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Interfaces between linguistic systems: Evidence from Child Language

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Abstract: Interfaces between grammatical domains have been considered from various perspectives in child language research and in general linguistics. The study aims to provide evidence for interfaces in acquisition of early clause-structure, based on longitudinal data from three Hebrew-acquiring toddlers. Two facets of their early speech output were examined: Usage productivity in verb-inflection, identified by a criterion of contextual appropriateness; and structural transparency/opacity of children's speech output, with transparent forms being unambiguous in relation to their grammatical targets. These factors yielded two distinct developmental periods for the three children: I – from the onset of verb usage to productive verb inflection, and II – from productive verb inflection to disappearance of structural opacity. Period II displays a puzzling mixture of both transparent and opaque usages, not only in verb inflection, but also in use of prepositions marking objects and adverbs. These puzzles are resolved by the significant correlations that emerged between apparently unrelated linguistic systems: (1) opaque verb-forms occur mainly together with object/adverbs, and (2) transparent prepositions occur mainly in combination with transparent verbs. These unexpected convergences between different linguistic systems are discussed as underlining the role of structural transparency/opacity and as shedding new light on between-domain interfaces in language acquisition.

Keywords: linguistic interfaces, verb-inflections, prepositions, transparency/opacity, early Hebrew clause-structure, concurrent analyses

1 Introduction: Interfaces in linguistic research

The notion of interfaces has been the subject of extensive research both in general linguistics and in language acquisition. Dictionary definitions of the term “interface” include such descriptions as: “a surface forming a common boundary between adjacent regions, bodies, substances, or phases” [Free Online

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Dictionary]; “a common boundary or interconnection between systems, equipment, concepts, or human beings” [dictionary.com]; or “the place or area at which different things meet and communicate with or affect each other” [Merriam-Webster dictionary]. These definitions imply that an interface is constituted of the following three components: (1) an area of contact between the interfacing systems/elements; (2) transmission of information in this area of contact; and (3) impact, either mutual or unidirectional, of the transmission of information between the interfacing systems. Below it is argued that these three requirements apply to linguistic interfaces, as well.

A key sense of the notion in linguistics refers to “The Interface” as the computational system that is accessed by conceptual, inferential, or sensorimotor systems through representations that are legible to language-external cognitive domains, termed “interface levels” by Chomsky (2000) and Reinhart (2006). Linguistic models such as theirs agree on the existence of inter-connections both between different domains of the grammar and between grammar and other cognitive domains. More debatable are questions such as the level of contact between systems, the amount of information transmitted from one domain to another, and the directionality of such transmissions. These issues are addressed in the linguistic literature from various points of view, including: the question of the division of labor between linguistic components (Reinhart and Siloni 2005; Magri 2009); the degree of sensitivity of linguistic systems to information from domains external to them (Chierchia 2004; Fox and Hackl 2006; Ariel 2008); which principles (e. g., economy, optimality) guide the interface between linguistic components (Heim 1992; Fox 2000; Reinhart 2006); or the effect of one domain on the manifestation of another (McCarthy and Prince 1990, 1995; Bat-El 1994). Given the complexity and controversiality of the very notion of interfaces in linguistics, one might ask why and how language acquisition could possibly shed light on the issue. Below it is proposed that the answer to this query lies in the phenomenon of partial marking of grammatical categories in children’s early speech.

1.1 Transitional periods as a source of evidence for interfaces

The acquisitional path of grammatical marking has been shown to proceed gradually from non-marking via partial marking to fully-blown grammatical systems in various domains. The sometimes quite prolonged transitional periods that have been identified in the literature between non- to full marking demonstrate partial markings of grammatical distinctions in diverse categories, including inflections (e. g., Dressler and Karpf 1995), prepositions (Veneziano and

Sinclair 2000), and inter-clausal connectives (Diessel 2004). In the domain of verb inflection, such intermediate levels of knowledge have been defined in terms of restrictedness of marking – when children’s usage is confined to one or more particular items or grammatical categories (e.g., Gathercole et al. 2002; Pizzuto and Caselli 1994) – or optionality of marking – when given elements are marked in some but not all contexts, as in the case of the “Optional Infinitive” period of early verb usage (Hyams 1986; Rizzi 1993/1994; Wexler 1993). Below, partial marking in transitional stages of acquisition is accounted for, rather, as revealing and possibly driven by inter-connections between different domains of the grammar.

As hypothetical illustrations of this proposal – if verb inflections were to occur initially only with transitive verbs, noun plurals only with animate entities, and/or multi-clausal constructions only in declarative utterances – such convergences might point to inter-domain relations. Alternatively, if marking in one domain (say, verb inflection) were to emerge at the same time as marking in another domain (noun plurals), this could also be taken as indicative of inter-domain relations. In other words, intermediate periods in the process of language acquisition might reveal between-domain inter-connections that are obscured when the systems in question are already fully in place. Such a state of affairs would make child language a valuable source of evidence for linguistic interfaces.

1.2 Analytical procedures: Concurrent versus separated analyses¹

Previous research on between-domain inter-connections in early child language makes use of two different types of analyses: (1) *post hoc correlations* derived from trends identified separately for children’s use of each of the relevant systems, for example, by analyzing all verbs and all grammatical subjects that occur in a given data-set and then checking for correspondences between the two systems, such as temporal overlap in emergence or other comparable developments between them; and (2) Studies using *concurrent analyses* identifying interfaces by examining the relevant systems within the boundaries of each and every child utterance in which instances of the two systems co-occur, for

¹ This distinction was initially phrased in terms of “online” (i.e., within the boundaries of a single utterance) versus “offline” analyses, but a more neutral terminology was chosen here, due to the usage of these terms in psycho- and/or neurological studies as referring to measurements of participants’ immediate reactions to stimuli.

example, by analyzing pairs of Subject + Verb or Verb + Object occurrences in each relevant stretch of child output across the corpus.

Examples of studies of the first type include, for example, those of Marchman and Bates (1994) and Thordardóttir et al. (2002), who show an interrelation between lexicon and grammar since children require a “critical mass” of vocabulary in order to achieve grammatical regularity in verb inflection. These analyses can be interpreted as relying on non-concurrent evidence for interfaces, since inflectional morphology and lexical growth were each examined separately and the interaction between them was deduced by a *post-hoc* analysis of a temporal overlap between productive inflection and a certain lexicon size. Another such study is Prieto et al.’s (2012) examination of the relations between lexical growth and intonation, showing a significant increase in development of intonational contours in Spanish- and Catalan-speaking children as emerging only after they had achieved a 25-word lexicon. A third line of studies, in situations where there is no temporal overlap between phenomena in different linguistic systems, identifies patterns in one domain as predicative of acquisition of another, later-developing linguistic domain. Thus Vihman et al. (1985) and Stoel-Gammon (2011) show that development in the prelinguistic period (including vocalizations and babbling) affects the age of onset of meaningful speech and rate of vocabulary growth, and that target words with phonetic properties that mirror a child’s prelinguistic vocalizations are acquired earlier.

In contrast to these are concurrent analyses such as those of Demuth and her associates (Demuth and Tremblay 2008; Demuth et al. 2012), whose examination of articles and word-length in each child utterance in their Spanish-language sample revealed an interaction between early use of articles and the number of syllables in the following noun, with children first using articles with monosyllabic nouns, and then gradually extending them to longer words. Brown’s (2008) concurrent analysis of the interface relations between verb semantics and argument realization points to verb-meaning specificity as promoting argument ellipsis in transitive clauses in adult as well as child speech in Tzeltal such that, for example, a highly specified verb lexeme meaning ‘eat something soft’ will occur more often with object ellipsis than will a less specified lexeme meaning ‘eat’. Concurrent analysis of inter-relations between domains is also represented by Allen’s (2000) investigation of the relations between referential informativeness and argument realization in child-Inuktitut, showing that argument ellipsis is affected by features of discourse-pragmatic informativeness, such as the newness of a given referent or the contrast between referents.

This approach to interfaces as co-realization of two linguistic systems within the boundaries of a single piece of speech output was selected for present

purposes in order to access the inter-communication or transmission of information between systems that underlie interfacing. To this end, two sets of interconnections between linguistic domains were analyzed: (1) verb inflection in relation to predicate elaboration by non-subject constituents (i. e., objects and adverbs) and (2) verb inflection in relation to use of prepositions to mark such constituents. Verb-inflection in Hebrew, as in many languages, functions independently of both predicate elaboration and use of prepositions, since the realization of one does not rely on the other (unlike, say, articles and nouns or argument ellipsis and informativeness). Consequently, issues of predicate constituency and/or prepositional marking are typically not analyzed in relation to verb-inflection, either in child language or general linguistic research. As a result, any interconnections that might emerge between them would constitute evidence for a novel class of interfaces in child language, possibly in language in general.

