The Acquisition of Inflectional Morphology

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Introduction

The acquisition of inflectional morphology has been a central topic in language acquisition research since the seminal works of Berko (1958), Cazden (1968) and Brown (1973) on the acquisition of English. Although morphology encompasses inflection, derivation and composition, most research on the acquisition of morphology has targeted inflectional morphology (but see Berko 1958). The reasons for this focus on inflectional morphology are manifold. For one, the languages of the world differ considerably with respect to the distinctions marked by inflectional affixes and the typological types of inflectional systems they employ, ranging from agglutinative inflectional systems to fusional and polysynthetic systems. This typological variance has ignited an interest in cross-language investigations. The last 30 years have seen a growing body of research targeting the acquisition of inflectional morphology in languages all over the world (cf. Slobin 1985a, Bittner, Dressler & Kilani-Schoch 2003a, Stephany & Voeĭkova 2009 for volumes covering the acquisition of verbal and nominal inflection across languages) – a research that has informed us on the importance of language-specific influences on the acquisition of inflectional morphology.

Another reason accounting for the preponderance of research on inflection is that inflectional morphology is situated at the interface of morphology, syntax and phonology. While inflection creates grammatical word forms and thus is part of morphology, the grammatical information added typically exerts effects on other constituents in a construction and hence is effective in syntax. Also, the choice between different inflectional allomorphs might be phonologically determined, and the word form resulting from an inflectional operation is subject to the phonological component which ensures that the word form adheres to the phonological constraints operative in a given language. Due to this location at the interface of different grammatical modules, the acquisition of inflectional morphology has been investigated from a variety of linguistic viewpoints targeting diverse aspects such as the

interdependency between the acquisition of inflectional morphemes and the acquisition of syllable structure and prosodic constituents, the emergence of functional categories and projections, or the development of inflectional paradigms.

Moreover, since the mid 80s the acquisition of inflectional morphology has been at the heart of the debate between two different approaches to human cognition: the symbolic and the anti-symbolic approach to mental computations (cf. Rumelhart & McClelland 1986, Pinker 1999, Marcus 2001, Ambridge & Lieven 2011, Penke 2012). According to the symbolic view of cognitive processing, inflected word forms are structurally composed out of component morphemes by application of a mental operation that combines morphemes displaying the right abstract features such as [+V] or [+PAST]. Hence, an English past-tense form such as *inflected* is composed by an operation combining the verb stem *inflect*$_{[V]}$ with a past-tense marker *-ed*$_{[PAST]}$. Antisymbolic approaches assume instead that inflected forms are structurally non-compositional and are learned and stored as whole-word forms in an associative memory network. The debate which ignited on the acquisition of the English past tense has since then quickly spread out to different languages and inflectional systems, fuelled by the attempts to provide evidence for or against the symbolic view.

The diversity of languages and inflectional systems covered in acquisition research and the wealth of literature that has been compiled in the field over the last 50 years precludes any in-depth overview on the acquisition of the various inflectional systems employed in the different languages studied so far (cf. Clark 1998 for overview). I will, rather, try to single out some major developmental steps in the acquisition of inflectional morphology in children, focussing on those aspects that seem to be relevant across languages and inflectional systems.

The beginning - unanalysed chunks

Utterances containing first inflected word forms appear from early on in language acquisition. In languages where uninflected stems cannot surface as possible words, inflected forms are already uttered in the one-word stage which usually starts around the first birthday (e.g.

MacWhinney 1976 on Hungarian, Toivainen 1980 on Finnish, Pizzuto & Caselli 1994 on Italian). In languages where this is not the case, first inflected word forms will, at the latest, appear in the two-word stage (usually around the 2nd birthday) when children produce first word combinations. Strikingly, these first inflected word forms are often correct with respect to the target language. Consider an utterance such as *kugel geht nich* 'ball works not' uttered by the German-speaking child Simone at the age of 1;10 (1year;10months). The verb stem *geh-* 'go, work' is inflected with the 3rd person singular marker *–t*, thus displaying agreement between the subject *kugel* 'ball' and the verb. Such examples have led to discussions on the issue whether they constitute evidence for an astoundingly early acquisition of inflection or whether they are unanalysed formulaic utterances that only mimic knowledge of inflectional processes and systems – a discussion that has, for instance, been vital for the controversy between Full-Competence (e.g. Poeppel & Wexler 1993) and Structure-Building approaches (e.g. Clahsen, Eisenbeiss & Penke 1996) in research on syntax acquisition. According to Full-Competence approaches, such utterances could be seen as evidence that from early on children have the functional category INFL/AGR at their disposal which controls the agreement between subject and verb. According to the latter view, such utterances might simply constitute formulaic expressions that the child has learned and stored as unanalyzed chunks and uses to express a fixed concept or situation (e.g. 'object X is not functioning as intended'), but they do not necessarily constitute evidence that inflectional affixes or systems and hence syntactic projections such as INFL/AGR have been acquired.

Not every appearance of an inflected form in a child's utterance provides evidence that the produced form constitutes an inflected form for the grammatical system operative in the child at this stage of development. Rather, it is generally assumed that first inflected forms are stored as unanalyzed chunks in the mental lexicon (Cazden 1968, MacWhinney 1976), resembling lexical entries for simple words. Thus, an utterance such as *kugel geht nich* might be composed out of a lexical entry '*geht nich*' that exhibits no further internal segmentation into verb stem, inflectional affix and negation and a lexical entry '*kugel'*. Evidence for this assumption would come from the observation that a chunk such as *geht nich* is repeated in

invariant form by the child in combination with other nouns (e.g. *Auto geht nich* 'car works not'). Also, chunks display formal integrity in that no verbal material can be placed inside the chunk. Thus, for instance, an adverbial such as *heute* 'today' cannot be placed inside the chunk between inflected verb and negation as in the target language (e.g. *kugel geht heute nich*), but would have to be placed outside the chunk (e.g. *kugel geht nich heute*). Finally, errors which result from use of the unanalyzed chunk in contexts which require a different inflected word form than the one used in the chunk (e.g. **autos*$_{[Pl]}$ *geht nich* '*cars works not') indicate that the inflected form used has not yet been analyzed by the child. While these criteria can be utilised to identify whether an inflected form used by a child at a specific stage of development constitutes an unanalyzed chunk or is already segmented into its constituent parts, such analyses require a large database of utterances from this child.

