acquisition, negative evidence being correction of child utterances by adults that the child takes into account in determining the structure of their language. Because correct parameter settings are observed immediately at the onset of the first utterances complex enough to warrant negative evidence, it would be impossible for negative evidence to have played any role in their setting. It should be noted that indirect negative evidence could still be at play, in that structures that do not appear could be taken to be impossible.

Phillips (1996) similarly characterizes the child grammar as structurally complete, with parameters correctly set and analogous to the adult grammar. His argument for why, if this is true, the Optional Infinitive still occurs is that the derivational step of verb movement to combine with inflection is not obligatory. There are still inviolable requirements of verb movement in some cases, such as V-to-T-to-C movement in questions in V2 languages like German, and in languages where V-to-C movement is required for Nominative case licensing. Phillips (1996) argues that children will not produce Optional Infinitive forms in these contexts but will do so in any construction that does not make verb movement obligatory, citing evidence from German, Dutch, and English to illustrate these contrasts. This difference in production of Optional Infinitive forms is taken to be very important, between *languages* that do and do not require verb movement in a given construction, and, within a given language, between *constructions* that do and do not require verb movement. This is taken by Phillips to be evidence that underspecification of the phrase structure cannot be considered to be a cause of the Optional Infinitive, because its effects would hold across constructions and across languages.

2.1.1.3. The Unique Checking Constraint

Relying on the assumption of structural completeness, via VEPS, Wexler (1998) pinpoints feature checking, not verb movement, as the locus of the problem of the Optional Infinitive. He describes the syntactic properties of OI errors using the Agreement/Tense Omission Model (ATOM), first proposed in Schütze &Wexler (1996):

(2) AGR/TNS Omission Model (ATOM) of OI Stage:

a. AGR or TNS (or both) may be deleted
b. AGR assigns NOM, if no AGR, subject gets default case
c. Default case in English is ACC, in German/Dutch it is NOM
d. Lack of TNS licenses PRO
e. Morphology inserted according to Elsewhere Principle, e.g. Distributed Morphology
f. Kid knows adult Syntax and Morphology (features, Elsewhere Principle, default forms)

(Wexler 1998, p.44)

Wexler's original argument held that omission of TNS alone was responsible for OI forms, but ATOM revises this to say that either AGR or TNS can be omitted in the child grammar, on the basis of patterns of subject case in OI forms in English. Accusative is the default case in English and is assigned to the subject when AGR is not present to assign nominative case, omission of AGR thus accounting for accusative-case OI constructions. Omission of TNS accounts for null-subject OI constructions (because the non-finite form licenses PRO), and for OI forms with nominative subjects, in which AGR is present.

ATOM leaves us with the following paradigm for OI and finite forms:

(3) a. he likes ice cream [+AGR, +TNS]
b. he like ice cream [+AGR, -TNS]
c. him like ice cream [-AGR, +TNS]
d. *him likes ice cream

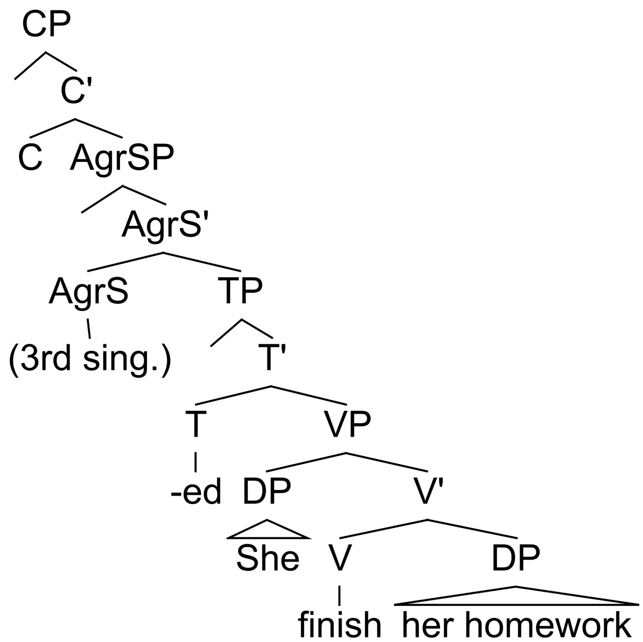
(Wexler 1998, p.45)

Wexler (1998) does not include a null-subject form but presumably the following form would also be predicted:

e. PRO like ice cream [-AGR, -TNS]

Inflection on the verb can only appear when both AGR and TNS are present because a morpheme cannot be inserted if it contains a feature that is not specified on the node. Thus in (b), with TNS omitted, neither */s/* nor */ed/* can be inserted because they have [+present] and [+past] features, respectively, which are not present on the node. The other OI form in (c) appears with accusative case because AGR is missing, and the verb cannot bear inflection because */s/* is specified for [+3rd, +singular], features that are not present on the node.

Omission of TNS and AGR may help explain the distribution of case and inflection in OI forms, but why is the omission of these functional projections permitted in the first place? Per Wexler (1998), this is unrelated to parameter-setting and results from the mechanism of feature-checking instead. We assume that subjects raise to INFL, as motived by the EPP, to check their D-features. This addresses a problem in Rizzi (1994)'s analysis, which makes OI forms bare VP's. A bare VP leaves only a Topic position higher in the structure for the subject to raise to, and no explanation for how the subject sometimes receives nominative case. In Wexler (1998)'s model, subjects raise to check their D-feature on AGR or TNS, depending on which is present. AGR and TNS both have uninterpretable D-features that must be eliminated for the derivation to converge, and the reason that one or the other is omitted in OI structures is that in the child grammar, a DP's D-feature can only be checked once. This is Wexler (1998)'s *Unique Checking Constraint* (UCC): a DP in the adult grammar would be able to check the D-features on both AGR and TNS, consecutively, but the child grammar is constrained to only one such feature-checking operation, and so must omit one of the projections for the derivation to converge. The tree below shows the underlying structure assumed for a sentence like "She finish her homework," in which both the subject DP and the verb start low in the VP and then move up to the Tense and then the Agreement projections, to check D-features or to receive inflection.



Under ATOM and the UCC, the D-feature on the DP can only be checked once, which requires that either TNS or AGR be omitted and therefore prevents a finite derivation from converging.

The crucial optionality of the Optional Infinitive results from a balancing act between violations of the UCC and violations of adult constraints, as several possibilities exist when the child is building a representation. The first would be producing a correct, finite form, which the child does in a significant percentage of utterances. In these cases the D-feature on the DP is checked twice, in violation of the UCC. When OI forms are produced, it is because the representation is faithful to the UCC, and the DP checks its D-feature on T but then cannot move up to check the D-feature on AGR. This is ungrammatical because it leaves an uninterpretable feature, and the derivation will crash, so the child builds an alternative representation instead, with only one functional category in INFL (either AGR or TNS). The D-feature can then be checked once without leaving any uninterpretable features in the derivation, but these types of structures violate the adult grammar's requirement (present in the child grammar from the start) of possessing both AGR and TNS. Wexler (1998) paints these—violation of the UCC in constructing a finite representation, and violation of the adult grammar's inflectional requirements in producing an OI form—as equal violations. The child's purpose is to minimize violations, but because both are equally bad there is no preference for one structure over the other.

The next question, then, is why the UCC exists in the child grammar. One possibility is that the child grammar, while a subset of UG and therefore theoretically UG-compatible, is simply more restricted than the adult grammar, allowing only one feature-checking operation instead of two, and as it matures it adds more representational and derivational possibilities (though Wexler (1998) doesn't acknowledge the fact that it is also true that a structure lacking AGR or TNS is technically an addition of a representational possibility not allowed by the adult grammar). The logic here is also rather unclear in that Wexler (1998) makes a generalization ("UG-Compatible Convergence (UGCC)") saying that anything that converges in the child grammar also converges in UG, but this is explicitly not the case with OI forms. Wexler (1998)'s explanation is that there is not in fact a requirement of the "computational syntax of UG," (Wexler 1998, p.63) that AGR and TNS both be present, only an interpretive or conceptual one, which means that the representations still converge.

The UCC's existence being explained by a restriction on movement is also a consideration. A more specific explanation for a constraint against double-checking, however, might be found in the interpretive features of the determiner in the child grammar. In adult syntax, the DP is able to check features on both AGR and TNS because its own D-feature is interpretable, and does not have to be eliminated after checking. In the child grammar the DP could have an uninterpretable D-feature and therefore cannot be checked more than once, although this is problematic because it seems that the idea of the D-feature on a DP being checked and then deleted should be a violation of UG, and variations in interpretability are plausibly parametric, which Wexler (1998) has explicitly ruled out.

Wexler (1998) proposes that this difference in interpretability could relate vaguely to a more general interface/pragmatic deficit, and broader issues that children seem to exhibit understanding specificity as manifested in determiners, and the difference between old and new information. I will revisit the idea of a pragmatic deficit as the root cause of the Optional Infinitive in Section 2.1.3.

In summary, syntactic explanations for the Optional Infinitive rest on the idea of impairment in the functional projections and derivations of INFL. Rizzi (1994) proposes truncation above VP and Phillips (1996) proposes intact phrase structure but a prohibition on verb movement in some cases. Wexler (1998) presents the most detailed analysis in claiming that parameters are correctly set from the outset, and the child grammar differs from the adult grammar in having an uninterpretable D-feature on its DP's. The DP can therefore only check the D-feature on one functional projection, AGR or TNS, or the derivation will violate the UCC, leading the child to construct representations in which only one is present.

2.1.2. Learnability Models

The syntactic theories outlined in the previous sections isolate specific issues in our abstract notions of structure-building to derive explanations for the Optional Infinitive in child grammars. Primarily at play is the idea of innate features in Universal Grammar, but many other theories take a broader view and look not at the architecture of the language system itself, but at the computational process with which it handles linguistic input. These computational approaches have the advantage of being able to train their models on corpus data and analyze the results in comparison to observed patterns in child utterances, a step beyond the more abstract predictions of hypotheses in theoretical syntax.