2 The study

The analyses presented below are based on naturalistic longitudinal samples from three Hebrew-acquiring children: Shachar – a boy, and two girls – Rotem and Lior, at a mean age-range of 1;4 to 2;5.² Analyses begin with their earliest predications (i. e., verb-containing utterances, including both one-word utterances of a single verb and verbs accompanied by other clausal constituents) produced by each child and cover approximately a year of their early clause usage, allowing for identification of both parallel developmental phases and between-domain convergences across the three children.

2.1 Participants and procedure

All three children are from well-educated, middle-class families resident in central Israel. Independent evidence that the three children can be described as “typically-developing” was derived by applying Dromi and Berman’s (1982) Hebrew-designed MPU (Morphemes per Utterance) measure of grammatical

² The data for Shachar and Rotem were collected in the Child Language Project of Bat-El and Adam, Tel Aviv University, ISF Research Grant #554/04; those for Lior are taken from the Child Language Data-Base of the Berman lab at Tel Aviv University, a subset of which is available in the Berman corpus on CHILDES (<http://childes.psy.cmu.edu/data/Other/Hebre>). Thanks are due to Brian MacWhinney and Aviad Albert for digitalization of Lior’s data.

Table 1: Age of MPU measure of 2 for the three children.

Child	No. of utterances	MPU	
		Mean	Median
Shachar (2;0)	54	125/54 = 2.3	2
Rotem (2;2)	46	106/46 = 2.3	2
Lior (2;0)	44	89/44 = 2.02	2

development to a sample recording session for each child, deriving the breakdown shown in Table 1.

Table 1 shows that two of the children (Lior and Shachar) reached a mean MPU 2 by age 2;0, and the third (Rotem), by age 2;2, so revealing all three as falling within the range of what Dromi and Berman documented for nearly forty other typically developing Hebrew-acquiring toddlers.

All children were audio-recorded for one hour per week in their home environment, during natural everyday interaction with their caregivers – Lior’s mother and paternal aunts of Rotem and Shachar (with Shachar recorded and transcribed by the author). All child and adult utterances were transcribed in broad phonemic transcription following the CHILDES conventions (MacWhinney 2005), as adapted in the Berman lab at Tel Aviv University to conform to the non-Latinate orthography and contemporary pronunciation of Israeli Hebrew. The speech output of Shachar and Rotem was also phonetically transcribed and, where possible, a corresponding phonetic target form entered for their usages, while Lior’s speech output was checked where necessary by reference to the digitalized data-base constructed of her auditory recordings. Interpretation of child speech took into account three kinds of evidence: extra-linguistic context, preceding adult utterances, and childrens’s subsequent utterances (Bloom 1970). The caretakers who did the recordings were explicitly instructed to provide what Brown (1973) calls “rich semantic context” in explaining the child’s intentions, and transcribers also regularly consulted with the mothers to resolve unclear child output.

2.2 Data-base analyzed

Data-analysis began with the earliest occurrences of forms identifiable as verbs in each child’s speech, and continued up until the point where verb inflections no longer exhibited “structural opacity” in the sense specified below, yielding a total of 6,506 analyzed utterances. Analysis applied to all concurrent

realizations of verbs with other clausal constituents within the boundaries of a single string of autonomous child speech output. Adult input was taken into account as providing linguistic and pragmatic contextualization for children’s speech, for example, in order to identify instances of unanalyzed and/or non-autonomous utterances, including: direct repetitions of adult input, non-clausal completions of adult utterances, rote-learned forms, and formulaic routines. Table 2 lists details of the data-base for each of the children, with “Total number of verbs” referring to verb tokens, that is, all occurrences of verb forms in the children’s speech, except for semantically empty reiterations (e. g., *tni li, tni li, tni li* ‘give me, give me, give me’).

Table 2: Data-base of the study, by age, number of sessions, number of utterances, and total number of verbs, for each child.

Child	Age-range	No. of analyzed recordings	Total utterances recorded	No. of child utterances	Total verb tokens
Shachar	1;4.17–2;3.24	48	26,469	13,070	2,083
Rotem	1;3.20–2;5.29	54	39,507	16,236	2,375
Lior	1;5.19–2;4.08	123	40,568*	17,203	2,048

* The transcripts of the recordings of Shachar and Rotem include only adult utterances that either preceded or directly interacted with the children’s output while those of Lior include all adult utterances recorded in each session.

Shachar and Rotem were recorded for one hour at a single weekly session each – in the tradition of child language sampling since the 1970s (Bloom, 1970; Brown, 1973) – while Lior represents a rather denser data-set, of between three to five sessions coming to a cumulative hour per week. This yielded, for each child, around 2,000 verb-containing utterances for a relatively long period of time (nearly a year for Shachar and Lior, over a year for Rotem), an important factor in the analyses undertaken here. The data-set thus diverges from currently accepted procedures of “dense” recordings, typically conducted over a relatively limited period of time (e. g., for English by Lieven et al. 2003; Maslen et al. 2004; and by Roy et al. 2006; for German – Behrens 2006). These may indeed be crucial for various purposes, such as to inspect short-lived phenomena, to identify precise age of emergence, or to track input-output correspondences. Given the idea that frequency of sampling needs to be suited to the particular domain at issue (Tomasello and Stahl 2004), the present study, which aims at tracing concurrent progressions in early child language across several areas of simple clause structure, called for a lengthy period of data-

analysis to characterize relevant developmental trajectories across several children.

2.3 Coding categories

All and only children’s verb-containing utterances were coded for word-internal inflectional form and for clause-level constituents. Children’s verb forms were coded in relation to the corresponding “target” or adult form for the following five inflectional categories: Mood (Infinitive, Imperative), Tense (Past, Present, Future), Number (Singular, Plural), Gender (Masculine, Feminine), and Person (1st, 2nd, 3rd). Table 3 illustrates the linguistic categories specified for verb forms used by the children, using as the citation form of verb lexemes the morphologically simple Past Tense Masculine Singular.

All objects and adverbs were coded in relation to the corresponding adult form and specified for their syntactic function and for whether or not they are marked by prepositions. Tables 4 and 5 specify the relevant non-marked and marked categories, respectively.

The coding categories apply to all possible forms available in the ambient language. Nonetheless, many verbs and prepositions produced by the children could not be assigned a conventional grammatical category, giving rise to the need for a further category of analysis, defined below as structural transparency versus opacity.

Table 3: Examples from three children of coding of four verb-form inflections.

Child utterance + Age of child	Target + Gloss	Relevant preceding context	Inflectional category	Lexeme
<i>Lator</i> [Rotem, 2;0.30]	<i>la’acor</i> ‘to.stop’	Adult: <i>ma la’asotla#nadneda?</i> ‘what (should I) do to the swing?’	INF	<i>‘acar</i> <i>‘stop’</i>
<i>kxi, íma</i> [Lior 2;3.26]	<i>kxi, íma</i> ‘take-2SG, F.IMP, mommy’	–	2SG, F.IMP	<i>lakax</i> ‘take’
<i>Xina</i> [Shachar, 1;9.19]	<i>mexina</i> ‘preparing- SG.F’	Adult: <i>ma ima osa im ha-tutim?</i> ‘what (is) mommy doing with the-strawberries?’	SG, F.PRS	<i>hexin</i> ‘prepare’
<i>na’ale</i> [Rotem, 2;4.05]	<i>na’ale</i> ‘will.go.up-1PL’	–	1PL.FUT	<i>‘ala</i> <i>‘go.up’</i>

Table 4: Zero-marked object and adverbial constructions, illustrated from the data-base.

Syntactic functions	Examples	Source
Direct objects – indefinite	<i>ftexi <u>tevízya!</u></i> ‘turn.on-2sg.f <u>television!</u> ’	Lior, 2;0.00
Lexical adverbs	<i>nasim kan.</i> ‘will-put-1pl <u>here</u> = ‘(let’s) put (it) here’	Rotem, 2;1.06
Information questions	<i>ma ose ha-dag</i> ‘ <u>what</u> does the-fish = what’s the fish doing?’	Shachar, 2;0.13
Complements	<i>at roa ma hu oxel?</i> ‘(do) you see <u>what he (is) eating?</u> ’	Rotem, 2;4.12

Table 5: Object and adverbial constructions marked by the Accusative marker *et* and other prepositions, demonstrated by examples from the data-base.