Segmentation of inflectional markers

How does the child proceed in discovering that some of her/his stored lexical entries are morphological complex and can be segmented into constituent morphemes?

A lexical entry constitutes an arbitrary association between a phonological representation that is connected to the articulatory/auditory system and a meaning representation related to conceptual knowledge systems. This association between a specific string of speech sounds and a specific meaning has to be established during language acquisition, probably by the simultaneous activation of conceptual and acoustic/articulatory representations. Between lexical entries, associative connections are established to entries that display an overlap in form (phonological) or meaning representations. Evidence for this comes from speech errors where a target word is replaced by a word with a similar phonological form or semantic meaning (Levelt 1989). By establishing these connections, similarities and differences between form and meaning representations become visible that might be employed to start morphological analysis. Consider the following rough sketch of how such a development might proceed (cf. Bybee 1988, 1995): The comparison of features which remain invariable between lexical entries sharing a high degree of overlap with respect to their phonological

and semantic representations allows for identifying lexical stems and roots (cf. fig.1a). The observation that in languages where bare stems are not licit, children will occasionally produce such bare stems is suggestive for a segmentation into root/stem and rest-of-word (cf. Batman-Ratyosyan & Stromswold 2001 for such evidence on Turkish). The discovery that and how changes of phonological form correlate to changes of meaning (i.e. the principle of contrast, Clark 1987) enables the child to detect inflected variants of a lexical root. Some inflected variants of different lexical roots display similarities in phonological form (e.g. the verb forms in fig.1b all end in the string [st]) and are hence connected. The identification of these invariant word parts helps to isolate those segments of the inflected word forms that express grammatical information and makes transparent how specific changes in form are related to changes in grammatical content and function. Distributional information such as the co-occurrence of inflected verb forms with a specific subject pronoun (e.g. the 2nd person singular pronoun *du* 'you' in fig.1c) serves to identify the grammatical features encoded by a specific inflected word form (e.g. *–st* is an exponent of 2nd person singular). Experimental research has provided evidence that children are able to employ such distributional co-occurrence relationships and, by the age of 18 month, prefer a legitimate string of auxiliary and progressive verb form (e.g. *the car is running*) to an illegitimate string including a modal and a progressive verb form (e.g. *the car can running*) (Santelmann & Jusczyk 1998, cf. also Nazzi et al. 2011). The process of comparison by which invariant and variable parts of word forms are identified and the exploration of distributional information that serves to highlight how changes in phonological form are correlated to changes in meaning or function constitute central processes in the acquisition of inflectional morphology.

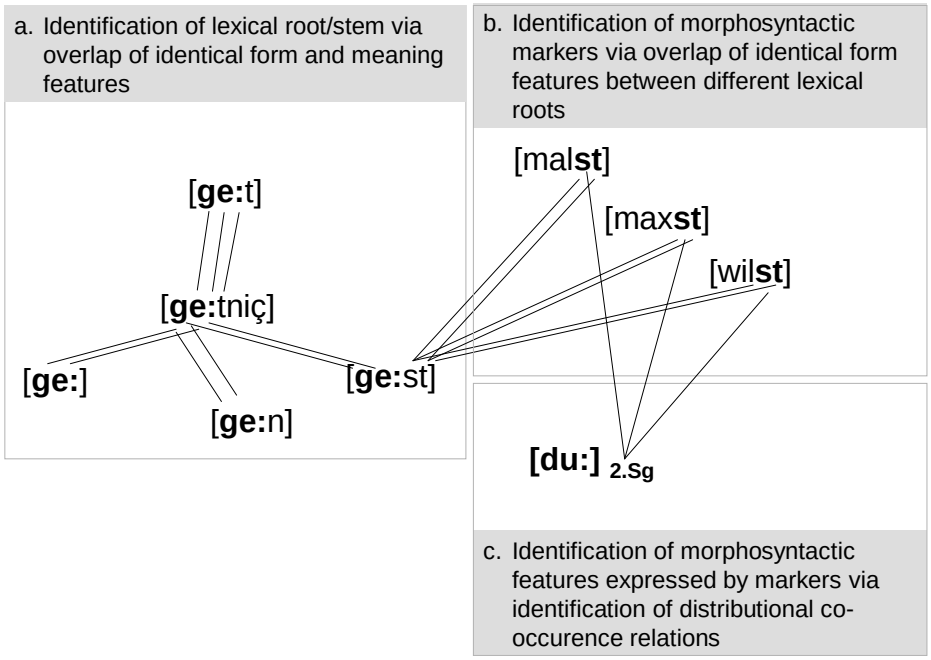

Fig.1: Sketch of processes in early segmentation. Lines indicate connections between identical phonological elements.

Factors that influence when segmentation is to start:

The available evidence suggests that morphological analysis starts only after the child has reached the two-word stage (MacWhinney 1976, Pizzuto & Caselli 1994, Bittner, Dressler & Kilani-Schoch 2003b). A number of factors are assumed to influence when children succeed in segmenting inflected forms (Peters & Menn 1993, Dressler 2010 for overview). Inflectional markers that appear frequently and with a number of different stems in the input are acquired before markers that appear only infrequently. Bybee (1995) has suggested that the *type frequency* of an inflectional marker, i.e. the number of stems an inflectional marker applies to, is a decisive factor in acquisition, with higher type frequency furthering the identification of invariable form features associated with an inflectional marker (cf. fig.1b). A critical mass of different stems might be necessary for segmentation to start (Plunkett and Marchman 1993). What constitutes this critical mass is, however, not easily specified and is likely to display variation between different subjects and inflectional systems (cf. Bittner, Dressler & Kilani-Schoch 2003b). Based on a connectionist network simulation Plunkett & Marchman (1993)

suggested that the transition from rote learning to system building for English past-tense formation starts when a minimum of 50 verbs have been acquired. In contrast, diary data on the acquisition of the very similar system of German past-participle formation reveals that the German child Eva first overapplied the regular participle marker to an irregular verb after she had used only 12 regular and 14 irregular participle types at age 1;7.14.