Croker, Pine, & Gobet (2000) set a hard line in refusing to ascribe to the child the wealth of abstract grammatical knowledge that Wexler (1998) describes. Instead they take language learning to be "an interaction between a performance-limited distributional analyser and the statistical properties of mothers' child-directed speech," (Croker, Pine, & Gobet 2000, p.78). The Optional Infinitive stage therefore does not derive from the parameter-setting process or any feature of UG, but arises instead as a reflection of the input to the child; the distribution of OI forms within and across languages should, therefore, reflect the usage patterns of those forms in the language of exposure. This is apparent in a basic way in that OI constructions in English are not independently licit but can appear within other strings, whereas simple subject-verb agreement errors are never produced in any fragment of adult speech. Thus "she going" and "him go" (Croker, Pine, & Gobet 2000, p.79) are not produced by adults but might appear in those sequence in such forms as "Where is *she going*?" or "Look at *him go*," but forms like "she am" and "he are" are never attested.

MOSAIC (Model of Syntax Acquisition in Children) is their computational model for the availability of Optional Infinitive forms to the child. MOSAIC, based on the cognitive architecture concepts of CHREST (Chunk Hierarchy and REtrieval STructures), is a hierarchical network of information nodes and links, which grows via discrimination (creation of a new node) or familiarization (augmentation of information at a given node) for each word in a child-directed utterance. Nodes are linked together vertically by their sequence in an utterance, but horizontal, generative links can also be formed among apparent categories. With a growing network of these utterance possibilities established, the child can begin to produce utterances either by tracing a sequence and producing a string effectively by rote ("by recognition"), or by traversing generative links to produce utterances that have not yet been encountered. Figure 2 from Croker, Pine & Gobet (2000), showing a network of generative link formation, is reproduced below.

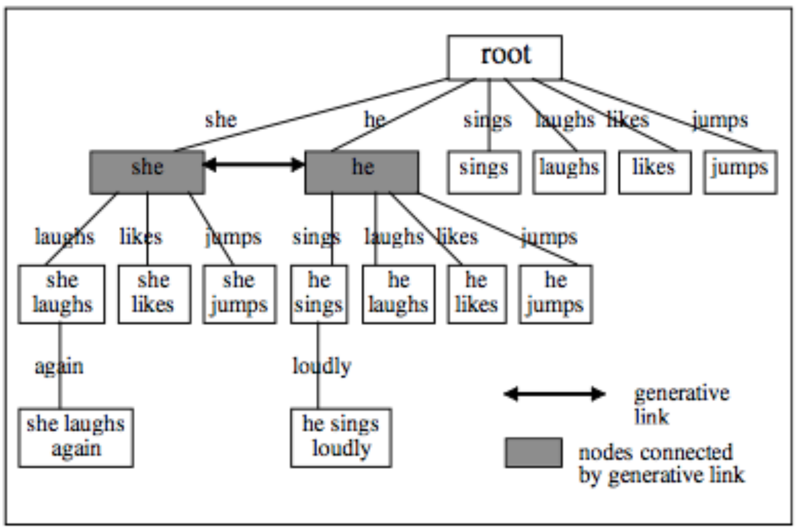


Figure 2: Fragment of a discrimination network showing generative link formation. This network can be used to produce utterances by both generation and recognition

Croker, Pine & Gobet (2000, p.81)

Croker, Pine, & Gobet (2000) applied this learnability model to a large corpus of child-directed speech, with input compiled from one child's mother during two half-hour sessions recorded every three weeks, for a duration of twelve months between the ages of 1 year, 10 months, and 2 years, 9 months. The model was presented with 33,390 utterances recorded during these sessions, and produced a list of utterances it was capable of making based on the input. These predictions were compared to the actual utterances produced by the child during these sessions, and the model was found to produce non-finite/OI errors and case-marking errors in similar proportion to the child. It also predicted agreement errors and over-tensing errors produced by the child but not predicted by Wexler (1998), as illustrated in Table 1 from Croker, Pine, and Gobet (2000):

Table 1: Types of error predicted in the OI hypothesis and their occurrence in children's speech and MOSAIC.

	examples	predicted by Wexler	occurs in child speech	occurs in the model
OI errors	"that go there"	√	√	√
agreement errors	"he are big"		√	√
overtensing errors	"that didn't went down"		√	√
case marking errors with untensed verb	"her sit by herself"	√	√	√
case marking errors with tensed verb	"him did it"	√	√	√
case marking errors with agreement	"her does it"		√	√

(Croker, Pine, & Gobet 2000, p.83)

Some of these errors, like "her does it," are never produced even in fragments of adult speech and can only be attributed to generative learning, in a way predicted by MOSAIC but not by models like Wexler (1998)'s.

The importance of child-directed speech is also emphasized by Tomasello (2000), who considers the fundamental psycholinguistic unit of speech, for children, to be the utterance, defined as a single linguistic act expressed to another person within one intonation contour. Very early child utterances consist of holophrases, in which a single linguistic symbol works to convey an entire goal-directed act: "the child's attempt," says Tomasello, "is thus not to reproduce one component of the goal-directed communicative act but rather the entire goal-directed act, even though she may only succeed in producing one element," (Tomasello 2000, 65). Some holophrases are single elements ("That!" "Ball?") and others are frozen phrases, and language development is therefore a process of both combining and deconstructing holophrases.

Tomasello (2000) holds that children use primarily item-based utterance schema, and particularly schema that revolve around verbs. The first syntactic categories for the child are therefore lexically defined, "such as 'hitter,' 'thing hit,' and 'thing hit with' (as opposed to subject/agent, object/patient, and instrument)," (Tomasello 2000, 68). This results in largely item-based development, with some highly constrained "slots" for new constituents, and the items that appear most frequently and develop most quickly are those that appear most often in the input. Token frequency, or *entrenchment*, is the first component of fluency; *abstraction*, resulting from type variation in the constituents of a construction, is the second. Tomasello (2000) cites evidence from a 500+ utterance corpus, recorded in one-hour sessions over a period of six weeks, showing that 78% of the child utterances had been previously uttered during the six-week recording period, and 18% had been uttered with one minor change, via "usage-based syntactic operations." Only 4% of the utterances were different in more than one way from any previous utterance.

Tomasello (2000) is vague on the point of integrating this data into a more coherent model, but the most salient point is that imitation should not be overlooked as a driving force in child language development, with abstract structure-building playing a secondary role to lexical, item-based assimilation of child-directed input.

Legate & Yang (2007) are also heavily focused on the specific character of the input as a dominant factor in patterns of language acquisition, but look more closely at the way it might influence implementation of syntactic structures. Theirs is a model of variational learning, capitalizing on the interaction between morphological learning and syntactic development, and, like Tomasello (2000), working to show that parametric variation and structure-building have certain shortcomings in their explanatory force. Legate & Yang (2007)'s premise at the outset is that categorical deficiency or parameter-switching are made very unlikely as theories by the fact that the extent of Optional Infinitive production across languages varies considerably, and its usage ends gradually. A processing deficit or maturational constraint on processing loads might also be called into question by the variation in OI rates across languages. Instead they cite the strong correlation between morphological richness in a language and the length and extent of its OI stage as evidence that a morphological learning process is quite likely at play.

In Legate & Yang (2007)'s variational learning model, the child maintains a set of syntactic parameters and probabilities associated with each one; the relative probability of each parameter then changes to reflect patterns in the input. Their system plays out as follows:

(4) For an input sentence *s,* the child

a. with probability P_i selects a grammar G_i
b. analyzes *s* with G_i
c. • if successful, reward G_i by increasing P_i
   • otherwise punish G_i by decreasing P_i

(Legate & Yang 2007, p.319)

In this way even unambiguous evidence isn't decisive, merely nudging the model closer to the target language. This also accounts for the gradual nature of acquisition and development and the fact that parameters aren't abruptly switched.

Weighing the different possible parameters also allows Legate & Yang (2007) to consider how deviations from the target language fit in with other grammatical options in UG, as manifestations of the other parameters in consideration, or not. In looking at parameters of tense, for example, all root infinitive (their term for the Optional Infinitive) languages are [+tense]. Languages like Mandarin, which are [-tense], express tense adverbially instead of morpho-syntactically, therefore lacking overt morphology for tense that could be omitted as part of an OI stage (and are considered not to exhibit an OI stage). Thus children using Optional Infinitives, in deviation from the tense-marking system of their target language, may have a [-tense] grammar initially present that is penalized and gradually accessed less and less, as overt tense morphology works to reward the [+tense] grammar and penalize the [-tense] grammar. This is crucially different from assumptions like Wexler (1998)'s that the child's syntactic parameters are correctly set for the target language from the start, with variation in tense-marking resulting from a constraint on the derivation. It should be noted, however, that it might be possible to employ a model of probability like Legate & Yang (2007)'s to explain why the UCC gradually ceases to have effect, and so the two theories might not be totally incompatible.

Legate &Yang (2007) consider the prediction their model entails: languages with less abundant morphological evidence should have longer OI stages, because there is less unambiguous [+tense] evidence to reward and penalize the [+tense] and [-tense] grammars, respectively. Their analysis of Spanish, French, and English appears to confirm this prediction, showing that Spanish has the most unambiguous tense evidence and the shortest OI stage, and English the least unambiguous tense evidence and the longest OI stage, with French somewhere in between. The contrasts are illustrated in Table 7 from Legate & Yang (2007):

TABLE 7
Quantitative Comparisons of the Amount of Morphological Evidence in Favor of the [+Tense] Grammar and the Reported Duration of the RI Stage in Three Languages

Language	*% for [+T]-% for [−T]*	*Duration of RI*
Spanish	60.2%	~2;0
French	39.6%	~2;8
English	5.8%	>3;5

(Legate & Yang 2007, p.336)

The correlation is striking. This model also offers a tempting characterization of the relationship between the OI stage and Specific Language Impairment (SLI), another realm in which the relative length of the OI stage is important. The lengthening of the OI stage that occurs in children with SLI might under this view be considered to have a cause in reduction of the weights of punishment and reward in the child's learning algorithm, such that evidence in the input does not push the model towards the target grammar as quickly as it does in typically-developing children.