Syntactic functions	Lexical/ Pronominal	Examples	Source
Direct objects – definite	Lexical	<i>roce <u>et Pu.</u></i> ‘wants <u>ACC Pooh</u> ’	Shachar, 2;1.11
	Pronominal	<i>ani ohévet <u>oti.</u></i> ‘I love <u>ACC-me</u> ’	Lior, 2;2.02
Oblique objects	Lexical	<i>at lo mefaxédet <u>me-arye?</u></i> ‘(are) you not scared <u>of-lion?</u> ’	Rotem, 2;5.15
	Pronominal	<i>hu hirbic <u>li.</u></i> ‘he hit <u>to-me</u> = ‘he hit me’’	Lior, 2;5.29
Indirect (dative) objects	Lexical	<i>le-kol <u>yéled</u> ani mexaléket oto,</i> <i>tov?</i>	Rotem, 2;4.19
	Pronominal	‘to-each child I share it, okay?’ <i>tni <u>li</u> sendvich</i> ‘give <u>to-me</u> (a) sandwich’	Lior, 2;4.02
Adverbs	Lexical	<i>lir’ot <u>ba-mar’a.</u></i> ‘to-see <u>in-the-mirror</u> ’	Shachar, 2;1.06
	Pronominal	<i>Luki, ce <u>mi-kan.</u></i> ‘Luki, get-out <u>of-here</u> ’	Lior, 2;4.08

2.3.1 Structural transparency

All verbs and prepositions used by the children were further coded as structurally *transparent* or *opaque*. Transparent verbs are grammatically and lexically clearly interpretable, including both fully adultlike and mispronounced forms

(e. g., *aflu* for *naflu* ‘fell-3sg’, *nafala* for *nafla* ‘fell-3sg.f’); opaque verbs are ones with unclear target forms, since they can correspond to more than a single possible target (Lustigman 2012, 2013). For example, in a form like *ber* ‘talk’ only the verb lexeme is identifiable as a combination of consonantal root and associated value for *binyan* morphological pattern – labeled P1 (for the pattern *CaCaC*), P2 (*niCCaC*), P3 (*CiCeC*), P4 (*hitCaCeC*), and P5 (*hiCCiC*) (Berman 1993). The opaque child form *ber* is thus represented here as [*d-b-r*, P3 = talk], since it could stand for infinitive *ledaber*, present tense *medaber*, past *diber*, future *yedaber*, or imperative (*te*)*daber*. Similarly, the verb-form *kel* ‘look’ [*s-k-l*, P4 = look] could stand for the target infinitive *lehistakel*, present-tense *mistakel*, past tense *histakel*, future *yistakel*. Such “bare-stem” forms (Adam and Bat-El 2008; Armon-Lotem and Berman 2003) may stand for different inflected forms and, in some cases, derivationally-related forms: For example, the stem *xec* not only has several inflectional targets, it is also ambiguous between the transitive lexeme *roxec* ‘wash’ in the P1 pattern and the reflexive P4 lexeme *mitraxec* ‘wash-oneself’ from the same consonantal root, that is, either [*r-x-c*, P1 = wash] or [*r-x-c*, P4 = wash.oneself]. On the other hand, “bare stems” are not necessarily opaque; for example *šon* can stand only for infinitival *lišon* ‘to-sleep’, and *šoméa* is unambiguously present tense masculine ‘hears’.

In the domain of *prepositional marking*, three types of constructions were identified as opaque in preposition-requiring contexts: omission of required prepositions (e. g., *halax gina* ‘went Ø playground’); use of filler syllables (Peters and Menn 1993; Veneziano and Sinclair 2000), usually in the form of the vowel *a* (e. g., *kafac a-mita* ‘jumped _{FILL}-bed’); and substitution by inappropriate prepositions (e. g., *kibel maka ba-kise* ‘got hit in.the-chair’ – instead of *kibel maka me-ha-kise* ‘got hit from-the-chair’).

Importantly, strings were identified as opaque even when the missing grammatical marking could be derived from the linguistic and/or extra-linguistic context. For example, an opaque verb like *tapes* ‘[*t-p-s*, P3 = climb]’ used in reply to the question *ma ha-yalda osa?* ‘what (is) the-girl doing?’ may be interpretable from the context as having the target *metapêset* ‘is.climbing-F’; yet the form *tapes* would still be counted as opaque, since in itself it contains no *structural* cues to a particular target and therefore could stand for *letapes* ‘to.climb’, *metapes* ‘is.climbing-m’, *yetapes* ‘will.climb-m’, and so on.

Another class of forms that do not provide sufficient clues as to their grammatical targets are *unanalyzed rote-learned* strings (Bybee and Slobin 1982; MacWhinney 1975). These are usually identifiable only when they are used in an obviously erroneous fashion in relation to the grammatical environment in which they occur. Examples from the present data-base in use of verb inflections include Lior’s [1;11:13] use of a masculine 2nd person suffix in

addressing her mother in the string *ima gamarta?* ‘mommy finished-2_{SG.M?}’ showing that the verb-form is unanalyzed (cf. contextually correct *gamart* ‘finished-2_{SG.F?}’); and Shachar’s [1;7.17] response *dahara* ‘galloped-3_{SG.F?}’ to the adult question *ma ha-sus ose?* ‘what (is) the-horse(M) doing(M)?’, where he uses a feminine suffix in referring to the masculine noun *sus* ‘horse’ (cf. masculine *dahar*). Unanalyzed uses of prepositions typically occur with the dative-marking *le-* ‘to’, either in a form fused with a verb-stem, as in *tini* for *tni li* ‘give to-me’ [Shachar, 1;3.14], or with an inappropriate pronominal suffix, as in *zor lax* ‘[P1, ‘-z-r=help] to-you’ [Lior, 1;7.19] instead of *li* ‘to-me’ when asking for help from her mother. These and other unanalyzed strings were specified as such, and were not assigned a grammatical target. Such clearly unanalyzed usages revealed the need to apply an explicit criterion for identifying productivity in the children’s use of grammatical marking.

2.3.2 Usage productivity

Usage productivity in language acquisition is broadly defined as the ability to apply structural operations to a set of items in a meaningful and consistent fashion (Berman 1978; Bowerman 1990; Ingram 1989; Wittek and Tomasello 2005). Numerous studies concerned with the acquisition of verb inflections address the problem of distinguishing rote-learned strings from productions that reflect grammatical knowledge (e. g., MacWhinney 1975; Bowerman 1985; Bassano 2000; Kilani-Schoch and Dressler 2002; Vihman and Vija 2006). Proposals for measuring productivity in early grammatical development in different languages have generally relied on quantitative criteria (e. g., Bloom 1991; Gathercole et al. 1999; Pizzuto and Caselli 1994), currently supplemented by sophisticated statistical algorithms (Lieven 2008; Tomasello and Stahl 2004). The present study, however, adopted a contextually based, qualitative criterion of productivity relating occurrence of inflections to the syntactic environment of the verbs to which they are attached.

The choice of a qualitative criterion was motivated by the fact that, as pointed out early on by Brown (1973), and more recently by Rowland et al. (2008), quantitative accounts depend critically on the nature of data-collection and sample size, and so may vary from one linguistic category to another, even from one child to the next. They may also fail to take into account that non-productive expressions common in children’s speech output at a given period of time tend to be associated with particular extra-linguistic situations, while forms which are in fact productively constructed may be relatively infrequent when they first begin to occur. Recent studies on acquisition of tense and agreement

(Hadley and Holt 2006; Rispoli et al. 2009, 2012) have addressed these problems by filtering out repeated uses of frequent and therefore potentially rote-learned combinations in scoring children's use of inflectional morphemes for productivity, yet even such elaborate procedures as theirs are in essence quantitative. The present decision to apply more qualitative, contextually sensitive criteria is based on the conviction that, as cogently argued by Richards (1990), merely counting occurrences in children's speech output runs the risk of either over-estimating (due to rote-learning) or under-estimating (due to non-canonic usages) their productive command of a given category.

Concern here is thus not with frequencies in children's use of inflectional affixes but, rather, with *change* in their behavior with respect to such affixes, as reflected in the shift to exclusive reliance on inflected forms that are grammatically well-motivated rather than rote-learned (Lustigman 2013). This context-sensitive criterion is an adapted version of Brown's (1973) "obligatory contexts", where grammatical context serves as a key criterion for productive use of inflectional morphemes. Unlike Brown, however, the productivity measure applied here does allow omission of affixes (in the shape of bare-stem verbs), disallowing only rote-learned use of affixes (in the shape of unanalyzed stem + affix amalgams), and these, moreover, are disallowed across the board, as against Brown's 90 % correct usages.

The utterances in (1) illustrate use of rote-learned, unanalyzed inflected verbs that are clearly grammatically erroneous in the contexts in which they are produced.