Besides type frequency, *token frequency* is another factor that influences the acquisition of inflectional markers (Bybee 1995). Inflected words that appear frequently in the input of children are among the first forms to be produced by the children themselves and are likely to be the first forms where form contrasts are identified (e.g. Gagarina & Voeikova 2009). Besides the token frequency of a specific inflected form, the token frequency of an inflectional marker, i.e. the number of times an inflectional affix occurs in the child's input, is also of relevance (e.g. Perroni Simoes & Stoel-Gammon 1979, Dabrowska & Szczerbinski 2006). By way of example consider the 2nd person markings in German verbal inflection. 2nd person is marked in the singular and the plural, albeit by different fusional markers conflating person and number information (e.g. *du*$_{[2Sg]}$ *geh<u>st</u>*$_{[2SG]}$ – *ihr*$_{[2PL]}$ *geh<u>t</u>*$_{[2PL]}$ 'you$_{[2SG/PL]}$ are walking'). Forms inflected with the 2nd person singular marker *–st* are very frequent in the child's input and *–st* is typically the first suffix whose morphosyntactic content is identified by German children, usually between two and three years (Clahsen & Penke 1992, Penke 2006). In contrast, the 2nd person plural marker is rare in the input and German children typically go through a longer stage where they apply the 1st/3rd person plural marker *–n* in 2nd person plural contexts (e.g. **ihr geh<u>n</u>* instead of *ihr geh<u>t</u>* 'you are going') (Penke 2006).

The *phonological salience* of an inflectional marker, i.e. its perceivability in the input signal, is another factor likely to affect segmentation. Thus, inflectional markers that are syllabic or multisyllabic are easier to detect than inflectional markers that consist of single obstruents (Brown 1973, Peters & Menn 1993).

The segmentation of inflectional markers that are *morphological transparent*, i.e. are affixed to a stem without altering its phonological form, is less demanding compared to inflections that lead to a change of the lexical root (Dressler 2010, Peters & Menn 1993).

Thus, whereas an English past-tense form such as *inflected* can be transparently segmented into stem *inflect* and past-tense morpheme *–ed*, past-tense forms such as *went* make it difficult to identify their lexical base and cannot be segmented into stem and inflectional affix.

Inflectional affixes that exhibit a one-to-one correspondence between meaning and form (*(bi)uniqueness* or *semantic complexity*) are likely to be acquired earlier than inflectional morphemes that express different grammatical features (Brown 1973, Slobin 1985b). A point in case is the English suffix *–s* which serves as 3rd person singular marker on verbs and as plural and possessive marker on nouns. The ambiguity between form and meaning expressed by the suffix might account for the observation that English-speaking children take an astoundingly long time to acquire this marker given that the inflectional morphology of English is so sparse (Brown 1973, Beyer & Hudson Kam 2009). Another example is the acquisition of German verbal agreement inflection. Four overt affixes (*-e*, *-st*, *-t*, *-n*) express the grammatical dimensions PERSON and NUMBER. Only the ending *-st*, however, displays a unique relationship between meaning and form: if the subject is the 2nd person singular pronoun *du* 'you', the verb is inflected with *–st*. The other markers express more than one PERSON/NUMBER feature combination and thus occur with variable subjects and/or they also realize different grammatical features. Due to its clear correlation between form and meaning *-st* is typically the first suffix whose morphosyntactic content is identified by German children, although unmarked as well as *-t-* and *–n*-inflected verb forms are earlier to appear in German child language (Clahsen & Penke 1992, Penke 2006).

Another relevant factor could be termed *semantic/conceptual transparency*. Thus it has been shown that inflectional morphemes that encode semantically/conceptually more basic or transparent notions such as NUMBER, TENSE, ASPECT or PERSON are acquired earlier than markers that are exponents of formal features (i.e. declensional or conjugational class features or grammatical gender) that lack a semantic/conceptual foundation (e.g. Eisenbeiss 2003, Bittner 2006).

Typological differences between inflectional systems (e.g. fusional vs. agglutinative systems; prefixing, suffixing or infixing systems; number of distinctions drawn) are also

relevant in determining the success of early segmentation. *Morphological richness*, i.e. the number of grammatical dimensions marked and distinctions drawn within a dimension, might tune the child to morphology with the effect that inflectional morphology is acquired earlier in comparison to languages with sparse inflectional morphology (Bates & MacWhinney 1987, Slobin 1985b, Dressler 2010, Xanthos et al. 2011). This proposal has been claimed to account for the fact that the sparse verbal-agreement morphology of English is only acquired relatively late compared to the acquisition of richer inflectional systems (e.g. Hyams 1986/2008). Also, the lesser semantic complexity of inflectional markers in agglutinating systems where an affix expresses only one grammatical dimension compared to fusional systems where affixes express a combination of feature specifications has been claimed to lead to earlier acquisition of agglutinating systems (Aksu-Koc & Slobin 1985, Argus 2009, Dressler 2010). Moreover, agglutinative systems generally display a greater morphological transparency compared to inflectional systems where inflection is associated with changes to the stem. Most revealing with respect to the influence of typological differences are studies on bilingual children acquiring typologically different inflectional systems. These studies have provided evidence for a lead-lag pattern in acquisition, with acquisition in the language with the morphologically richer inflectional system preceding acquisition in the language where the corresponding inflectional system is less elaborate (cf. Austin 2010).

The discussed factors interact, sometimes adding up to further early acquisition, sometimes negating each other. To establish the exact effect a specific factor might have requires a scale to determine how efficient or important this factor is vis-à-vis the other ones. Such a scale has, however, not been established and it is unlikely that this goal will be achieved as the effects of the relevant factors differ between languages and inflectional systems in dependency of the particularities of the inflectional system under acquisition. In addition to timing differences related to the acquisition of different inflectional systems in different languages, huge differences have also been reported within children acquiring the same inflectional affix or system. In his longitudinal study of three English-speaking children Brown (1973) found that the acquisition of the 3rd person singular marker *–s* varied between

the ages of 2;3 for Eve and 3;6 for Adam. Individual differences, sometimes spanning more than a year, have also been reported for the acquisition of Italian verbal inflection (Pizzuto & Caselli 1994). Although the age when an inflectional marker is first applied as well as the age when it is acquired may differ largely between individual children acquiring the same language, the influence of the discussed factors nevertheless determines similarities in the order with which inflectional morphemes appear across individual children acquiring the same language (cf. Brown 1973, Pizzuto & Caselli 1994).