Freudenthal et al. (2010) provide a direct comparison of the predictions and results of the two algorithmic models I have considered here, Croker, Pine, & Gobet (2000)'s MOSAIC, and Legate & Yang (2007)'s Variational Learning Model. MOSAIC, to recap, does not entertain any notions of burgeoning syntax, and is a purely constructivist model of language learning. Predictions for the patterns in child utterances are based on analyses of child-directed speech and the utterances a child should be able to extrapolate from that input, based on current models of cognitive architecture and learning. This allows for analysis of cross-linguistic variation in production of a given construction or error. VLM (Variational Learning Model), on the other hand, considers the child grammar to have a set of innate hypotheses that changes with input over the course of learning, rewarded when an utterance is consistent with the grammar used to parse it, and punished when the utterance is not consistent. The distribution of probabilities associated with each possible grammar thus changes incrementally as input is added.

Inconsistent hypotheses are eventually abandoned, which allows the correct grammar to be converged upon. The Optional Infinitive stage, according to the VLM, should arise from the hypothesis of a [-tense] grammar like Mandarin, and the rate at which that hypothesis is abandoned depends on the richness of morphological evidence at hand.

Legate & Yang (2007) having compared morphological evidence and OI stage duration in English, French, and Spanish, Freudenthal et al. (2010) extend the analysis to Dutch and German, which along with French are intermediate between English and Spanish in terms of the length of the OI stage, to see if the VLM's predictions still hold. They also look at how predictions made by MOSAIC might compare to those of the VLM. One important difference is that "MOSAIC predicts input-driven lexical effects on the distribution of OI errors in child's speech," (Freudenthal et al. 2010, p.652), while the VLM says only that OI errors happen because of the continued maintenance of the [-tense] grammar. Thus MOSAIC would predict that verbs that appear often in non-finite forms as part of compound finite constructions like "He can kick the ball" will also manifest more frequently in OI form than those that don't, but in the view of the VLM, different verbs should appear at the same rate in OI constructions across the board, because all are governed by the [-tense] parameter.

Freudenthal et al. (2010) show that both models account for the difference in OI rates across languages relatively well. Both MOSAIC and the VLM, for example, are able to explain the difference in OI rates between French, German, and Dutch, which are relatively similar, raising support for the idea of systematic variation in the OI stage across languages. However, Freudenthal et al. (2010) found a "significant correlation between the extent to which particular verbs occur as OI errors in the child's speech and the extent to which those same verbs occur as infinitives in compound structures in the input," (Freudenthal et al. 2010, p.664), a pattern predicted by the input-focused MOSAIC by not by the VLM. This would also seem to play into Tomasello's point regarding verb-based utterance schemas, and is interesting as further evidence that input patterns must be taken into account alongside Wexler (1998)'s ideas about derivation of the syntax.

2.1.3. Discourse & Pragmatic Interface Development

I have considered theories that locate the cause of the Optional Infinitive stage in the development of syntactic structure and structure-building operations, and theories that take broader ideas about cognitive architecture and learnability to situate the Optional Infinitive in the context of child-directed input and the morphosyntactic learning that results. Now I will describe an additional perspective that takes a step back from the intricacies of tense-marking, looking instead at the interface of syntactic architecture with the larger understanding of discourse that must underlie it.

Pratt & Grinstead (2007) look at the Optional Infinitive as it applies to Spanish, a topic I will revisit in Section 2.2, but in doing so they offer an interesting take on the way pragmatic development affects tense-marking, among a variety of other things, in young children. Their proposal is that failure to mark tense is due to a delay in the development of the discourse-syntax interface, an issue subsumed by more general syntax-pragmatics interface delays that are related to problems that surface with Principle B, object clitics, scrambling, and definiteness marking on DP's. The interface mismatch rests on a faulty discourse presupposition made by the child: tense marking requires a conception of the time course of the event in question relative to the speech time, and young children appear to incorrectly assume, in some cases, that this is an understanding shared with their discourse partner. The result "in the case of tense is that children assume that their listeners are aware of their temporal presuppositions and consequently use morphosyntactic verb forms which do not mark tense morphologically," (Pratt & Grinstead 2007, p.360). Pratt & Grinstead formalize this as the *Temporal Interface Delay Hypothesis:*

> Children have adult-like morphosyntactic competence, but lack adult-like access to discourse-pragmatic information regarding tense and consequently allow verb forms which may either mark tense through a T-chain in the adult way, or deictically when they assume that their interlocutors share their access to discourse-pragmatic tense information.
>
> (Pratt & Grinstead 2007, p.360)

One of the more promising extensions of this hypothesis is in the way it applies to theories about autism and language impairment. Children with Autism Spectrum Disorders have been observed to exhibit difficulties marking finiteness (Roberts, Rice, & Tager-Flusberg 2004, as cited by Pratt & Grinstead 2007), and are also known to show deficits in "Theory of Mind" (Baron-Cohen 1995, Tager-Flusberg 1997; as cited by Pratt & Grinstead 2007) that complicate access to pragmatic information in the discourse. That the pragmatic deficits at the core of Autism

Spectrum Disorders might also be responsible for seemingly unrelated tense-marking difficulties would hold theoretical appeal.

Avrutin (1999) proposes a related account resting heavily on the idea of faulty presupposition on the part of the child, suggesting that the "syntactic" issues of tense omission stem in reality from pragmatic errors. In his view tense is underspecified and the child constructs a temporal representation via insertion of an "Event card" unrelated to the syntax.

The theories described by Pratt & Grinstead (2007) and Avrutin (1999) are important alternatives to the syntactic and input-driven models described earlier in Section 2.1. and are deserving of further study, but I will restrict my analysis in the remainder of the paper to the implications of these first two perspectives. Having considered various theories as to why the OI stage happens, I will now briefly explore the role of the Optional Infinitive in languages other than English, in L2, non-native acquisition, and in error processing patterns in adults who longer produce OI forms. An understanding of the importance of the Optional Infinitive in these different contexts will clarify our understanding of the competing claims described above, and informs the experimental question I will describe in Section 3.

2.2. The Optional Infinitive in Spanish

The Optional Infinitive is well-attested in English and in many other languages, and is understood not to occur in Chinese, which does not show overt tense morphology, but Spanish represents an interesting case in the study of child language development because it was originally classed with other null-subject languages that do not appear to exhibit an Optional Infinitive stage, and has since been reanalyzed. Pratt & Grinstead (2007) summarize the consensus of the field that "there did not appear to be substantial numbers of nonfinite verbs in these child languages, and specifically that morphological infinitives did not seem to occur often or at all in root contexts and that in general child speakers of Southern Romance gave the impression of producing quite adult-like tense and agreement marking on verbs," (Pratt & Grinstead 2007, p.351). They argue however that this reflects a faulty analysis of the data given a crucial fact about null-subject languages: it is impossible to tell without context whether a verb agrees with its (null) subject. This is a major problem for any analysis based on corpora of child utterances.

Pratt & Grinstead (2007) maintain that the third person singular present (bare stem) verb form in Spanish can act as a nonfinite in addition to the morphological infinitive, e.g. *baila* for the verb *bailar* (to dance). Though finiteness can be difficult to discern in child utterances, there are several reasons for the plausibility of the third person singular present as Spanish's bare stem, the first being that it is the language's least specified possible root. It is homophonous with other nonfinite expressions like the second person singular imperative and the impersonal passive, as in the following examples from Pratt & Grinstead (2007):

(5) Corre.
Run-2nd, sg., imperative
"Run."

(6) Corre.
Run-3rd, sg., indicative
"(He, she, it) is running./(He/she/it) runs."

(7) Se corta árboles.
Imp. Cl. cut trees
"Trees cut."

(Pratt & Grinstead 2007, p.351-352)

They also cite examples of overt disagreement between a bare stem/third person singular verb form with first and second person pronouns, and examples where context makes it clear that the subject is the speaker and therefore does not agree with the bare stem verb.

If the third person singular present form is assumed to be the root or bare stem form for Spanish, Pratt & Grinstead (2007)'s corpus analysis shows that its usage is similar to patterns observed with English OI forms in being gradually replaced by correct agreement. The error rate for Spanish-speaking children in elicited production tests is 15%, as compared to a 20-40% error rate in English-speaking children. Error rates do however show the same distribution in that OI errors represent 35% of all errors made by the child at three years old, but 15% of all errors in five-year-olds. Similar patterns hold for grammaticality judgment tasks, meaning that children accept these nonfinite forms as readily as they produce them.

As further confirmation of the analogy between these patterns of production, Pratt & Grinstead (2008) examine OI forms in child Spanish speakers with SLI (Specific Language Impairment), a condition known to be associated, in English, with an extended OI stage (Rice, Wexler, & Cleave 1995). Their proposal is that if the use of bare stem forms in Spanish does represent an OI stage, than a prolonged use of these OI forms in SLI children should occur as well. They find exactly this to be true: a statistically significant difference in the proportion of Spanish Tense Composite errors between the SLI and control groups, taking this to be "a strong confirmation of the hypothesis that the nonfinite forms of the Spanish Tense Composite are important nonfinite forms in child Spanish, that child Spanish is an optional infinitive grammar and that tense marking may serve as a clinical marker of SLI in child Spanish speakers as it does for child English speakers," (Pratt & Grinstead 2008, p.124).