- (1) a. *kēlev rāca*
 'dog(M) is.running-F'
 (Shachar, 1;7.02])
 b. *macat*
 'found-2SG.F' (when referring to herself)
 (Rotem, 1;11.25)
 c. *boxa*
 'is.crying-SG.F' (when referring to her baby brother)
 (Lior, 1;7.16)

The criterion taken here as indicative of productivity in use of verb inflections is that, at a given period of development, instances like those in (1) no longer occur in the child's speech. This qualitative criterion applies relatively independently of sample-size, since it does not count occurrences of alternating affixes with a given verb lexeme or of a given affix with different lexemes, nor does it measure correct against incorrect usages. It is also particularly relevant in Hebrew, which

has no morphologically unmarked forms of verbs like English *talk*, *go*, *sleep* (Berman 1978) that may appear grammatical in a range of syntactic environments. As a result, Hebrew-acquiring children continue to produce child-like bare stems for a relatively long period, even after they start using inflections productively. In fact, due to the lack of unequivocal base forms in their paradigms, Hebrew verbs provide valuable evidence for the developmental route of inflectional morphology.

2.4 Predictions

Against this background, two broad predictions were formulated for the acquisition of verb inflection and early clause structure in Hebrew:

- (i) Children's productions will shift gradually from non-marking and pervasive opacity to consolidation of transparent verb inflections and prepositional marking in all and only required contexts – in keeping with prior research demonstrating a developmental trajectory from non-specification via partial to full specification (Lustigman 2013, Lustigman in press).
- (ii) Analyses of concurrent realization of two grammatical systems in a given utterance will display a cognitively motivated “trade-off” effect, with opacity in one domain co-occurring with elaboration in another, specifically:
 - a. opaque verbs will occur in the syntactic environment of elaborated rather than isolated predications, and
 - b. opaque verbs will co-occur with transparent prepositions and transparent verbs will co-occur with opaque prepositions

3 Analyses and findings

Findings are presented for a period of slightly over a year, from the beginning of verb production until inflectional opacity disappears. All verb-containing utterances (yielding a total of 6,506 child utterances) were analyzed following the coding procedure detailed in Section 2.3. Coding reliability was scored on a randomly selected 5% of the total number of verb-containing utterances that included predicate-elaborating objects and/or adverbs (154 out of a total of 3,163 elaborated verb-containing utterances), independently rated by a Hebrew-speaking graduate linguistics major who indicated (1) what she took to be the possible target forms of the verbs, if any, and (2) how grammatical each form was in the context provided. Inter-judge agreement with the author came to 98.6% (Krippendorff's $\alpha = 0.969$).

3.1 Developmental periods

Productive use of verb inflection was specified for each child by the productivity criterion defined in Section 2.3.2 above, yielding a developmental shifting point that divided the children's verb usage into the following two time-frames: *Period I* – from the onset of verb production until productive inflection, and *Period II* – from the beginning of productive inflection up to the disappearance of verb forms defined as “opaque”. Tables 6 and 7 summarize the distribution of verb forms during Period I and II, respectively, for the three children.

Despite differences in the duration of the periods and raw numbers of total verbs, all three children show an expected decrease in proportion of opaque verbs in period II (from 41% to 14% for Shachar, 58% to 16% for Rotem, and 37% to 9% for Lior). That is, opacity in verb use continues into Period II, but at a much lower extent than formerly for the three children. Note that reliance on opaque, non-affixed verb forms in children's Hebrew is best explained as morphologically motivated rather than deriving from strictly phonological constraints. As argued by Adam and Bat-El (2008), such forms cannot be attributed to either omission of unstressed inflectional affixes or restrictions on word-length, since children at this stage (i) also omit stressed suffixes (e. g., *tax* for *patxá* ‘opened-F’; *fel* for *noflím* ‘are.falling-M’), and (ii) even in Period I, produce

Table 6: Breakdown of verb-forms for each child in Period I.

Child	Age-range	Total verbs	Transparent stems*	Opaque stems	Unanalyzed affixed
Shachar	1;4.17–1;8.10	201	94	83	24
Rotem	1;3.20–2;0.16	420	102	243	75
Lior	1;5.19–1;11.14	681	166	255	260

*These include non-ambiguous verb stems (e. g., *šon* that can only correspond to *lišon* ‘to-sleep’; or *šomea* ‘hears-MS.SG’) but they were not taken to represent inflectional knowledge while rote-learned forms were still in use.

Table 7: Breakdown of verb-forms for each child in Period II.

Child	Age-range	Total verbs	Transparent stems	Opaque stems	Transparent affixed
Shachar	1;8.17–2;3.24	1,882	654	261	967
Rotem	2;0.30–2;05.29	1,955	272	310	1,373
Lior	1;11.15–2;4.08	1,367	224	121	1,022

many di- and even trisyllabic (non-verb) forms, including with unstressed inflectional affixes (e. g., *táktorim* for the plural noun *tráktorim* ‘tractors’ [Shachar, 1;7], *šišáfa* for *djiráfa* ‘giraffe’ [Rotem, 1;9]), *ugiyá* ‘cookie’ [Lior, 1;9]). That is, while the children produced di- and tri-syllabic non-verb elements that corresponded more accurately to their target forms, their verb forms during this period still appear to be limited to bare-stem forms. The fact that they already demonstrate the phonological ability to produce non-verbal affixes and longer phonological words implies that there are differential constraints on verb-affix production that stem from morphological factors applying to the category of verbs.

In Period II, inflectionally affixed forms constitute the bulk of the verb output of the two girls (70 % for Rotem, 75 % for Lior), and around half (51 %) for Shachar who, as a boy, used fewer forms with feminine affixes (and considerably more non-affixed masculine stems) when reporting his own actions. These figures show that opaque verb forms do not disappear once productive inflection emerges, but continue to occur alongside productively inflected forms, so much so that the same verb lexeme sometimes occurred as both opaque and inflected in the same recording session, as shown in (2) below.

(2) Verb lexemes occurring as both inflected and opaque verb form *in a single recording session*:

a. Shachar (2;00.00), the lexeme [k-f-c, P1] ‘jump’:

(i) Transparent use:

Child: **koftsim.**

‘jumping-PL.M’

Adult: *koftsim.*

‘jumping-PL.M’

Child: *gam al zot.*

‘also on this-one’

(ii) Opaque use:

Adult: *likfoc, hi kafca la-argaz-xol?*

‘to jump, she jumped into.the-sandbox?’

Adult: *ve-ma asu Roi ve-Ofer?*

‘and what did Roi and Ofer do?’

Child: **foc agaz-xol.**

‘[k-f-c, P1]=jump sandbox.’

b. Rotem (2;01.19), the lexeme [c-y-r, P3] ‘draw’:

(i) Transparent use:

Adult: *at metsayéret et ha-bet-bubot šelax?*

‘you are drawing your doll house?’

Child: *ken.*

‘yes.’

Adult: *az tetsayri.*

‘so draw.’

Child: *bubot. seri li bubot*

‘dolls. **draw-2SG.F.IMP** for-me dolls.’

(ii) Opaque use:

Child: *ma ze? varod.*

‘what (is) that? Pink.’

Adult: *ken, ze varod.*

‘yes, this (is) pink.’

Child: *ani cayer be-ze.*

‘I [**c-y-r, P3**]=**draw** in-this (=with this).’

c. Lior (2;00;20), the lexeme [*p-t-x*, P1] ‘open’:

(i) Transparent use:

Adult: *boi ani e’ezor lax lehoci et ha-atifa me-ha-šeni.*

‘let me help you take-off the wrap from-the-other-one.’

Child: *me ha-šeni?*

‘from the other-one?’

Adult: *ken.*

‘yes.’

Child: *kaze ima?*

‘like.this, mommy?’

Adult: *ken ze.*

‘yes, this.one.’

Child: *efšar liftóax?*

‘(is it) possible **to-open**?=can I open?’

(ii) Opaque use:

Adult: *roca lašir Pinokyo?*

‘(do you) want to-sing Pinocchio?’

Child: *koy.*

‘Pinocchio.’

Adult: *taširi li.*

‘sing for-me.’ (mother and child sing together)

Child: *ima, itax lax*

‘mommy, [**p-t-x, P1**]=**open** for-you.’

These examples suggest that Period II is “mixed”, a time when both finite and non-finite verbs occur in finite contexts.

Tables 8 and 9 present the distributions of *prepositions* during Period I and Period II, respectively, for all three children.

Table 8 shows that Shachar and Rotem’s verb-containing utterances involved hardly any preposition-requiring contexts; Lior, who relied heavily on rote-learned strings, produced a markedly larger number of verb-containing

Table 8: Breakdown of preposition-requiring contexts [PRCs] in combination with verbs for each child in Period I.