Predispositions that might help in achieving segmentation:

Cognitive predispositions that might be restricted to the computation of language (domain-specific) or that might be relevant across cognitive domains (domain-general) are likely to help the child in achieving the segmentation task. Thus, there might be a predisposition to expect morphosyntactic information to be expressed at the end of a word instead of at its beginning (Clark 1998). Typologically, more languages employ suffixation than prefixation. Out of 772 languages investigated by Dryer (2005), 69% prefer suffixation over prefixation, whereas the reverse only holds for 19% of the languages investigated. This typological preference for suffixation might be related to preferences in language processing and acquisition mechanisms. Slobin (1973), for instance, suggested that the child is equipped with a number of universal Operating Principles (OP) which help her/him in tackling the task of language acquisition, among these the OP: “Pay attention to the ends of words” (Slobin 1973:191). Given the preponderance of suffixing languages, such a predisposition would certainly come helpful in identifying inflectional markers and in segmenting root/stem and affix morphemes in such languages. Studies have indeed confirmed a suffixation preference in English-speaking children who prefer to provide nonsense suffixes over nonsense prefixes (e.g. Kuczaj 1979, MacWhinney 1983). Also, studies on the acquisition of languages which employ both prefixes and suffixes have found that suffixes are produced earlier than prefixes (Mithun 1989, Kunene 1979). The issue, however, is whether such a preference guides the acquisition of inflectional morphology or whether it develops while the child encounters more

and more inflectional systems in her/his language that employ suffixes, thereby implementing processing mechanisms that are shaped to optimally deal with the primary language data s/he receives.

A second issue relates to the question whether predispositions such as the suffixation preference are specific to language or derive from domain-general cognitive principles not restricted to language. Spoken language is transmitted serially over time. Information that is transmitted at the beginning of a temporal sequence might be of particular relevance in parsing since it provides a key to identification (Hupp, Sloutsky & Culicover 2009). Word recognition starts as soon as the first phonological segments are available and potential word candidates are eliminated as more and more segments of the word become available. Segments that only modulate a word's function or meaning, such as inflectional affixes, are thus better placed at the end of a word instead of at its beginning, so as to not affect this lexical-identification process. In a recent article Hupp, Sloutsky & Culicover (2009) provide experimental evidence for the assumption that the suffixation preference in language constitutes a case of a domain-general principle affecting processing of sequential information in general. They suggest that a preference to focus at information at the beginning of a temporal sequence is wired into any mechanism that processes temporal information as such information is essential for early discrimination and identification. Putting to use such a domain-unspecific principle in language processing might result in the typological suffixation preference observed across languages.

Predispositions might also guide the child in finding out which grammatical information is expressed by inflectional morphemes (Slobin 1985b, 1997, Eisenbeiss 2003, Bowerman & Levinson 2001). Such predispositions might come in the form of a set of universal functional categories such as INFL, C or D that help to determine whether and how the target language overtly realizes these categories by free or bound functional morphemes such as tense and agreement affixes, complementizers or articles (Chomsky 1993, Ouhalla 1993); or they might take the form of general cognitive or semantic prerequisites that pace and determine language acquisition (Slobin 1997, Bowerman & Levinson 2001). It has been suggested, for

example, that a mastery of the concept of time is a necessary prerequisite for the acquisition of tense marking (Weist 1986, see Behrens 2001 for discussion). These suggestions are grounded in the observation that despite the variation that can be observed across languages, many possible notions are never expressed by inflectional morphemes (e.g. inflections marking whether it was rainy or not during the time an event took place), whereas grammatical dimensions such as PERSON, NUMBER, TENSE, ASPECT and MOOD are expressed by inflectional affixes in many languages (e.g. Wunderlich 2007). These dimensions are central for the conceptual representation of events or entities as they involve the number of participants, the function of these participants in the context of the utterance (e.g. speaker or addressee) and the anchoring of the event with respect to a specific time and world (e.g. actual, non-actual, desired) (cf. Wunderlich 1993, 2007, Eisenbeiss 2003). A predisposition to expect such markings in language would considerably help the child to figure out how minimal changes in the phonological form of words are related to changes in function/meaning and what a specific form contrast indicates since it constrains the space of possible hypotheses the child might entertain. Thus the child will not assume that a given contrast in phonological form relates to the weather outside, mummy's mood or whether it was spinach for lunch.

Whether there are universal conceptual categories that children expect to be expressed in language is a matter of debate. Clark & Nikitina (2009) give a number of examples which indicate that children try to express a conceptual/grammatical category before having acquired the conventional means used in the target language. For instance, English-speaking children will typically express plurality by a numeral and a bare noun stem (*two blanket*) before they have identified the noun plural marker *–s*. This suggests that some grammatical categories are conceptually salient and children will try to express them by scrutinizing the target language for means to express these categories, although the means children employ might differ from the conventional means of the target language. Another controversy concerns the issue whether such predispositions are specific to language or result from domain-general cognitive principles or operations that guide how humans

perceive and represent events and entities. And lastly, it is also conceivable that language-specific predispositions require a development in a different cognitive domain. For example, the marking of number is dependent on the capacity to distinguish and represent one from more-than-one entity (Clark & Nikitina 2009), and the marking of tense requires a memory of actions that happened in the past. At present, the evidence suggests a complex interaction between conceptual development and the acquisition of inflectional markers expressing grammatical dimensions. Whereas there seems to be a restricted set of conceptually salient categories guiding acquisition, the distributional patterns observable in the child's input play an important role in identifying which dimensions are actually realized and which specific distinctions are drawn in a given target language.

Productivity and acquisition of inflectional markers

As soon as form and function of an inflectional marker have been determined, it can and will be applied productively to produce other inflected forms than the ones stored by this time in the child's mental lexicon. The child is now able to contrast different inflected forms of a stem. Hence, the ability to use a specific inflectional marker with more than one root while at least for one of these roots another distinct inflected form can be produced is considered a basic criterion for determining productivity (Pizzuto & Caselli 1994). Productivity requires that the child draws a contrast between at least two differently inflected forms of a root and uses these forms consistently to express a grammatical difference between these inflected forms, i.e. s/he has established an association between formal and functional features. Consistency in use, thus, constitutes another criterion for productivity – although one that is in need of an operational definition.