Grinstead et al. (2009) look beyond the third person singular present form to expand these conclusions. Previous elicited production studies had shown use of the third person singular as a nonfinite bare stem form, and Pratt & Grinstead (2007) had shown in a grammaticality judgment task that Spanish-speaking children in the OI stage accept OI-type errors in forms other than the third person singular present. Grinstead et al. (2009) show that these alternate forms also appear in elicited production tasks, the most prominent and likely being the bare progressive participle, and re-confirm the accuracy rates found in Pratt & Grinstead (2007).

These results shed serious doubt on the idea that Spanish does not exhibit an OI stage, and most accounts of OI in null-subject languages have shifted to accommodate this data. It remains to be seen whether other languages will undergo similar re-analysis as the overt manifestations of the Optional Infinitive are better understood.

2.3. OI & Bilingualism

In the context of debate about the origins of the pattern of tense-marking issues that characterizes the OI stage, the fact that it does not appear in L2 acquisition is extremely informative, insinuating quite strongly that it is a feature of the *child* language processor, in particular, that drives the phenomenon. L2 acquisition is defined by Schwartz (2004) as beginning at age four or later, because the majority of the L1 grammar is established by that point, and displays a markedly different level of cognitive maturity. Evidence that L2 acquisition does not include an OI stage comes from Prévost and White (2000)'s *Missing Surface Inflection Hypothesis*, which says that variability in morphological marking can be attributed to a problem with surface morphology rather than underlying morphosyntactic structure. This is further supported by Ionin & Wexler (2002)'s finding of fully specified inflectional categories in native-Russian-speaking L2 learners of English, their production patterns being misaligned with those of OI-stage L1 learners. Haznedar (2003) finds the same result in L2 English and L2 Turkish, concluding that impairment of syntactic representations is impossible. That the OI stage appears maturationally constrained is an important assumption in our understanding of its relevance in the adult grammar.

2.4. OI Error Processing in Adults

Production of OI errors, it has been established, ceases to occur after age four in L1 acquisition and does not occur as a stage in later language acquisition processes. Kovelman et al. (under review), however, are the first to consider the way these errors are handled by the adult grammar, and show in a grammaticality judgment task that adult monolingual English speakers are slower to react to OI errors than to non-developmental errors, and less accurate in doing so. Deciphering the apparent relationship between production and processing here is complicated, but Kovelman et al. (under review) propose that the UCC, the root of OI error production in constraining feature-checking operations in the child grammar, requires constant suppression as it persists into adulthood. That extra step of suppressing nonfinite representations that have been licensed by the UCC in order to arrive at a correct, finite form might explain the processing slow-down for OI errors in adults, because it is not necessary in the processing of non-developmental subject-verb agreement errors. Beyond these findings from Kovelman et al. (under review), however, the relationship between the developmental stage and the processing issues has not been explored.

3. Experimental Question

The constellation of facts described in Section 2 leads me to my experimental question: if adult English speakers show difficulty processing the types of errors that are produced during the Optional Infinitive stage, in contrast to errors not produced systematically during child language development, will speakers who did **not** go through an OI stage show those processing issues as well? Are adult processing slow-downs for OI errors, in other words, the result of having gone through a stage in which these structures were permitted?

To test this, I replicate the auditory grammaticality judgment task conducted in Kovelman et al. (under review) and extend it to afford comparisons between English speakers who went through an OI stage in English and English speakers who did not. The first logical group for comparison to a monolingual English group is native speakers of Mandarin Chinese, a language that does not exhibit a productive OI stage. Native Chinese speakers who learned English after age five would not have undergone an OI stage in their L1 acquisition process because their L1 lacks the verbal morphology that would allow tense to be omitted, and would not have undergone an OI stage in English because their L2 acquisition began after the OI stage had ended. If Chinese/English bilinguals show processing slowdowns in English, going through the OI stage, therefore, could not feasibly be the cause, unless, crucially, we assume the possibility of covert tense-marking and a covert UCC in Chinese.

The second group for comparison is native speakers of Spanish who learned English after age five. These speakers, again, would have learned English too late for an OI stage to occur, but did undergo a productive OI stage in Spanish. Any processing influences from the OI stage, in this case, would have to cross over from Spanish. This idea of cross-over raises larger questions about bilingualism, and whether a causal constraint (the UCC) could apply to both languages of the bilingual processor or only to the language in whose child grammar it outwardly manifested.

4. Methods

This study consisted of an auditory grammaticality judgment task measuring reaction time and accuracy for three sentence conditions, in three language groups. It was approved by the Yale University Human Subjects Committee on January 7, 2013, under HSC Protocol #1212011242.

4.1. Subjects

35 undergraduate students from Yale participated in this study. These 35 subjects formed three experimental groups: native/monolingual English speakers, native Chinese speakers also fluent in English, and native Spanish speakers also fluent in English. All were right-handed, with normal or corrected-to-normal vision, normal hearing, and no history of neurological disease.

14 subjects were monolingual English speakers with no exposure to a second language before age 12 (six males, age range 18-22, average age of 21). Though many had been exposed to languages other than English, no subject self-identified as bilingual. This was confirmed with a detailed language history.

15 subjects were bilingual Chinese and English speakers (eight males, age range 18-23, average age of 21), whose only linguistic exposure before age five was to Mandarin Chinese but who learned English before age 12. The age range of exposure to English for the native Chinese speakers was 5-10 years, and the average age of exposure to English was seven years. Though many of these subjects had been exposed to languages other than Chinese and English, English was the second language for all 15 subjects, and all self-identified as bilingual in Chinese and English.

The final six subjects were bilingual Spanish and English speakers (one male, age range 18-22, average age of 20). Because of the extreme difficulty of finding native speakers of Spanish whose exposure to English began after age five, a full group was not recruited. The age range of exposure to English for this pilot group of native Spanish speakers was 3-8 years, and the average age of exposure to English was four years.

All subjects gave informed consent and were compensated $5 for their participation, which took approximately 20 minutes.

4.2. Stimuli

Auditory stimuli were provided by Ioulia Kovelman, as developed for use in Kovelman et al. (under review), belonging originally to John Gabrieli and Ken Wexler at MIT. Stimuli consisted of 108 sentences, 36 for each of three conditions. Because the Kovelman et al. (under review) study involved fMRI, the order of the sentences, which was maintained in the current study, was randomized by the Kovelman group using Optseq software for optimization in an event-related design. All sentences contained five words, and were matched across the three conditions according to the following criteria by Kovelman et al. (under review): verb and noun age of acquisition, written frequency, concreteness, imageability, and familiarity. All sentences were recorded by the same female speaker, with an average duration of 1.61 seconds.

4.2.1. Condition geA: Non-developmental Errors

The first condition consisted of non-developmental errors of a type not systematically produced by typically developing children, which would be judged ungrammatical by children in the Optional Infinitive stage. Two types of non-developmental errors were represented, with 18 sentences per type.

a) Participle *–ing* omission errors were analogous to OI errors in constituting both a verb-verb agreement violation and a morpheme omission, but were not of the type produced by OI-stage children.

Participle error: He is **bite** the food.
Correct form: He is **biting** the food.

b) Subject-verb agreement errors consisted of agreement violations between the subject and the copula.

Agreement error: Dad **are** washing the car.
Correct form: Dad **is** washing the car.

4.2.2. Condition geB: Optional Infinitive Errors

The second condition contained Optional Infinitive errors. These errors corresponded to tense omission errors characteristic of children in the Optional Infinitive stage, and included temporal adverbs to make the omission of tense unambiguous. Three types of OI errors were represented, with 12 sentences per type.

a) Past-tense omission errors included six regular verbs omitting the *–ed* past-tense ending, and six irregular verbs in the infinitive instead of past-tense form.

Type 1 past-tense error: Yesterday he **try** to win.
Correct form: Yesterday he **tried** to win.

Type 2 past-tense error: Last night she **eat** supper.

Correct form: Last night she **ate** supper.

b) Present tense third-person singular omissions lacked the *–s* ending. Only forms ending with voiced consonants were included, so that omission was more salient.

Present-tense error: My brother always **hurry** home.
Correct form: My brother always **hurries** home.

c) Copular omissions occurred in adjectival and prepositional constructions.

Type 1 copular error: She the nicest of all.
Correct form: She **is** the nicest of all.

Type 2 copular error: You under the big umbrella.
Correct form: You **are** under the big umbrella.

4.2.3. Condition gC: Correct Sentences

The third condition consisted of grammatically correct sentences structurally matched to Conditions geA and geB, though they did not form minimal pairs. 18 were matched to Condition geA and equally distributed among the three subtypes (third-person singular past tense, third-person singular present tense, copular). 18 were matched to Condition geB and equally distributed among participial and simple copular forms.

a) Matched to Condition geA:
Past-tense: Last week she said goodbye.
Present-tense: He hurries out every night.
Copular: She is the nicest cat.

b) Matched to Condition geB:
Participial: He is biting the potato.
Copular: Dad is washing the dishes.

4.3. Procedure

Participation in this study involved first filling out a detailed questionnaire. Subjects provided information regarding age, education, handedness, vision and hearing, and history of reading or learning disabilities, neurological disease, and developmental or language delays. The second half of the questionnaire requested a detailed language history, asking the following questions:

1. What languages do you currently speak? Next to each language, please indicate **the age at which you were first exposed** to that language, and **your proficiency** (basic, intermediate, fluent).
2. What language do you consider to have been your primary language **before age 5**? What do you consider to be your primary language **now?**
3. What language(s) did you speak with each of your parents as a child and which languages do you currently speak with them?
4. What language did you speak with other caregivers (nanny, daycare, etc.) before age 5?
5. Do you have older siblings with whom you spoke a language different from the one you spoke with your parents? If yes, please explain.
6. Were you exposed to or fluent in another language as a child that you no longer speak now? If yes, please explain.
7. In what language did the majority of your formal education take place?
8. Did you study a foreign language in school? Indicate language(s) and years of study.
9. Do you currently consider yourself bilingual? If yes, please explain.