Child	Age-range	Total PRCs	Transparent prepositions	Opaque prepositions	Unanalyzed prepositions
Shachar	1;4.17–1;8.10	5	0	1	4
Rotem	1;3.20–2;0.16	5	2	3	0
Lior	1;5.19–1;11.14	109	48*	15	46

*these appeared grammatical in the context in which they were used, but need to be treated with caution owing to Lior’s pervasive use of unanalyzed prepositions during this period.

Table 9: Breakdown of preposition-requiring contexts [PRCs] in combination with verbs for each child in Period II.

Child	Age-range	Total PRCs	Transparent prepositions	Opaque prepositions
Shachar	1;8.17–2;3.24	615	474	141
Rotem	2;0.30–2;05.29	618	490	128
Lior	1;11.15–2;4.08	535	447	88

utterances with prepositional phrases, but since most were clearly unanalyzed in context, they failed to represent consistent grammatical knowledge. Table 9 shows a marked increase in the number of preposition-requiring contexts in the speech of all three children. Interestingly, as with verb inflection, this period also demonstrated a “mixed” pattern in use of prepositions. Thus, all three children demonstrated both opaque and transparent use of prepositions in the same grammatical contexts, again in a single session, as shown in (3), where *FILL* stands for a filler syllable.

- (3)
- Preposition-requiring contexts (sharing the same verb lexeme and the same type of predicate elaboration) manifested with both transparent and opaque prepositions *within a single recording session*:

- a. Shachar (1;11.16), the preposition *le-* ‘to’:
- (i) Transparent use:
 Adult: *ma osa ima?*
 ‘what is.doing Mommy?’
 Child: *holéxet la-avoda*
 ‘is.going **to.the**-office’
 - (ii) Opaque use:
 Adult: *ma asu aba ve-Ofer?*
 ‘what did daddy and Ofer (do)?’
 Child: *aléxet a-xalav.*
 ‘go **FILL**-milk’ (intended meaning: went to the milk-store)
- b. Rotem (2;2.25), Accusative marker *et*:
- (i) Transparent use:
 Adult: *at lo ma?*
 ‘you don’t what?’
 Child: *ani lo yodáat liftóax et-ze.*
 ‘I don’t know (how) to.open **acc-it**.’
 - (ii) Opaque use:
 Adult: *hopa, ma kara?*
 ‘whoops, what happened?’
 Child: *ani lo yaxol dištóx a-ze.*
 ‘I not can (=cannot) open **FILL**-this.’
- c. Lior (2;0.29), preposition *im* ‘with’:
- (i) Transparent use:
 Adult: *sixeq itax?*
 ‘(he) played with-you?’
 Child: *lo sixeq iti aba.*
 ‘not played (=did not play) with.me Daddy’
 - (ii) Opaque use:
 Adult: *sixeq hayom Kuki?*
 ‘played today Kuki?’
 Child: *xxx, hu sixeq Ø šteynu kuki aba.*
 ‘he played **Ø** both.of.us Kuki daddy.’

Period II thus displays concurrent opacity and transparency in both verb inflection and prepositional marking, for all three children, as opaque and transparent forms appear to be used interchangeably. The distribution of such opaque versus transparent forms is, however, not entirely random, as shown below.

3.2 Analyses of convergence

Two sets of concurrent analyses were performed on the “mixed” distributions in Period II to account for the distribution of opaque versus transparent verbs (Section 3.2.1) and opaque versus transparent prepositions (3.2.2).

3.2.1 Analysis A: Verb inflection and predicate elaboration

The first concurrent analysis aimed to account for the distribution of opaque versus transparent verbs was applied to a subset of 40 verb lexemes that occurred across the data-sample for all three children, so allowing for comparability across the data-base. Importantly, these 40 items represent two lexico-syntactic classes of (a) intransitive verbs that stand alone without any supporting linguistic context, both change-of-state “unaccusatives” as well as agentive activity or stative verbs – e. g., English *fall*, *cry/weep*, *sleep*), and (b) verbs that do take an object – including both verbs that require an obligatory object to construct a well-formed utterance (e. g., verbs like English *lift*, *peel*, *bring* – including when obligatorily governed by a preposition – e. g., *histakel al-look at*’, *paxad me-* ‘be-scared from=of’), and verbs that can occur either with or without an object (e. g., the Hebrew equivalents of *eat*, *play*, *draw*). These 40 lexemes are shown in Table 10.

Analysis was conducted on the total 1,733 utterances in which these 40 lexemes occurred in the speech of the three children, each considered concurrently for both inflectional opacity/transparency and syntactic isolation/elaboration (i. e., whether or not containing an object and/or an adverb).³ This yielded four possible types of verb-containing utterances, as specified in (4).

(4) Possible types of children’s verb-containing utterances:⁴

a. isolated transparent verbs:

sixáqti

‘played-1sg’

[Rotem, 2;5.15]

³ Intransitive verbs may be elaborated by an adverb (e. g., *rac maher* ‘runs fast’), while verbs that require an object may occur in isolation due to the interactive nature of the data (e. g., Adult: *ma ima osa?* ‘what (is) mommy doing?’ Child: *mekaléfet* ‘peeling’).

⁴ Adult targets could not be specified in cases of opaque child forms.

Table 10: Forty verb lexemes selected for analysis A, by lexico-syntactic category.

Lexico-syntactic category	Lexeme*
Intransitive	<i>amad</i> 'stand (up)' <i>baxa</i> 'cry' <i>hišta'el</i> 'cough' <i>hitgaleš</i> 'slide' <i>hitorer</i> 'wake up' <i>nafal</i> 'fall' <i>niftax</i> 'open (Intrans.)' <i>nišbar</i> 'break (Intrans.)' <i>nišpax</i> 'spill' <i>rakad</i> 'dance' <i>šaxav</i> 'lie.down' <i>yašan</i> 'sleep' <i>yašav</i> 'sit'
Transitive (obligatory/optional object)	<i>asaf</i> 'collect' <i>herim</i> 'lift' <i>hexin</i> 'prepare' <i>hirbic</i> 'hit' <i>hoci</i> 'take.out' <i>horid</i> 'take.down' <i>kilef</i> 'peel' <i>nigev</i> 'wipe' <i>patax</i> 'open' <i>sagar</i> 'close' <i>šataf</i> 'wash (Trans.)' <i>šavar</i> 'break (Trans.)' <i>sider</i> 'tidy' <i>hevi</i> 'bring' <i>natan</i> 'give' <i>siper</i> 'tell' <i>zarak</i> 'throw' <i>kibel</i> 'get' <i>lakax</i> 'take' <i>tipes</i> 'climb' <i>axal</i> 'eat' <i>ciyer</i> 'draw' <i>sixek</i> 'play (a game)' <i>nizhar</i> 'be.careful' <i>kam</i> 'get up' <i>kafac</i> 'jump' <i>nasa</i> 'ride, drive'

*Verb lexemes are represented in the morphologically simplex form of past tense masculine singular.

- b. elaborated transparent verbs:
mesaxéqet ba-maxšev
 ‘playing-SG.F in=with-the-computer’
 [Lior, 2;1.14]
- c. isolated opaque verbs
xek ‘[s-x-k, P3=play]’,
 [Shachar, 1;8.17]
- d. elaborated opaque verbs
xek im zaxal
 ‘[s-x-k, P3=play] with caterpillar’
 [Lior, 2;2.25]

Figure 1 shows the proportion of isolated opaque verbs out of total opaque-verb occurrences compared with the proportion of isolated verbs out of total verbs, in all 1,733 verb containing utterances.

Figure 1: Proportion of isolated verbs out of total verbs compared with proportion of isolated opaque verbs out of total opaque verbs, in Period II, by child.

As shown in Figure 1, all three children used isolated opaque verbs at lower rates than the general distribution of isolated verbs (for Shachar, 40 % isolated opaque compared with 62 % isolated verbs in general distribution; 45 % versus 58 % for Rotem, and 27 % versus 39 % for Lior). A single-proportion Z-test revealed that these differences were consistently significant: The children produced a significantly lower proportion of isolated opaque verbs compared with the general distribution of isolated verbs (for Shachar: $Z = 4.901826$, $p < 0.0001$; for Rotem: $Z = 3.247999$, $p = 0.0006$; for Lior: $Z = 2.497474$, $p = 0.006$).