Overgeneralisation errors:

The clearest evidence for productivity comes from inflectional errors which display an illicit combination of stem and affix (Cazden 1968). Two types of such errors can be distinguished: (i) overgeneralisation errors where an inflectional marker is applied to a root/stem of a

different inflectional class and (ii) substitution errors where an inflectional marker is applied in a grammatical context expressed by a different marker in the target language. An example illustrating error type (i) in English child language would be a past-tense form such as **singed* where the regular past-tense ending *–ed* is used with a verb that has an irregular past-tense form (i.e. *sang*). Such errors are also called overregularisation errors as a regular inflectional pattern is overextended to roots that have an idiosyncratic stored inflectional form which deviates from the regular pattern. Overgeneralisation errors, however, do not require a distinction between regular and irregular inflection. In a German utterance such as **der darft nich* 'he is not allowed to ....' the 3rd person singular marker *–t* is incorrectly applied to a modal verb, a verb class that does not take the *–t* ending of German main verbs to express 3rd person singular (e.g. correct *darf*). Here, both inflectional patterns are regular, although restricted to different classes of verbs. Note that in overgeneralisation errors the chosen inflectional pattern marks the intended grammatical information. Thus, the past-tense affix *–ed* in **singed* and the 3rd singular ending *–t* in **darft* convey the correct grammatical information but on roots that express this information by different means. In contrast, in substitution errors (type (ii)) the inflected form realizes grammatical information that is incorrect with respect to the context. As an example from German child language consider (1) where the 3rd person singular marker *–t* is produced with a 3rd person plural subject.

(1) a. *da alle$_{[3rd\ pl]}$ läft 'all are sleeping there' (Simone, 2;2)

Example (1) illustrates that the capacity to use an inflectional affix productively does not necessarily entail that the child has already determined the grammatical features expressed by the respective inflectional marker. Only if the child has achieved this task, has s/he acquired the inflectional ending. To determine this point in acquisition requires an operational definition. If the child has uncovered the grammatical features an inflectional ending marks, s/he will be able to use this marker correctly with respect to the target language. Correctness

of inflection, however, can be determined in two different ways that do not necessarily concur (cf. fig.2).

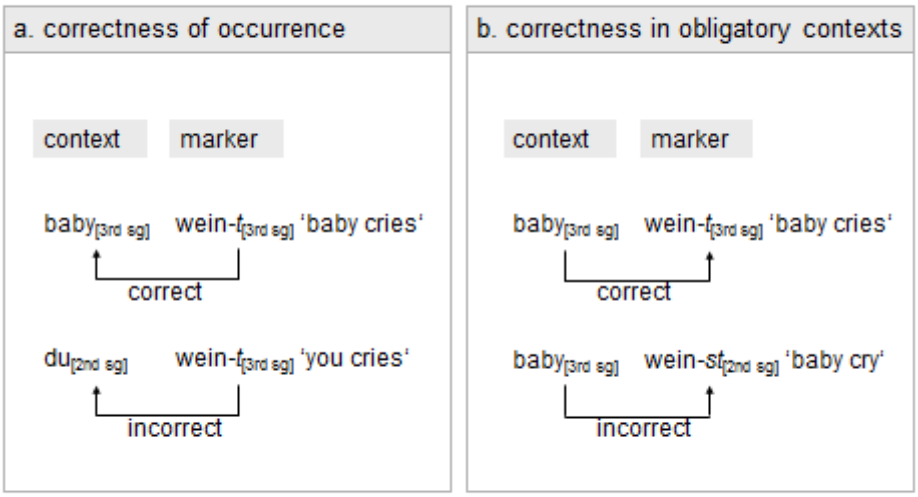

Fig.2: Two ways to determine the correctness of an inflectional marker

The first analysis proceeds from the inflectional marker produced by a child and tests whether the grammatical features expressed by this marker are correct with respect to the features required by the grammatical context (= *correct occurrence* of a marker, affix-based analysis). Consider as an example the German child utterances in (2). In (2a), the marker *–t* produced by the child does not agree with the 2nd person singular subject *du* 'you' yielding an incorrect utterance, whereas in (2b) it concurs with the 3rd person singular subject *der* 'he'.

(2) a. *du$_{[2nd\ sg]}$ darft nich 'you are not allowed to do it' (Mathias 3;0)

b. der$_{[3rd\ sg]}$ holt apfelsine 'he fetches (an) orange' (Mathias 3;0)

The second type of analysis takes the grammatical context as starting point and determines whether the inflected form produced is correct with respect to this context (= *correctness in obligatory contexts* for a marker, context-based analysis). Thus, the occurrences of the

marker *–t* in (3a,b) are correct since this marker agrees with the 3rd person singular subjects expressed in these utterances. In contrast, utterances (3c,d) provide a context for a *–t*-inflected verb, the subjects being 3rd person singular, but *-t* is not produced in these obligatory contexts for the marker *–t*.

(3)	a.	das$_{[3rd\ sg]}$ geht nich mehr	'that does not work any more'	(Mathias 3;0)
	b.	Julia$_{[3rd\ sg]}$ kricht keks	'J. gets a cookie'	(Mathias 3;2)
	c.	*beiss_ Julia$_{[3rd\ sg]}$ das kaputt	'J. bite it through'	(Mathias 3;1)
	d.	*das$_{[3rd\ sg]}$ komm_ nich in frage	'that is out of the question'	(Mathias 3;5)

Fig.3 illustrates that the two correctness measures lead to different data concerning the acquisition of inflectional markers. The figure gives the two correctness scores for the inflectional marker *–t* observed in longitudinal spontaneous-speech data from the German child Simone (Clahsen & Penke 1992). From its earliest occurrences on the marker *–t* is usually correct when it is produced. The scores for correctness of occurrence are over 90% throughout the developmental time-span illustrated in the figure. In contrast, correctness scores in obligatory contexts are considerably lower and only surpass 90% by age 2;4, indicating that the marker *–t* is often not applied where required by the grammatical context (cf. e.g. examples (3c,d)). Which measure is the more revealing with respect to the issue when the grammatical content of an inflectional marker has been acquired, is controversially discussed. Do we overestimate the child's knowledge by concentrating on correct occurrences and by assuming that Simone has acquired the marker *–t* from early on? Why then doesn't she produce the ending in all the relevant grammatical contexts? Or do we underestimate her knowledge by focussing on correctness in obligatory contexts? Why then is *–t* correct when it occurs? The figure illustrates that correctness in obligatory contexts is the stricter criterion in determining when an inflectional affix has been acquired. According to the classical criterion proposed by Cazden (1968) and still adopted in acquisition research, an inflectional marker is acquired when its correctness score in obligatory contexts is at least

at 90% for three successive speech samples. The first of these samples is then defined as the point of acquisition for the respective inflectional marker. This criterion, of course, refers to a stage where the inflectional marker in question is used productively and is no longer part of unanalyzed chunks (see above).