These questions were intended to provide the most complete assessment possible of the subject's relative fluency in each language, given the inherent difficulty of defining objective parameters of bilingualism.

The second component of the study was an auditory grammaticality judgment task measuring reaction time. Subjects were seated in front of a laptop computer, wearing headphones. The experimental task was designed and conducted using PsyScope software. Subjects were instructed that they would hear a series of English sentences and would need to respond as quickly as possible to say whether the sentences were grammatical or not. They were instructed to respond, via button press (the "a" key on the keyboard was labeled "YES" and the "l" key was labeled "NO"), as soon as they realized whether the sentence was grammatical or not, and not to wait until the end of the sentence. The task was designed so that when either key was pressed, the sentence stopped playing and the next trial began. Subjects were warned of this feature of the design and were told that it was acceptable if they cut off many of the sentences.

Subjects completed a practice task of six sentences and then were allowed to ask questions about the experimental setup or the nature of grammaticality before proceeding to the full-length task. All subjects expressed after the practice task that the nature of grammaticality was clear, but it was emphasized that they should consider, as intuitively and quickly as possible, whether the sentence sounded like a natural sentence of English. The full-length task was then initiated while the experimenter sat on the opposite end of the table, in a quiet room.

Subjects pressed the space bar when they were ready to start the task. During each trial, a two-second fixation cross appeared on the screen (white on a black background) and then a question mark appeared as the sentence began to play through the headphones. Subjects were instructed to keep a finger on each button in anticipation of responding. When a button was pressed, the sentence stopped playing and the next trial began with the same fixation cross. 108 sentences were presented in this manner, with a 20-second break halfway through the run. The order of the sentences was randomized among the three conditions, and the same order was presented to all subjects. PsyScope recorded which key had been pressed and the reaction time starting from the time the sentence began playing.

The run of sentences lasted approximately 10 minutes, after which subjects were debriefed and compensated. Some subjects commented on the nature of the syntactic error being consistently verbal, but none mentioned noticing a contrast between verbal errors.

5. Results

5.1. Data Processing

After each subject completed the grammaticality judgment task, PsyScope produced a data output file containing a list with each item label and the condition it belonged to, expected YES/NO answer, recorded reaction time from the beginning of the sentence, and actual YES/NO answer. Each subject's data file showed the same 108 items in the same order, which had been previously randomized among the three conditions.

From each data file, I inputted the reaction time for each item into worksheets divided by language group, into a column of data points for each subject. I then sorted each subject's column of data by condition, and separated the 36 data points for each of the three conditions into separate worksheets. For each language group (English, Chinese, Spanish), I therefore had separate data sheets for each condition: grammatically correct (gC), non-developmental errors (geA) and OI errors (geB). For each reaction time data point I had noted from the PsyScope file whether the response was correct or not, and at this point I discarded the wrong responses, noting the number of wrong responses for each subject in each condition, and the number of wrong responses for each item in each condition.

It was then necessary to adjust the reaction times for the geA and geB conditions, because the crucial aspect of measuring reaction time was that it should reflect the subject's reaction starting from the onset of the error, and the error occurred at a slightly different point in each sentence. Each sentence was five words long, and I tagged each sentence according to the position of the verbal error (1, 2, 3, 4, 5) to determine if the error position varied systematically by condition, which I suspected would be the case because adverbs were frequently used in the OI sentences to make the omission of tense more salient. I averaged the verb position for each condition and found a mean of 2.5 for non-developmental errors (geA) and 2.86 for OI errors (geB). This was problematic because a systematically earlier error in the non-developmental condition would result in seemingly faster reaction times.

To correct this, I used Praat to mark, in each sentence, the exact time of the error onset in milliseconds. In the non-developmental (geA) condition the errors were participles lacking *–ing* endings and copulas with agreement violations; I therefore marked the onset of the participle or copula. In the OI (geB) condition the errors were verbs lacking *–ed* and *–s* endings, and copula omissions; I therefore marked the onset of the verb or the onset of the word immediately following the omission, at which point the omission became clear. The mean error onset time for condition geA was 392.6 milliseconds. The mean error onset time for condition geB was 613.44 milliseconds.

Having sorted the recorded reaction times by condition, I then subtracted the error onset point from the raw reaction time for both the geA and geB conditions, so that for each subject I had a set of adjusted reaction times for each item, in each condition. I retained the raw reaction times in a separate file for future reference.

I then calculated a mean reaction time for each subject for each condition, and a mean reaction time for each item for each condition.

I also calculated the error rate for each subject in each condition by dividing the number of wrong answers by the number of items per condition (36). I then calculated the error rate for each item by dividing the number of wrong responses for that item by the total number of responses for that item (which varied depending on the group).

This left me with mean reaction times and error rates for each subject and each item, in all three language groups.

For a preliminary gage of the direction of difference, for each subject I subtracted the mean reaction time for condition geB from the mean reaction time for condition geA. The majority of the subjects showed a greater mean for geB than for geA. I identified three subjects in the English group and one subject in the Chinese group who exhibited the opposite direction of difference.

I then used Minitab to analyze the significance of this difference in means, using 2-way t-tests to compare reaction time and accuracy for the two error types in each language, and between languages.

Unless otherwise noted, for each t-test I discarded any data point outside of 2 standard deviations from the mean. All of a subject's data points were removed for a given analysis if the subject was identified as an outlier in any one of the three conditions.

5.2. Analysis of Difference between Error Conditions geA and geB

In general I found significant differences in reaction time and accuracy between conditions geA and geB for both the English and Chinese language groups. Because I was able to test only 6 subjects for the Spanish language group, I will present those results separately.

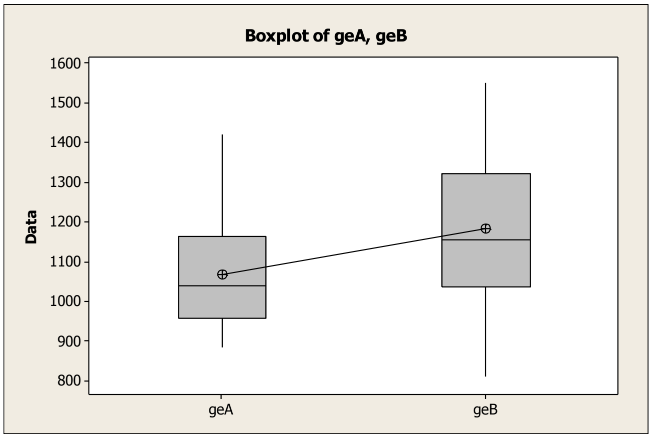
5.2.1. Native English Speakers

Figure 1: Reaction time and accuracy for geA and geB errors in native English speakers

	Non-developmental errors/geA Mean (SD)	OI errors/geB Mean (SD)
Reaction Time (msec.) [by item]	1067 (143)	1184 (181)
Accuracy (% errors) [by subject]	1.39 (1.45)	3.7 (3.42)

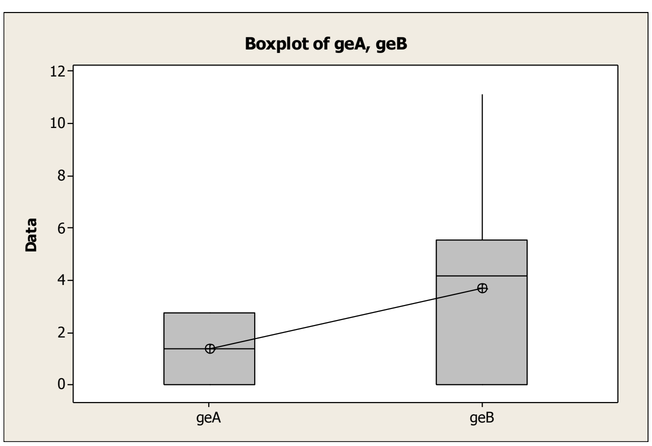
The reaction time difference between conditions geA and geB was not significant by subject (-130.6, t(13) = -1.39, p = .177), which I attribute to the low number of subjects (13), but was significant by item (-117.2, t(33) = -2.92, p = .005), as shown in Figure 2.

Figure 2: Reaction time for geA and geB errors in native English speakers



I also found a significant difference in error percentages between conditions geA and geB by subjects (-2.31, t(12) = -2.16, p = .049) (shown in Figure 3) and by items before removing outliers: (-3.57, t(36) = -2.19, p = .034) but not after removing outliers from the items analysis (-1.562, t(32) = -1.86, p = .068).

Figure 3: Error percentage for geA and geB errors in native English speakers



This indicates that native English speakers were on average 117 msec. slower to react to OI (geB condition) than non-developmental (geA condition) errors. Their error rate for OI errors was also more than double their error rate for non-developmental errors.