This indicates that, in the early phases of grammatical affixation when opaque uninflected stems occur side by side with productively inflected verb forms (Period II), the distribution of opaque versus transparent verb usage is not

entirely random. Rather, opaque verb forms appear to be largely “reserved” for more elaborated, non-isolated predicative environments. Recall that in Period I, most verb forms, including opaque stems, occurred in isolation (Table 8), suggesting that prior but not subsequently to the emergence of productive inflection, opaque verbs tend to appear in isolated syntactic contexts. In other words, once children apply verb inflection productively, inflectional opacity and elaborated syntagmatic environment become interconnected in their language use.

3.2.2 Analysis B: Verb inflection and prepositional marking

A second analysis, aimed to account for the distribution of transparent versus opaque prepositions during Period II, was applied to a total of 1,768 utterances with verbs in preposition-requiring contexts. Each such utterance was coded concurrently for both opacity/transparency of verb inflection *and* opacity/transparency of prepositional (non-)marking. The following patterns were found for all three children in co-occurrence of verb inflections and prepositions: *transparent pairing* – transparent verb forms plus transparent prepositional marking (5a); *opaque pairing* – opaque verb forms plus opaque prepositional (non-) marking (5b); and *mixed pairing* – opaque prepositional marking with transparent inflection (5c) or vice versa, opaque inflection with transparent prepositional marking (5d).

- (5) Possible types of utterances with verbs in preposition-requiring contexts
 - (a) Transparent pairing
gam ani sixákti ba-gan [Rotem, 2;2.11]
 ‘also I played-1SG at.the-kindergarten’
 - (b) Opaque pairing
ikanes Hodaya a-ze’ev [Shachar, 1;10.07]
 ‘[k-n-s, P2=enter] Hodaya FILL-wolf’
 (Apparent target: ‘Hodaya came (to visit) at the wolf’s house’)
 - (c) Mixed pairing (i): transparent verb + opaque preposition
laruc argaz-xol [Shachar, 1;11.07]
 ‘to.run $\emptyset$ sandbox’
 - (d) Mixed pairing (ii): opaque verb + transparent preposition
ani cayer be-ze [Rotem, 2;1.09]
 ‘I [c-y-r, P3=draw] with-this’

Mixed pairings (as in Examples (5c) and (5d)) turned out to be less common than “homogeneous” transparent (5a) or opaque (5b) pairings for all three children.

Figure 2 shows the distributions of mixed versus homogeneous pairings for all three children during Period II.

Figure 2 shows that the children used far more homogeneous than mixed pairings in Period II: Shachar – 188 mixed versus 464 homogeneous pairings, Rotem – 144 mixed vs. 585 homogenous pairings, and Lior – 96 mixed vs. 414 homogeneous pairings. Further analysis was required in order to ascertain what, if any, relation obtains between the two variables of prepositional and inflectional opacity. All utterances that contained a verb in a preposition-requiring context (total 1,768) were then examined to compare the proportion of transparent as against opaque prepositions that co-occurred with transparent versus opaque verb forms. Figure 3 presents these proportions for the three children.

Figure 2: Distributions of mixed versus homogeneous pairings during Period II, by child.

Figure 3: Proportions of transparent and opaque verb forms in co-occurrence with transparent versus opaque prepositional marking, during Period II, by child.

Figure 3 presents a similar picture for the three children, such that the proportion of transparent prepositions in co-occurrence with transparent verbs is much higher than in co-occurrence with opaque verbs: 89 % for Shachar; 82 % for Rotem; and 91 % for Lior. A chi-squared test reveals a significant effect for transparency of prepositional marking for all three children (for Shachar: $\chi^2(1, N=596)=84.185$, $p < 0.0001$; for Rotem: $\chi^2(1, N=562)=44.204$, $p < 0.0001$; and for Lior: $\chi^2(1, N=510)=50.79$, $p < 0.0001$), revealing a consistent pattern, with transparent prepositions significantly more likely to be used together with transparent rather than with opaque verb forms, while opaque prepositions occur with both types of verbs in more equal proportions. From the opaque verb perspective, the chances of an opaque verb occurring with an opaque preposition are proportionally higher than occurring with a transparent preposition. Naturally, from the transparent verb perspective, the chances of a transparent verb occurring with a transparent preposition are proportionally higher than occurring with an opaque preposition. These trends suggest that the distribution of transparency and opacity in prepositions, as well as verbs, during Period II is not entirely random. These distributional trends for transparency and opacity in use of verbs (analysis A) and of prepositions (analysis B) are discussed below as reflecting between-domain interfaces in the acquisition of early Hebrew clause structure.

4 Discussion

A key goal of the study was to provide evidence for linguistic interfaces in early language development. To this end, our analysis concerned partial markings of linguistic distinctions in a transitional period of acquisition, on the assumption that subsequently, once the grammatical systems stabilize, relevant inter-dependencies might be obscured. Specifically, the study aimed to resolve the acquisitional puzzle that emerged from examination of a particular transitional period in early Hebrew grammar, one in which marking of verbs by inflections and of objects or adverbs by prepositions appeared to be randomly distributed between transparency and opacity.

This transitional phase was identified by applying the productivity criterion and the principle of structural opacity delineated above (Section 2.3) to children's verb usage, defining two developmental periods: Period I – from the beginning of verb production up to productive application of inflections, and Period II – from productive inflection up to the disappearance of inflectional opacity. As predicted (Hypothesis 1) Period I was characterized by pervasive

opacity in both verb inflection and prepositional marking (Tables 6 and 8). Period II exhibited a “mixed” pattern in the two domains, so that opaque and transparent usages of verbs and prepositions occurred concurrently (Tables 7 and 9, and Examples 2 and 3). Two additional analyses were applied to children’s verb output during this period: One examined isolated as against elaborated verb-containing utterances, and the other focused on verb + object/adverb pairs in preposition-requiring contexts.

These two analyses that applied to co-occurring domains within the boundaries of a single child-utterance met the three requirements stipulated in the definition of interfaces presented in the Introduction: by designating an *area of recurrent contact* – here, verb-containing simple clauses – so making it possible to document the *concurrent effect* on each of the systems examined, in order to provide evidence for “communication” between the domains in question. The analyses applied here revealed two statistically significant trends as applying to the children’s simple-clause structure in Period II: opaque verbs are more likely to occur in elaborated syntactic environments; and transparent prepositions are more likely to occur with transparent verb forms. These trends indicate that the distribution of transparency and opacity in verbs and in prepositions during the transitional Period II are not entirely random, while further pointing to the existence of between-domain interfaces in early child language. The first interrelation, between inflectional opacity and predicate elaboration (Analysis A), underlines the role of opacity in breaking into new grammatical domains, and as such has implications for language development in general. Recall that initially, in Period I, opaque verb forms (the morphologically motivated “bare stems” discussed in Section 3.1) occur in isolation (Table 8), whereas in Period II, these same forms favor syntactically elaborated environments (Figure 1). This change in use of opaque verb forms is taken to represent progressive levels of generalization from one developmental period to the next, in the following sense: At first, the ambiguity of these non-affixed opaque verb-forms provides children with an initial means of breaking into the production of verbs; once they acquire productive knowledge of inflection, in Period II, they can be credited with a *higher level of generalization* across the grammatical class of verbs. Thus, these same inflectionally non-specified opaque verbs appear to change their role as a means of breaking into verb production to serving as syntactically neutral elements for breaking into early clause structure. Inflectional opacity thus turns out to be *functionally vague* both in terms of the paradigmatic form of verbs and in relation to clause-based syntagmatic combinations.

These findings provide unexpected evidence for the well-documented claim for form/function relations in development of different types of linguistic knowledge (Berman 2009; Slobin 1973, 2001). The fact that opaque verb forms occur

relatively more in elaborated predications than their transparent counterparts suggests that, syntactically, opaque verbs serve to mediate Subject-NonSubject relations. As long as they fail to specify Subject-Verb Agreement by inflection, children are free to associate verbs more flexibly with other, non-Subject clause constituents. In other words, in the transitional stage of optionality in marking of grammatical relations, inflectionally opaque verb forms constitute a useful means of “gluing” together clausal constituents: they are less restricted in terms of agreement and tense marking, and hence allow for more flexibility in constructing simple clauses. And further, although opaque verb forms retain their uniquely neutral surface form across Period I and II, once productive morphology emerges, their *developmental function* changes, as noted, from helping children to break into verb production to promoting clause-level combinations.

This *trade-off* that emerges between predicate elaboration and word-level non-specification of verb inflections (confirming prediction 2a) suggests that consolidation of grammatical knowledge is not merely a matter of a linear progression from simpler to more complex constructions. Rather, the development of linguistic constructions appears to operate on several levels concurrently, so that “higher” levels of linguistic structure (here, Verb + Objects/Adverbs) may be deployed before “lower” levels (Verb Inflections) are fully specified. Given the compositional nature of language in general, it could well be that non-specification (opacity) of smaller units like verbs in fact paves the way for combinations of larger units like elaborated clauses, so facilitating their early acquisition. Importantly, these directions of explanation rely on interaction between different levels of grammar in development (here, between clause-structure syntax and word-internal morphology).