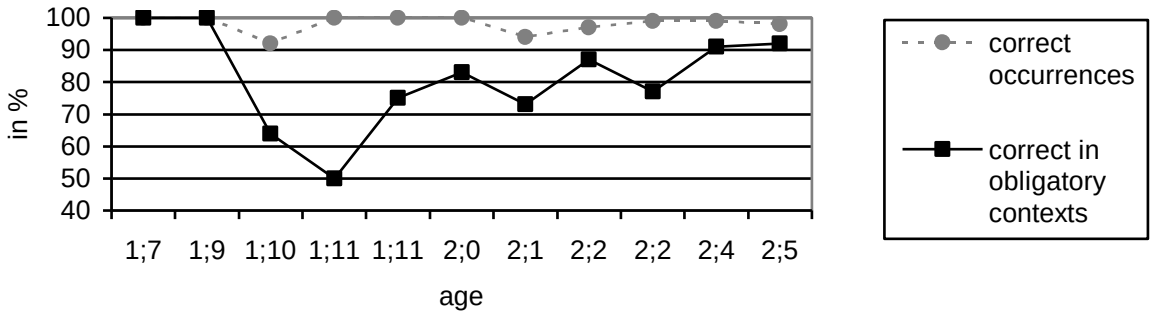

Fig. 3: Correctness scores for the marker *–t* in data from the German child Simone (based on Penke & Clahsen 1992:192).

U-shaped curve of development:

The developmental curve depicted in fig.3 reflects the stages in the acquisition of inflectional markers discussed above: (i) a first stage where the inflectional marker appears on unanalyzed chunks that typically display correct inflection with respect to the target language (age range 1;7-1;9 in fig.3); (ii) A second stage where the inflectional marker has been identified and is used productively to build new verb forms (starting with age 1;10 in fig.3). However, as long as the grammatical content of the marker has not been identified, it will often not be used in contexts that require this marking, leading to a clear decrease in the correctness scores in obligatory contexts. When the child has identified which grammatical information is expressed by the inflectional marker, correctness scores in obligatory contexts increase until they surpass and stay over 90% (from age 2;4 onwards in fig.3), indicating that the final stage (iii) has been reached and the inflectional marker has been acquired. Due to its shape a developmental curve as depicted in fig.3 has been dubbed a u-curve. It is characterised by an initially high performance due to the production of stored chunks, a

subsequent stage of decreasing performance and higher error-rates due to productive although sometimes incorrect application of inflectional markers until, finally, acquisition is complete and the inflectional marker or system is mastered.

The u-shaped developmental curve has most often been linked to the acquisition of irregular inflected forms such as irregular English past-tense forms where an initial stage of correctly produced irregular forms is followed by a stage where children overapply the regular inflectional pattern to irregular verbs and produce overregularisation errors such as *goed* instead of *went,* leading to a decrease of correctness values. The weeding out of these overregularisation errors subsequently causes correctness scores to increase again, until adult correctness levels are reached (Marcus et al. 1992). Fig.4 illustrates this characteristic development of the English irregular past-tense acquisition. A comparison of the developmental curves depicted in figures 3 and 4 indicates that u-shaped development is, however, not restricted to the development of irregular inflectional forms but depicts a typical development trajectory in the acquisition of inflectional markers (cf. Eisenbeiss 2003).

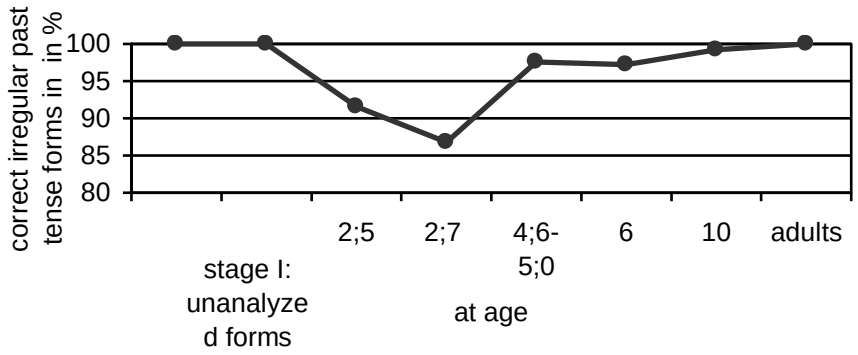

Fig. 4: Correctly inflected irregular English past-tense forms as calculated from the data provided in Marcus et al. (1992).

Rules or analogy – how is productivity achieved?

The issue how productivity is achieved has led to one of the major debates in cognitive science during the last 30 years – the so-called dual-mechanism debate (cf. Penke 2012 for

overview). In brief the controversy centres on the issue whether or not regular inflected word forms such as the English past-tense form *inflected* are composed by means of a mental symbolic operation that combines two independent morphemes: a verb stem *inflect*$_{[V]}$ and a past tense marker *-ed*$_{[PAST]}$.

Anti-symbolic approaches argue against the assumption that regular inflected forms are structurally composed out of independent morphemes merged by a mental operation and assume instead that in representation and processing inflected forms are structurally non-compositional. According to such connectionist or constructivist approaches, inflected forms are stored in an associative network structure in the mental lexicon (cf. Rumelhart & McClelland 1986, Bybee 1988, 1995, Ambridge & Lieven 2011). Learning, representation and processing of inflected word forms are based on simple associative connections between the stored entries that share phonological, functional or semantic features. As the child encounters more and more inflected forms in the input and stores them in an associative network structure, a pattern or schema develops of how particular inflected forms look like. Fig.5 illustrates such a structure for regular German past-participles. The more forms display overlapping features, the stronger are the associative connections between these entries (indicated by the thickness of connection lines in fig.5). Based on these connections an inflectional schema becomes visible that associates a participle form with the ending /t/. This schema, however, does not consist of independent morphemes but is tied to the lexical elements it is based upon. Once a schema has developed, it can be used productively: new inflected forms can be built via analogy to forms stored in the mental lexicon if they display a sufficient overlap with respect to their phonological form. Thus, a participle form *gekacht* for the novel verb *kachen* can be produced since this novel verb is phonologically similar to the stored participle forms *gelacht* and *gemacht* of the verbs *lachen* ‘laugh’ and *machen* ‘make’.