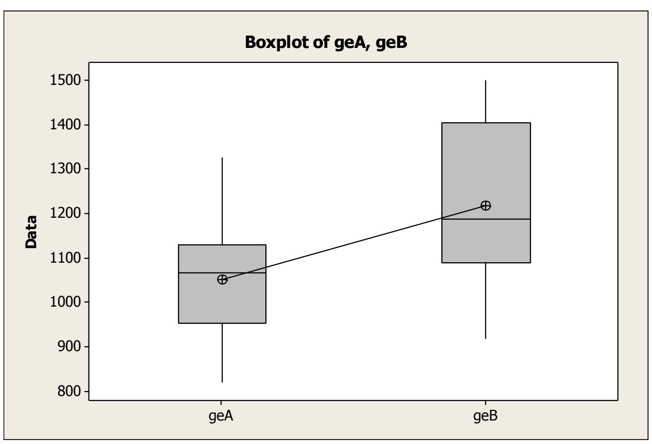
5.2.2. Native Chinese Speakers

Figure 4: Reaction time and accuracy for geA and geB errors in native Chinese speakers

	Non-developmental errors/geA Mean (SD)	OI errors/geB Mean (SD)
Reaction Time (msec.) [by item]	1052 (128)	1218 (171)
Accuracy (% errors) [by subject]	4.76 (4.42)	9.52 (5.42)

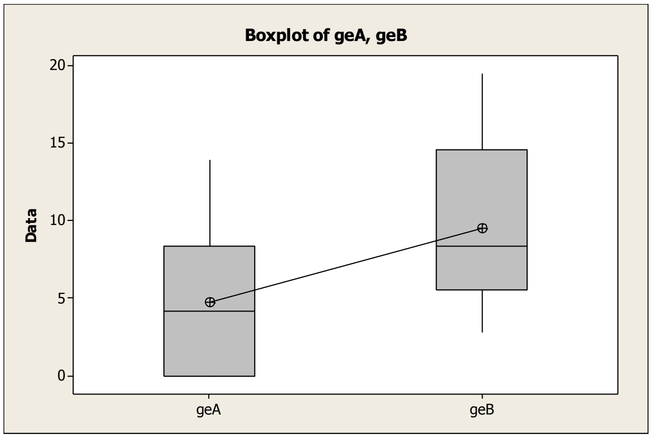
The reaction time difference between conditions geA and geB was not significant by subject (-153.9, t(15) = 1.6, p = .121), which I attribute to the low number of subjects (15), but was significant by item (-165.7, t(32) = -4.39, p = 0.000), shown in Figure 5.

Figure 5: Reaction time for geA and geB errors in native Chinese speakers



I also found a significant difference in error percentages between conditions geA and geB by subjects (-4.76, t(14) = -2.55, p = .018) (shown in Figure 6), but not by items (-2.55, t(34) = -1.32, p = .192). The error rate for condition geB was exactly double the error rate for condition geA.

Figure 6: Error percentage for geA and geB errors in native Chinese speakers



This indicates that native Chinese speakers were on average 165.7 msec. slower to react to OI (geB condition) than non-developmental errors (geA condition). Their error rate for OI errors (geB) was also exactly double their error rate for non-developmental errors (geA).

5.3. Analysis of Difference between Language Groups

In general I did not find significant differences in reaction time between the English and Chinese language groups for either of the error conditions. I did, however, find significant differences in accuracy between the English and Chinese groups.

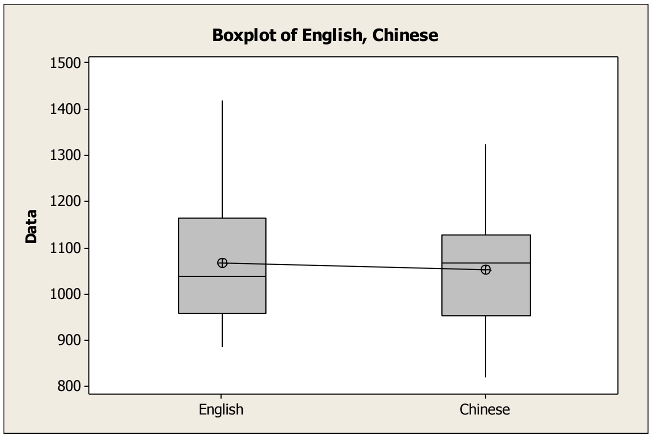
5.3.1. Condition geA: Non-developmental Errors

Figure 7: Reaction time and accuracy for geA errors in English and Chinese speakers

	English	Chinese
Reaction Time (msec.) [by item]	1067 (143)	1052 (128)
Accuracy (% errors) [by subject]	1.39 (1.45)	4.76 (4.42)

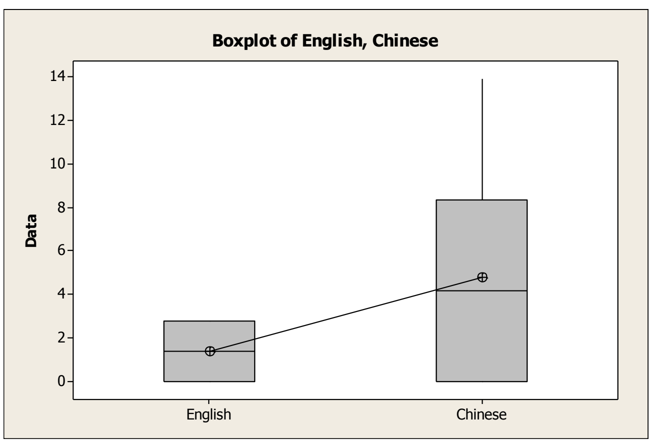
I did not find a significant difference in reaction time between native English and Chinese speakers for condition geA, by item (14.8, t(33/32) = .44, p = .662) (shown in Figure 8) or by subject (-62, t(13/15) = -.70, p = .492).

Figure 8: Reaction time for geA errors in English and Chinese speakers



I did, however, find a significant difference in percentage of errors by subject (-3.37, t(12/14) = -2.69, p = .016) (shown in Figure 9) and by item (-3.97, t(32/34) = -3.0, p = .004).

Figure 9: Error percentage for geA errors in English and Chinese speakers



This indicates that native English and native Chinese speakers showed the same mean reaction time for non-developmental (geA) errors. However, the native Chinese speakers made significantly more errors.

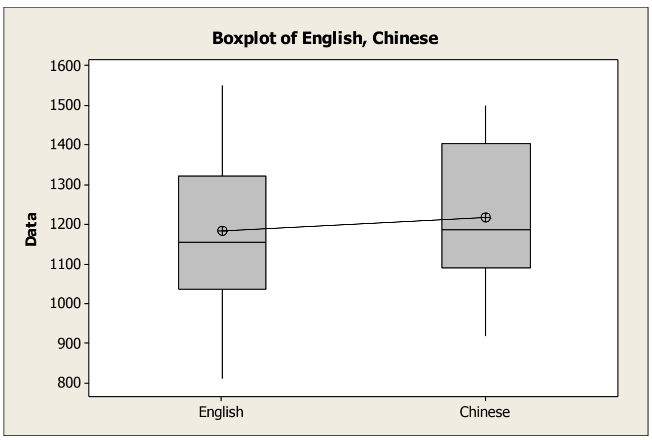
5.3.2. Condition geB: Optional Infinitive Errors

Figure 10: Reaction time and accuracy for geB errors in English and Chinese speakers

	English	Chinese
Reaction Time (msec.) [by item]	1184 (181)	1218 (171)
Accuracy (% errors) [by subject]	3.7 (3.42)	9.52 (5.42)

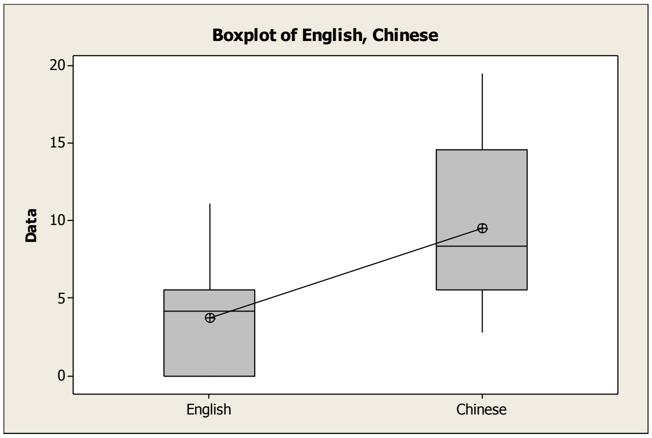
I did not find a significant difference in reaction time between native English and Chinese speakers for condition geB by subject (-85, t(13/15) = -.85, p = .404) or by item (-33.8, t(33/32) = -.77, p = .442), as shown in Figure 11.

Figure 11: Reaction time for geB errors in English and Chinese speakers



I did, however, find a significant difference in percentage of errors by subject (-5.82, t(12/14) = -3.32, p = .003) (shown in Figure 12), and by item (-4.77, t(32/34) = -2.83, p = .007).

Figure 12: Error percentage for geB errors in English and Chinese speakers



This indicates that native English and native Chinese speakers showed the same mean reaction time for OI (geB) errors. However, the native Chinese speakers made significantly more errors.

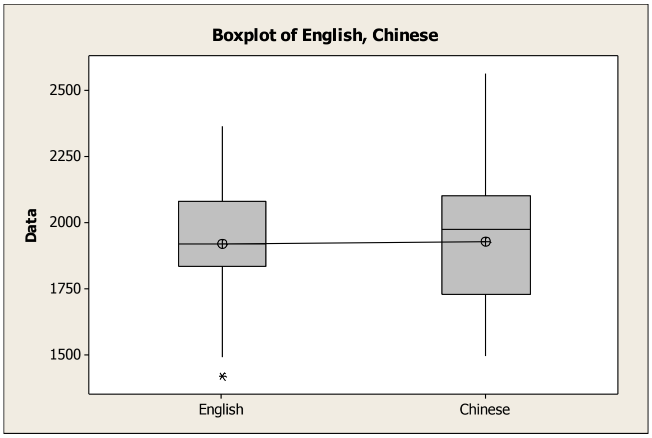
5.3.3. Condition gC: Correct Sentences

Figure 13: Reaction time and accuracy for gC sentences in English and Chinese speakers

	English	Chinese
Reaction Time (msec.) [by item]	1919 (215)	1929 (252)
Accuracy (% errors) [by subject]	1.62 (2.77)	5.36 (3.85)

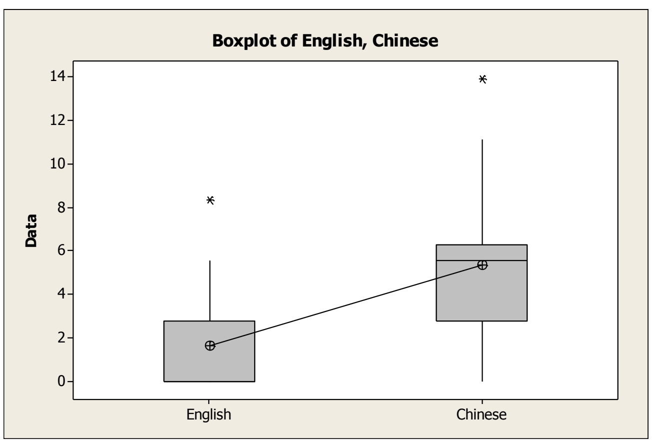
I did not find a significant difference in reaction time between native English and Chinese speakers for condition gC by subject (-11.2, t(13/15) = -.11, p = .911) or by item (-9.9, t(33/32) = -.17, p = .866), as shown in Figure 14.