The second correlation between transparency/opacity of verbs and prepositions (Analysis B) suggests that transparent marking in one domain *promotes* transparent marking in the other. This implies that the two ostensibly distinct clause-internal domains do not develop in isolation, but communicate, and may actually facilitate each other’s development. This convergence is not *a priori* obvious since a converse pattern might have been assumed in terms of cognitive load (Prediction 2b): In situations where one domain is marked explicitly (say, by use of transparent prepositions), children might be expected to attend less to the other (in this case, by leaving verbs unmarked inflectionally). The lack of opaque verb + transparent preposition pairings revealed by Analysis B suggests that, in contrast to what was hypothesized, there is in fact no “trade-off” between verb inflection and prepositional marking. On the contrary, transparent prepositions were found to be significantly more likely to appear with transparent inflections (Figure 3). This convergence may be explained in terms of verb-constituent relations, so that structural specificity in one area of intra-clausal

relation marking contributes to the clarity in the grammatical function, and hence the grammatical marking of the other clausal constituents within the boundaries of a given utterance. In Hebrew, when verb inflectional agreement is transparently marked, the grammatically specified Subjectness of one constituent stabilizes the syntactic function of other constituents, too, as reflected in transparency of prepositional marking of Non-Subject constituents. In terms of directionality, while these across-the-board convergences do not entail a clear unidirectional cause-effect relationship between the two systems of signaling clause-internal relations, the nature of the verb as the pivotal core around which other clausal elements revolve suggests that transparent marking of Subject-Verb relations will facilitate overt marking of other clause constituents rather than the other way around.

To sum up, the apparent effect observed by Analyses A and B – whether mutual or unidirectional – of opacity/transparency in one domain on realization of elements in other domains is taken here as indicative of linguistic interfaces. That is, if manifestation of one domain depends on information conveyed by another, then such dependences by themselves provide evidence for transmission of information between the two domains, and hence for the existence of an interface. The results of Analysis A suggest that in construction of elaborated predicates attention is paid not only to predicate-internal verb-object/adverb relations, but also to more “external” features such as subject-verb agreement or tense. Children who already show productive command of tense and agreement in Period II appear to reduce the level of inflectional specificity when producing elaborated predicates, perhaps in order to ensure the verb form can be accommodated to more syntactic environments. As for Analysis B, it shows, as noted, that structural specificity (transparency) in one domain is, to some extent, dependent on the level of specificity in another. Taken together, these observations suggest that once children start producing inflections productively and combine clausal constituents, they compute each clause as a whole, where the manifestation of each element may be affected by the features encoded by the other members of the clause. If this is indeed the case, it depicts the acquisition of early clause structure as driven by linguistic interfaces.

5 Conclusion

The convergences revealed by this study between verb inflection and predicate elaboration, on the one hand, and verb inflection and prepositional transparency, on the other, point to a communication between ostensibly distinct domains, ones that are typically treated separately in linguistic analysis and in

child language research. In fact, the interfacing between paradigmatic and syntagmatic abilities such as those analyzed here might well underlie acquisition of clause structure in general, since children need to compute several aspects of clause-internal relations *concurrently* every time they produce a clausal utterance. From this perspective, each fresh level of knowledge progresses from opaque combinations to transparent inter-dependent grammatical markings, so consolidating the interfaces between gradually more fully-fledged systems of the ambient language. The conclusion is that, throughout the process of acquisition, grammatical systems do not (and perhaps cannot) develop in isolation, but are crucially dependent on one another for consolidation across development. Further research is needed to demonstrate whether these, and possibly other interfaces are active in adult language processing as well.

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References

- Adam, Galit & Outi Bat-El. 2008. Morphological knowledge without morphological structure. In Sharon Armon-Lotem, Gabi Danon & Susan D. Rothstein (eds.), *Current Issues in generative Hebrew linguistics*, 197–222. Amsterdam & Philadelphia: John Benjamins.
- Allen, Shanley E. M. 2000. A discourse-pragmatic explanation for argument representation in child Inuktitut. *Linguistics* 38(3). 483–521.
- Ariel, Mira. 2008. *Pragmatics and grammar*. Cambridge: Cambridge University Press.
- Armon-Lotem, Sharon & Ruth A. Berman. 2003. The emergence of grammar: Early verbs and beyond. *Journal of Child Language* 30(4). 845–878.
- Bassano, Dominique. 2000. Early development of nouns and verbs in French: Exploring the interface between lexicon and grammar. *Journal of Child Language* 27(3). 521–559.
- Bat-El, Outi. 1994. Stem modification and cluster transfer in Modern Hebrew. *Natural Language and Linguistic Theory* 12. 571–593.
- Behrens, Heike. 2006. The input-output relationship in first language acquisition. *Language and Cognitive Processes* 21(1/2/3). 2–24.
- Berman, Ruth A. 1978. Early verbs: How and why a child uses her first words. *International Journal of Psycholinguistics* 5. 21–29.
- Berman, Ruth A. 1993. Developmental perspectives on transitivity: A confluence of cues. In Yonata Levy (ed.), *Other children, other languages: Issues in the theory of acquisition*, 189–241. Hillsdale, NJ: Lawrence Erlbaum.
- Berman, Ruth A. 2009. Beyond the sentence: Language development in narrative contexts. In Edith Bavin (ed.), *Handbook of child language*, 354–375. Cambridge: Cambridge University Press.

- Bloom, Lois. 1970. *Language development: Form and function in emerging grammars*. Cambridge, MA: The MIT Press.
- Bloom, Lois. 1991. *Language development from two to three*. New York: Cambridge University Press.
- Bowerman, Melissa. 1985. Beyond communicative adequacy: From piecemeal knowledge to an integrated system in the child's acquisition of language. In Keith E. Nelson (ed.), *Children's language*, 369–398. Hillsdale, NJ: Lawrence Erlbaum.
- Bowerman, Melissa. 1990. Mapping thematic roles onto syntactic functions: Are children helped by innate linking rules? *Linguistics* 28(6). 1253–1289.
- Brown, Penelope. 2008. Verb specificity and argument realization in Tzeltal child language. In Melissa Bowerman & Penelope Brown (eds.), *Crosslinguistic perspectives on argument structure: Implications for learnability*, 167–189. Mahwah, NJ: Lawrence Erlbaum.
- Brown, Roger. 1973. *A first language: The early stages*. Cambridge, MA: Harvard University Press.
- Bybee, Joan L. & Dan I. Slobin. 1982. Rules and schemas in the development and use of the English past tense. *Language* 58(2). 265–289.
- Chierchia, Gennaro. 2004. Scalar implicatures, polarity phenomena and the syntax/pragmatics interface. In Adriana Belletti (ed.), *Structures and beyond*, 39–103. New York: Oxford University Press.
- Chomsky, Noam. 2000. *New horizons in the study of language and mind*. Cambridge: Cambridge University Press.
- Demuth, Katherine, Meghan Patrolia, Jae Yung Song & Matthew Masapollo. 2012. The development of articles in children's early Spanish: Prosodic interactions between lexical and grammatical form. *First Language* 32(1/2). 17–37.
- Demuth, Katherine & Annie Tremblay. 2008. Prosodically-conditioned variability in children's production of French determiners. *Journal of Child Language* 35(1). 99–127.
- Diessel, Holger. 2004. *The acquisition of complex sentences*. Cambridge: Cambridge University Press.
- Dressler, Wolfgang U. & Annemarie Karpf. 1995. The theoretical relevance of pre- and proto-morphology in language acquisition. *Yearbook of Morphology*. 99–122.
- Dromi, Esther & Ruth A. Berman. 1982. A morphemic measure of early language development. *Journal of Child Language* 9(2). 403–424.
- Fox, Danny. 2000. *Economy and semantic interpretation* (Linguistic Inquiry Monographs 35). Cambridge, MA: MIT Press.
- Fox, Danny & Martin Hackl. 2006. The universal density of measurement. *Linguistics and Philosophy* 29. 537–586.
- Gathercole, Virginia C. Mueller, Eugenia Sebastián & Pilar Soto. 1999. The early acquisition of Spanish verbal morphology: Across-the-board or piecemeal knowledge?. *International Journal of Bilingualism* 3, 133–182.
- Gathercole, Virginia C. Mueller, Eugenia Sebastián & Pilar Soto. 2002. The emergence of linguistic person in Spanish-speaking children. *Language Learning*. 52(4). 679–722.
- Hadley, Pamela A. & Jannet K. Holt. 2006. Individual differences in the onset of tense marking: A growth curve analysis. *Journal of Speech, Language, and Hearing Research* 49(5). 984–1000.
- Heim, Irene. 1992. Presupposition projection and the semantics of attitude verbs, *Journal of Semantics* 9(2), 183–221.
- Hyams, Nina. 1986. *Language acquisition and the theory of parameters* (Studies in Theoretical Psycholinguistics). Dordrecht: D. Reidel.