While in anti-symbolic approaches productivity is achieved via analogy to already stored forms and thus depends on phonological similarity between the new and already stored verbs/verb forms, productivity in symbolic approaches is not likewise constrained by

phonological similarity. Instead regular inflected forms are produced on the fly by a mental operation that combines a stem and an affix morpheme and that applies freely whenever the respective grammatical requirements of the affix (e.g. a word stem of a particular phonological shape or class) are met. Affixation is only blocked when it results in an inflected word form that expresses the same grammatical information as a form stored in the mental lexicon. Thus, production of an overgeneralized past-tense form such as **singed* is blocked when an already stored past-tense form *sang* can be retrieved from the mental lexicon.

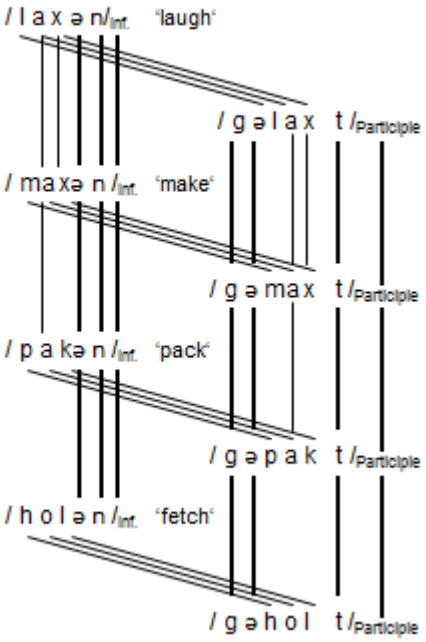

Fig. 5: Sketch of an inflectional schema on German past-participle formation

Another critical difference between the two approaches concerns the issue whether or not regular inflected forms consist of morphemes that are independent entities in the mental lexicon. Whereas symbolic approaches adopt the view that regular inflected forms are composed out of independently represented stem and affix morphemes (cf. Wunderlich 1996, Penke 2006), anti-symbolic approaches assume that inflected forms are non-compositional and hence do not consist of independent component morphemes (cf. Ambridge & Lieven 2011). Evidence relevant for this issue comes from the acquisition of German past-participle inflection. Under a symbolic approach to inflection, German regular

past-participle forms are structurally composed by adding a participle affix *-t* to a verbal stem. But what if the verb stem already ends in a coronal stop [t] such as the stem *hust-* 'cough'? Composition of the verbal stem *hust-* with the participle affix *-t* would result in a participle form *gehustt* where two identical segments, the stem final [t] and the affix *-t*, directly follow each other. Sequences of two adjacent identical elements are avoided in languages. Therefore, an epenthetic *Schwa* vowel is inserted between the stem final [t] and the inflectional suffix *–t:* the target participle form for the stem *hust-* is hence *gehustet*. If regular participle forms are composed out of a verb stem and a participle affix *–t,* we might expect that children produce participle forms such as *gehustt* until they have figured out how to deal with the phonologically problematic tt-sequence that results from the affixation process (i.e. insert Schwa). In anti-symbolic approaches, in contrast, there is no composition of stem and affix and, hence, no tt-problem to solve in the first place. Children simply store and retrieve the participle forms they encounter in their input (i.e. *gehustet*). Alternatively, if they have not yet stored the target inflected form but have already acquired a schema for participle inflection (as indicated in fig.5) according to which participles end in /t/, they might also produce a participle form *gehust* that conforms to this schema (cf. Ambridge & Lieven 2011). What we would not expect to find, is a form such as *gehustt* because such a form can only arise from a compositional operation combining two independent morphemes: a stem ending in a coronal stop [t] and a participle affix *–t.* However, we found precisely such forms in the longitudinal data of the monolingual, typically developing German child Naomi (Grijzenhout & Penke 2005). Between age 1;8 to 2;1 Naomi experiences considerable problems in producing *–t*-inflected participle forms for verbs with a verbal stem already ending in a coronal stop [t]. During this time she produces a number of cases such as *gehustt* where the stem segment [t] and the affix *–t* directly follow each other (8 out of 27 cases, 29.6%). These very marked tt-forms provide strong evidence that affixes such as the regular participle suffix *-t* are independent units of the language system that are added to a stem by a compositional affixation process, hence, confirming the symbolic approach to inflection.

Interactions with syntax

Inflectional morphology realizes morphosyntactic information concerning e.g. NUMBER, PERSON, TENSE or CASE that is effective in syntax since it encodes the grammatical function of arguments (e.g. subject, object) and/or establishes agreement relationships between sentence constituents. In current generative frameworks grammatical features such as the agreement or tense features expressed by verbal inflection project functional phrases such as AGRP or TP into syntactic structure. How these functional projections are acquired, has been a focus in language acquisition research since the 1990s. According to the Full-Competence hypothesis (e.g. Poeppel & Wexler 1993), children are able to project the full set of functional projections (e.g. IP, CP) that is effective in the adult grammar from the two-word stage onwards. In contrast, Structure-Building approaches assume that children's grammars initially generate phrase-structure representations which contain only a reduced set of functional categories, or no functional categories at all. These reduced structure representations are then expanded during language acquisition, either by maturational processes (e.g. Radford 1990) or by the learning of new lexical elements such as inflectional markers (e.g. Clahsen, Eisenbeiss & Penke 1996).

The acquisition of inflectional morphology is of crucial relevance in this debate on the presence or absence of functional projections in early child grammars. Whereas proponents of the Full-Competence approach focus on observations indicative of an early acquisition of inflectional paradigms, advocates of Structure-Building approaches try to show that inflectional paradigms are not yet available in the early two-word stage (e.g. Clahsen & Penke 1992, Eisenbeiss 2003). Thus, controversies have targeted whether utterances displaying early correct inflection should or should not be considered as unanalyzed stored chunks (see above) and whether the percentage of correct occurrences of an inflectional affix or the percentage of correctness in obligatory contexts is the more revealing with respect to the acquisition of inflectional markers (see above) (e.g. Poeppel & Wexler 1993).