Figure 14: Reaction time for gC sentences in English and Chinese speakers



I did, however, find a significant difference in percentage of errors by subject (-3.74, t(12/14) = -2.87, p = .009) (shown in Figure 15) and by item (-3.79, t(32/34) = -2.57, p = .013).

Figure 15: Error percentage for gC sentences in English and Chinese speakers



This indicates that native English and native Chinese speakers showed the same mean reaction time for correct (gC) sentences. However, the native Chinese speakers made significantly more errors.

5.4. A Preliminary Examination of Spanish

Because of the difficulty of finding native Spanish speakers whose exposure to English began after age five, I was only able to test six subjects. I will therefore refrain from presenting a full-fledged analysis, but will indicate the apparent direction of the results.

Figure 16: Reaction time and accuracy for geA and geB errors in native Spanish speakers

	Non-developmental errors/geA Mean (SD)	OI errors/geB Mean (SD)
Reaction Time (msec.) [by item]	1467 (317)	1615 (421)
Accuracy (% errors) [by item]	2.15 (5.68)	13.4 (14.5)

The difference in reaction time between conditions geA and geB was not significant by subject (-218, $t(6) = -.36$, $p = .729$) or by item (-147.8, $t(34) = -1.63$, $p = .107$). The difference in error percentage between conditions geA and geB was not significant by subject (-12.78, $t(5) = -3.47$, $p = .056$) but was significant by item (-11.29, $t(31) = -4.03$, $p = 0.000$).

Although the reaction time difference was not significant, its magnitude and direction lined up strikingly with that observed in the English and Chinese groups, and I predict that further investigation with a larger sample size would confirm significance.

6. Discussion

6.1. Findings

In this study I investigated differences in the auditory processing of developmental and non-developmental errors, comparing reaction time and accuracy in English-speaking adults responding to two types of incorrect sentences: errors in finiteness that would be produced by children in the Optional Infinitive stage of language acquisition, and subject-verb agreement errors not produced systematically by children. I compared the responses of monolingual English speakers to the responses of native Chinese speakers whose exposure to English began after the close of the OI stage. The goal of the study was to determine if a relationship existed between having undergone the OI stage in English and showing difficulty processing OI errors as an adult. In comparing language groups I therefore manipulated whether or not the speaker had undergone an OI stage: monolingual English speakers had, and native Chinese speakers had not. I also compared those responses to native Spanish speakers who would have undergone an OI stage in Spanish, but not in English, in a small-scale pilot of the same task.

In an auditory grammaticality judgment task, monolingual English speakers were significantly slower to react to OI errors than to non-developmental errors, and were significantly less accurate in identifying them as wrong. Native Chinese speakers were also significantly slower to react to English OI errors than to non-developmental errors, and significantly less accurate, to a greater degree than the English speakers. A comparison between language groups showed that reaction times for native English and native Chinese speakers in any of the three conditions did not differ significantly. Accuracy rates were significantly different between the two groups: across the board, native Chinese speakers made more errors.

Preliminary analyses of a small group of native Spanish speakers showed a comparable difference in reaction time between OI and non-developmental errors, though the number of subjects was not sufficient for statistical significance. The Spanish-speaking group did show a significant difference in accuracy between OI and non-developmental errors, making more errors in identifying OI errors as wrong.

The net effect of these results is that the two language groups showed identical processing delays for OI as compared to non-developmental errors, despite the fact that the native English speakers had undergone an OI stage in which those types of errors were produced and the native Chinese speakers had not. It therefore appears that processing issues with OI errors in English-speaking adults cannot be attributed to the production of OI errors that English-speaking children exhibit, which makes it necessary to propose alternative explanations for this effect in adults. I will do so in the remainder of Section 6, after considering the implications of these findings for the syntactic and input-driven models of language acquisition I described in Section 2, and their larger significance in our understanding of error processing and bilingualism.

6.2. Implications for the UCC

Wexler (1998)'s theory of the Optional Infinitive depends fundamentally on the idea that phrase structure in the child grammar is fully articulated, with all syntactic parameters correctly set from the outset. OI-stage errors in marking finiteness occur because of the Unique Checking Constraint, which restricts the derivational process to just one feature-checking operation. It is thus impossible to check both tense and agreement features without violating the UCC, and the child builds an alternate representation in which either the tense or agreement projection is omitted, and subsequently the tense markers whose omission defines the OI stage. Omission of tense or agreement constitutes a violation of the adult grammar, and the balancing of equivalent violations (of the UCC, or of the adult grammar) is what explains the optionality of tense omission, and the ability of the child to produce correct inflection in many cases.

The UCC is described by Wexler (2002) as a biological, maturational constraint on the child grammar, gradually suppressed by adult constraints, which is why children gradually stop making this type of error. Kovelman et al. (under review), who first showed that a processing difference exists between OI and non-developmental errors in English-speaking adults, proposed that the UCC might never completely cease to influence the derivation. Instead of being eliminated completely, it may persist into adulthood, suppressed by constraints of the adult grammar to an extent that speakers do not produce these types of errors, but still licensing representations and requiring suppression during processing. This extra step of suppressing UCC-licensed representations, which is not necessary in processing simple subject-verb agreement errors, could explain the difference in reaction time.

The idea that these two phenomena, in two very different stages of language but involving the same type of tense error, are caused by the same feature of the grammar (namely, a persistent UCC) is appealing. The relationship could be construed causatively, such that the presence of an OI stage in a child grammar causes the difficulty that adults show in processing OI errors. A child grammar not exhibiting an OI stage, therefore, should not mature into a grammar that would react to OI and non-developmental errors differently; we would expect, then, that native Chinese speakers would not show a processing difference in the grammaticality judgment task. However the results of this study showed that this is not the case, which would seem to disprove the causal force exerted by the UCC and require an independent explanation for slower adult processing of OI errors.

The problem in that deduction, though, is that Wexler (1998) does not necessarily equate the UCC with the production of OI errors: it would theoretically be possible for the UCC to exist in the child grammar but not produce any outward effects, depending on the parameters of the grammar it is constraining. This possibility is further strengthened by the conception of the UCC as an inherent biological constraint on the child language processor, which should in that view occur in every child language learner regardless of the language of exposure. Adopting this universal, genetic view of the UCC, in the face of evidence that some languages do not exhibit an OI stage, forces us to consider the idea that the UCC might exist in a child grammar without producing any overt effects.

This could be the case, then, for Chinese, which has a sparse verbal morphology system that does not include inflectional morphemes that could be omitted. The UCC could constrain a language like Chinese in the same way it constrains English, forcing the derivation of representations lacking tense or agreement, but because there are no overt morphemes occupying these projections, their omission has no effects on the pronounced sentence. In that case a Chinese-speaking child would not appear to undergo an OI stage, but would still be under the influence of the UCC. Presumably the effects of the UCC are also obscured, in different ways, by other types of parametric variation in the languages other than Chinese that are considered not to show an OI stage.

The results of this study, then, rule out the possibility that the production of OI errors is a necessary cause or prerequisite for OI-related slow-downs in adult processing: the native Chinese speakers tested did not undergo a productive OI stage but still exhibited relative difficulty with OI errors. This knowledge is valuable in itself. But the results cannot speak to or rule out the possibility or the theory of the UCC as the cause of the OI stage, because it is not necessarily the case that a UCC-governed child grammar will produce OI errors. It is possible that native Chinese speakers had child grammars constrained by the UCC, but did not produce OI errors because of their lack of inflectional morphology. The UCC could still be present in adult speakers, then, causing the processing slow-downs observed in this study, in the same patterns as in native English speakers, even though no OI stage was exhibited (though this would require an assumption that the UCC acts globally on both languages executed by the bilingual language processor). It would be difficult to say definitively that the UCC is operating covertly, but this remains a valid possibility, and thus the results of this study may very well be compatible, after all, with Wexler (1998)'s explanation for the OI stage. That the UCC causes the OI stage and an independent force is at work in the processing slow-downs exhibited by adults is an equally viable alternative; the UCC, in other words, may be implicated regardless of whether or not we give the OI stage and adult processing slow-downs a unified explanation.

6.3. Processing Difficulties in the Context of Input-Driven Models

Input-driven models like MOSAIC (Croker, Pine, & Gobet 2000) and VLM (Legate & Yang 2007) hold that the patterns of OI-type errors evident during the OI stage follow predictably from the patterns of inflection evident in child-directed input. Cross-linguistic variation in the OI stage is readily explained by these views, depending on the extent to which non-finite forms appear in the target language. It is thus apparent why an English-speaking child would produce nonfinite forms and a Chinese-speaking child would not, and these models make no predictions that the presence or absence of an OI stage should affect the usage or processing of these types of errors by an adult speaker. This fact aligns well with the finding of the present study that having gone through an OI stage is irrelevant to OI-related slow-downs in adults.