- Ingram, David. 1989. *First language acquisition: Method, description, and explanation*. Cambridge: Cambridge University Press.
- Kilani-Schoch, Marianne & Wolfgang U. Dressler. (2000). Are fillers as precursors of morphemes relevant for morphological theory? A case story from the acquisition of French. In Wolfgang U. Dressler, Oskar E. Pfeiffer, Markus A. Pöchtrager & John R. Rennison (eds.), *Morphological analysis in comparison*, 89–112. Amsterdam & Philadelphia: John Benjamins.
- Kilani-Schoch, Marianne & Wolfgang U. Dressler. (2002). The emergence of inflectional paradigms in two French corpora: An illustration of general problems of pre- and protomorphology. In Maria D. Voeikova & Wolfgang U. Dressler (eds.), *Pre- and protomorphology: Early phases of morphological development in nouns and verbs*, 45–59. Munich, Germany: Lincom Europa.
- Lieven, Elena V. M. 2008. Learning the English auxiliary: A usage-based approach. In Heike Behrens (ed.), *Corpora in language acquisition research: Finding structure in data*, vol. 6 (Trends in language acquisition research [TILAR]), 60–98. Amsterdam & Philadelphia: John Benjamins.
- Lieven, Elena V. M., Heike Behrens, Jennifer Speares & Michael Tomasello. 2003. Early syntactic creativity: A usage-based approach. *Journal of Child Language* 30(2). 333–370.
- Lustigman, Lyle. 2012. Non-finiteness in early Hebrew verbs. *Brill's Annual of Afroasiatic Languages and Linguistics (BAALL)* 4. 213–231.
- Lustigman, Lyle. 2013. Developing structural specification: Productivity in early Hebrew verb usage. *First Language* 33(1). 47–67.
- Lustigman, Lyle. in press. From opacity to transparency: Transitional categories in early Hebrew grammar. In Ruth A. Berman (ed.), *Acquisition and development of Hebrew: From infancy to adolescence* (Trends in Language Acquisition Research [TILAR]). Amsterdam & Philadelphia: John Benjamins.
- MacWhinney, Brian. 1975. Rules, rote, and analogy in morphological formation by Hungarian Children. *Journal of Child Language* 2(1). 65–77.
- MacWhinney, Brian. 2005. *The CHILDES project: Tools for analyzing talk*, vol. 1: *The format and programs*, 3rd edn. Mahwah, NJ: Lawrence Erlbaum.
- Magri, Giorgio. 2009. A theory of individual-level predicates based on blind mandatory scalar implicatures. *Natural Language Semantics* 17(3). 245–297.
- Marchman, Virginia A. & Elizabeth Bates. 1994. Continuity in lexical and morphological development: A test of the critical mass hypothesis. *Journal of Child Language* 21(2). 339–366.
- Maslen, Robert J., Ana L. Theakston, Elena V. M. Lieven & Michael Tomasello. 2004. A dense corpus study of past tense and plural overregularization in English. *Journal of Speech, Language and Hearing Research* 47(6). 1319–1333.
- McCarthy, John & Alan Prince. 1990. Foot and word in prosodic morphology: The Arabic broken plural. *Natural Language and Linguistic Theory* 8. 209–282.
- McCarthy, John & Alan Prince. 1995. Faithfulness and identity in prosodic morphology. In René Kager, Harry van der Hulst & Wim Zonneveld (eds.), *The prosody morphology interface*, 218–309. Cambridge: Cambridge University Press.
- Peters, Ann M. & Lise Menn. 1993. False starts and filler-syllables: Ways to learn grammatical morphemes. *Language* 69(4). 742–777.
- Pizzuto, Elena & Maria Cristina Caselli. 1994. The acquisition of Italian verb morphology in a cross-linguistic perspective. In Yonata Levy (ed.), *Other children, other languages: Issues in the theory of language acquisition*, 137–187. Hillsdale, NJ: Lawrence Erlbaum.

- Prieto, Pilar, Ana Estrella, Jill Thorson & Maria del Mar Vanrell. 2012. Is prosodic development correlated with grammatical development? Evidence from emerging intonation in Catalan and Spanish. *Journal of Child Language* 39(2). 221–257.
- Reinhart, Tanya. 2006. *Interface strategies: Optimal and costly computation* (Linguistic Inquiry Monographs). Cambridge, MA: MIT Press.
- Reinhart, Tanya & Tal Siloni. 2005. The lexicon-syntax parameter: Reflexivization and other arity operations. *Linguistic Inquiry* 36(3). 389–436.
- Richards, Brian J. 1990. *Language development and individual differences: A study of auxiliary verb learning*. Cambridge: Cambridge University Press.
- Rispoli, Matthew, Pamela A. Hadley & Janet K. Holt. 2009. The growth of tense productivity. *Journal of Speech, Language, and Hearing Research* 52(4). 930–944.
- Rispoli, Matthew, Pamela A. Hadley & Jannet K. Holt. 2012. Sequence and system in the acquisition of tense and agreement. *Journal of Speech, Language, and Hearing Research* 55(4). 1007–1021.
- Rizzi, Luigi. 1993/1994. Some notes on linguistic theory and language development: The case of root infinitives. *Language Acquisition* 3. 371–393.
- Rowland, Caroline F., Sarah L. Fletcher, & Daniel Freudenthal. 2008. How big is big enough? Assessing the reliability of data from naturalistic samples. In Heike Behrens (ed.), *Corpora in language acquisition research: Finding structure in data: vol. 6* (Trends in Language Acquisition Research [TILAR]), 1–24. Amsterdam & Philadelphia: John Benjamins.
- Roy, Deb, Rupal Patel, Philip DeCamp, Rony Kubat, Michael Fleischman, Brandon Roy, Nikolaos Mavridis, Stephanie Tellex, Alexia Salata, Jethran Guinness, Michael Levit & Peter Gorniak. 2006. The Human Speechome Project. <http://www.media.mit.edu/cogmac/publications/cogsci06.pdf> (accessed 24 December 2015)
- Slobin, Dan I. 1973. Cognitive prerequisites for the development of grammar. In Charles A. Ferguson, & Dan I. Slobin (eds.), *Studies of child language development*, 240–249. New York: Holt, Rinehart, & Winston.
- Slobin, Dan I. 2001. Form function relations: How do children find out what they are? In Melissa Bowerman & Stephen C. Levinson (eds.), *Language acquisition and conceptual development*, 406–449. Cambridge: Cambridge University Press.
- Stoel-Gammon, Carol. 2011. Relationships between lexical and phonological development in young children. *Journal of Child Language* 38(1). 1–34.
- Thordardóttir, Elin. T., Susan Ellis Weismer & Julia Evans. 2002. Continuity in lexical and morphological development in Icelandic- and English-speaking 2-year-olds. *First Language* 22(1). 3–28.
- Tomasello, Michael & Daniel Stahl. 2004. Sampling children's spontaneous speech: How much is enough? *Journal of Child Language* 31(1). 101–121
- Veneziano, Edy & Hermine Sinclair. 2000. The changing status of 'filler syllables' on the way to grammatical morphemes. *Journal of Child Language* 27(3). 461–500.
- Vihman, Marilyn M., Marlys A. Macken, Ruth Miller, Hazel Simmons & Jim Miller. 1985. From babbling to speech: A re-assessment of the continuity issue. *Language* 61(2). 397–445.
- Vihman, Marilyn M. & Maigi Vija. 2006. The acquisition of verbal inflection in Estonian. In Natalia Gagarina & Insa Gültzow (eds.), *The acquisition of verbs and their grammar: The effect of particular languages*, 269–295. Dordrecht: Springer.
- Wexler, Kenneth. 1993. Optional Infinitives, head movement and the economy of derivations in child grammar. In David Lightfoot & Norbert Hornstein (eds.), *Verb movement*, 305–382. Cambridge: Cambridge University Press.
- Wittek, Angelika & Michael Tomasello. 2005. German-speaking children's productivity with syntactic constructions and case morphology: Local cues help locally. *First Language*. 25(1). 103–125.