Unlike in Wexler (1998)'s model, abstract knowledge of phrase structure, impaired or not in the child grammar, does not come into play in models like MOSAIC, which rely on theories about the cognitive architecture of learning and information structure. MOSAIC employs a relatively simple learning mechanism but is shown by Croker, Pine, & Gobet (2000) to predict the production of OI errors quite straightforwardly from the statistical properties of the input, in which OI-form sequences do occur. "Him go," for example, which includes both a tense and a case-marking error, is produced as a sequence in child-directed utterances such as "Look at him go" (Croker, Pine, & Gobet 2000, p.79). This is also evident in examples like "I watched her open the door" and "It's important that he hurry home" which include OI-type fragments. Non-developmental subject-verb agreement error strings like "He are" and "I is" presumably occur rarely or never in the child-directed input, and would therefore not be produced by the model.

This is important to consider because it appears to present a valid alternative to the idea of impairment in the syntactic derivation, per Wexler (1998), that might have anything to do with the way OI errors are processed later on. It holds that the reason that children produce OI errors rests fundamentally on extrapolation from the input, underlyingly because these strings do appear as fragments in licit English utterances. This speaks to the implicit suggestion of the results of this study that there exists a fundamental difference between OI and non-developmental errors that causes processing slow-downs regardless of previous production of OI errors. This might therefore be the most important contribution of a learnability model like MOSAIC: although it offers no account of why processing issues might be evident for OI errors in adults, its explanation for the occurrence, or not, of the OI stage can double as a reason for why all speakers of English might struggle in detecting OI errors in general, namely, the systematic occurrence, and therefore familiarity, of OI strings in other constructions. I will consider this further in Section 6.5, after reprising the similar contributions of the VLM, and considering some of the problems these learnability accounts might pose.

Legate & Yang (2007)'s Variational Learning Model ascribes more underlying syntactic structure to the child grammar, but maintain the importance of the statistical properties of the input in driving the trajectory of learning. Ready explanations for both cross-linguistic variability and the gradual phasing out of the OI stage are two of the strongest arguments for the VLM, which holds that a variety of (possibly conflicting) syntactic parameters are maintained by the child grammar, weighted with relative probabilities that are driven up or down based on alignment or disagreement with the input. Thus an OI stage child might start out entertaining both a [+tense] and a [-tense] (in which tense is not expressed morphosyntactically) grammar, and will produce non-finite forms until probability of the [-tense] grammar is driven down to zero by morphosyntactic evidence for tense marking. An English-speaking child would eventually settle on a [+tense] grammar, while a Chinese-speaking child would receive no evidence against a [-tense] parameter, which therefore needn't be eliminated. Like MOSAIC, the VLM does not make any predictions about how these learning mechanisms might influence adult processing patterns. The nonfinite strings that lead to production of OI errors in MOSAIC work to slow the elimination of the [-tense] grammar, per VLM, because they do not contradict it, which again means that more nonfinite strings predicts more OI errors during the stage, but nothing about the processor itself. As with MOSAIC, processing difficulties must then be ascribed by the VLM to something fundamental about OI constructions themselves. As described with reference to MOSAIC, the fact of OI sequences being licit as subparts of more complex grammatical sequences is a likely candidate.

6.4. Problems for Input-Driven Models

There are, however, several facts explained by Wexler (1998)'s biological constraint that are less clear under the learnability theories. The first is the fact that production of OI errors gradually phases out. Wexler (1998) explains this by saying that the UCC is gradually dominated by adult constraints, or, in alternate terms, that the biological constraint that it represents is slowly inactivated, though in both cases the possibility of it persisting without being strong enough to license actual production of OI errors is important. The VLM also provides a ready explanation in that the probabilities of the syntactic parameters that do not match the target language are gradually driven down by the input. Croker, Pine, & Gobet (2000) do not explain why, under MOSIAC, the child would stop producing OI errors given the links between those nodes that seem to lead to OI constructions. The most likely explanation, if this is allowed by the system they are proposing, would have to be a notion of the network growing larger and more intricate, strengthened by repetition. With enough input the network grows complex enough that the pattern of nonfinite forms licensed only in embedded contexts becomes clear, and the child stops producing them in place of finite forms.

This question as to why OI production eventually phases out leads into a second, related issue: why does the OI pattern of tense errors not occur in L2 acquisition? Attributing the phenomenon in L1 acquisition to a learnability problem makes its absence in L2 acquisition surprising, since input to a three-year-old and to a six-year-old should not be so radically different as to result in vastly different patterns of inflection, though shifts in the properties of child-directed utterances may be at play to some extent. This forces us to consider what differs in the acquisition process of an older child, which comes down to the same idea of maturation of the processor explored above, such that the network of input in an older child is sophisticated enough to place OI errors in a larger context. We might then say that, in the input-driven models, a five-year-old's L2 acquisition takes place in a more powerful computational hierarchy that is capable of restricting or characterizing isolated strings based on the properties of the larger structures and contexts in which they occur, something that may not be too advanced or computationally demanding for the younger processor. Newport (1990) proposes that this is related to the way information is processed and stored in the younger processor, because:

> […] young children and adults exposed to similar linguistic environments may nevertheless have very different internal data bases on which to perform a linguistic analysis. The young child's representation of the linguistic input will include many *pieces* of the complex forms to which she has been exposed. In contrast, the adult's representation of the linguistic input will include many more whole, complex linguistic stimuli (Newport 1990, 26).

Under this view, non-finite fragments are correctly relegated by the maturing processor to the context of embedded clauses and are never taken to be acceptable on their own. Thus while the reason that the OI stage happens still reduces to statistical properties of the input and is not necessarily biological or maturational, as Wexler (1998) holds, the parser itself is maturing, and thus contextualizes the input in a different way in L2 acquisition and any acquisition taking place after the OI stage ends. Wexler (1998), in contrast, says that because the UCC is no longer powerful enough to cause production errors after age five, L2 acquisition never shows tense errors in the pattern of the OI stage.

6.5. Fundamental Differences in the Processing of OI Errors

In the previous sections I have outlined the findings of the current study and the possibilities for their alignment both with the traditional analysis of Wexler (1998) that the OI stage is caused by a biological constraint on feature-checking (the UCC) and with input-driven, statistical models of tense-marking error patterns. To summarize: the results of this study are compatible with the idea of the UCC causing OI errors and requiring suppression into adulthood, if we assume a covert OI stage in non-OI-stage languages. They do not support an analysis of processing slow-downs for OI errors depending on OI errors having been produced in L1 acquisition. Input-driven models also account quite well for the present findings because they show that the distribution of OI-stage errors in child-directed input predicts their existence in the output, but require an independent explanation for processing slow-downs in adults, which I have shown to occur regardless of an OI stage in L1 acquisition.

The crucial question remaining is what might constitute that difference. Though an in-depth analysis is beyond the scope of this paper, I will propose two possibilities. The first relies on frequency effects, and the fact that the rate of occurrence of the subject-verb strings in non-developmental subject-verb agreement errors should be vastly smaller than that of OI constructions, which appear relatively frequently in embedded clauses. Forms that are less probable or less familiar based on these frequency rates should provoke a greater, and quicker, first-pass error response, theoretically resulting in faster reaction times for these more rare and less probable subject-verb agreement error strings, and fewer instances in which the error is wrongly accepted as correct, thus higher rates of accuracy. Kutas & Hillyard (1984) demonstrate this relationship between probability and strength of error response in showing that the amplitude of the N400 semantic error response in ERP is an inverse function of the “Cloze probability” or likelihood of the target word. Another possibility rests on feature violations: under-specification of tense should represent less of a violation than features that explicitly do not agree. Both of these explanations would hold in native and non-native speakers of English, and the presence or absence of a productive OI stage is irrelevant.

One interesting, and unexpected, result of this study, however, was that Chinese speakers showed a greater relative difference in accuracy rates between non-developmental and OI errors than native English speakers did (although reaction times were not significantly different between the two groups) which runs counter to the expectation that difficulty with OI errors should be more salient in the English group with its native OI-stage grammar. This suggests important questions about the nature of non-native or L2 error processing in general and how it may differ from error processing as it occurs in L1 speakers. It seems plausible that in this case the lack of verbal inflection in Chinese might play a role, leading native Chinese speakers to accept non-finite bare forms as correct in English at a higher rate than native English speakers. In light of this possibility a comparison of relative error rates in Spanish becomes more important, something worth investigating further in an expansion of the pilot study of Spanish speakers conducted in this study. The preliminary results presented here suggest that Spanish speakers trended more similarly to Chinese speakers than to English speakers in terms of relative accuracy, but this requires confirmation in a larger group, as does exploration of reaction time differences, which were not significant in the current study. Another fruitful avenue would involve neuroimaging to explore these contrasts on a deeper level: Kovelman et al. (under review) found a different neural pattern for the processing of OI vs. non-developmental errors in the same grammaticality judgment task measured here, and it would be extremely interesting to see whether bilingual, non-native speakers of English would show the same neural patterns of activation in detecting these errors.

7. Conclusion

The present study expands ideas first explored in Kovelman et al. (under review)'s assessment of reaction time and accuracy for OI and non-developmental errors in native English speakers. Replicating these results, and expanding them in order to compare the processing patterns of native Chinese speakers who did not undergo an OI stage, showed that experiencing an overt OI stage appears to be irrelevant to adult processing issues. The idea of a persistent UCC causing issues with OI forms in both children and adults is therefore called into question. A lack of clarity remains as to what differentiates the two types of errors to cause these slow-downs. I propose that the evidence from input-driven models of the Optional Infinitive, showing the importance of frequency effects for OI error strings, may play an important role.

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