In this controversy between the different frameworks, two observations render Lexical-Learning approaches most promising. First, research on the acquisition of inflectional

morphology has provided evidence that inflectional paradigms are acquired gradually affix by affix (cf. Pizzuto & Caselli 1994, Eisenbeiss 2003, Bittner, Dressler & Kilani-Schoch 2003a, Stephany & Voeĭkova 2009). An illustration of the build-up of the German verbal-agreement paradigm is provided in fig.6. As indicated in the figure, the 2nd person singular affix *–st* is typically the first affix whose morphosyntactic content is identified by German children (cf. fig.6a) because it displays a unique relationship between meaning and form (Clahsen & Penke 1992). The acquisition of the 2nd person marker *–st* indicates that the morphosyntactic dimension PERSON is marked on finite German verbs and furthers the acquisition of the 1st and 3rd person singular markers (cf. fig.6b). The contrast between person markings in singular contexts and the respective markings in plural contexts subsequently helps in acquiring the affix *–n* that is initially used as plural marking in 1st, 2nd and 3rd person plural contexts (cf. fig.6c), before the children discover that PERSON is also distinguished in the plural and identify the marker *–t* for 2nd person plural (cf. fig.6d).

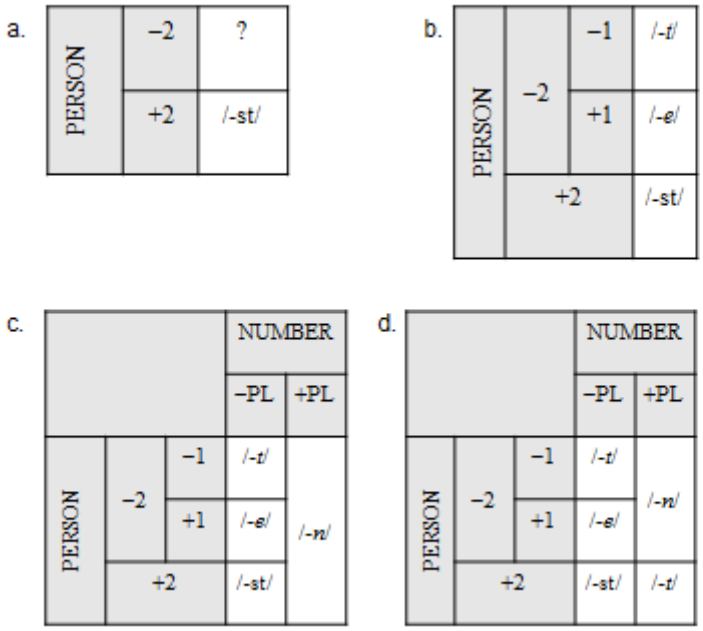

Fig.6: Acquisition of the German verbal-agreement paradigm (cf. Penke 2006:177)

Second, it can be shown that the acquisition of inflectional markers has effects on syntactic structure. When an inflectional marker has been acquired, the grammatical features

expressed by this marker will project into syntax and become syntactically active. Developmental correlations between the acquisition of inflectional markers and the acquisition of syntactic properties associated with the relevant grammatical features have been observed, for instance, for the German 1st person singular marker. Once this marker has been integrated into the verbal-agreement paradigm, verbs inflected with this marker are categorized as finite and will move to the V2 position occupied by finite verbs in German main clauses (Clahsen, Eisenbeiss & Penke 1996). Approaches which assume that the acquisition of syntax and inflectional morphology procede independent from each other such as Full-Competence or Maturation approaches cannot account for such correlations.

Interactions with phonology

The acquisition of inflectional morphology is closely tied to the phonological component. The perceptual/acoustic salience of inflectional markers affects the detection of these elements in the input (cf. Song, Sundara & Demuth 2009). The observation that the noun plural marker *–s* is acquired before the 3rd person singular *–s* in English has, for instance, been attributed to the observation that the latter is typically shorter in duration and hence less perceptually salient than the former in the input (Hsieh, Leonard & Swanson 1999). Differences in perceivability also account for the observation that German hearing-impaired children display unaffected behavior with respect to the verbal plural marker *–n* whose perception is typically less affected by the hearing impairment, but show impaired performance with respect to the verbal person markers *–st* and *–t* that require intact auditory perception of the frequency range above 4000 Hz, a frequency range often affected in hearing-impaired children (cf. Penke et al. subm.).

Moreover, the production of segmental inflectional affixes is constrained by the syllable structure the child has acquired so far. At each moment in development only those verb inflections can be produced that are licit by the rhyme structure acquired so far. Thus, a German child who has not yet acquired a coda position in syllable structure will not be able to produce a 3rd person singular verb form [ge:t] of the verb *geh-* ‘go’, because there is no

syllable position where the consonantal suffix *–t* could be realized. The suffix has to be omitted in this case. Likewise, production of the German 2nd person singular suffix *–st* requires that a post-coda consonantal position – the appendix – has been built up in syllable structure to allow for both suffix consonants to be realized (Grijzenhout & Penke 2005). This accounts for the observation that the ending *–st* is the last ending to appear in German child language. The acquisition of syllable-structure positions thus posits a lower limit on when segmental inflectional suffixes are to appear in child language.

That the production of segmental inflectional affixes is dependent on the acquisition of relevant syllable-structure positions also accounts for the observation that inflectional affixes are sometimes produced and sometimes omitted by children (cf. Song, Sundara & Demuth 2009). Until the syllable structure acquired is complex enough to accommodate an inflectional affix independent of the phonological shape of the stem, segmental inflectional affixes will appear with some stems but not with others. Consider for illustration, German verbal inflection. A German child that has acquired a coda position in syllable structure will be able to provide the 3rd person singular marker *–t* for verb stems which end in a vowel (e.g. [ge:]+t 'goes'). A problem, however, arises for verb stems ending in a consonant (e.g. mal+t 'draws') where either the affix *–t* or the stem final consonant can be produced but not both. In these cases, omissions of the affix *–t* are likely to occur. Similarly, the 2nd person singular marker *–st* first occurs in instances such as [has.tə] 'have you' where the pronoun *du* 'you is cliticized to the verb form (ha+st+du). This leads to resyllabification whereby the affix is split up into /s/ in the coda position and /t/ in the onset of the following syllable. When the first appendix position behind the coda has been acquired, *-st* can appear on verbs with a vocalic stem ending (e.g. *ha+st* 'have'). Only after the 2nd appendix position has been acquired, can *–st* also be realized with stems ending in consonant (e.g. *krieg+st* 'get'). The acquisition of syllable structure is hence likely to be a crucial factor in explaining the variability observed in child data with respect to the realisation of inflectional affixes.

Whereas segmental affixes depend on the acquisition of syllable structure, syllabic or multisyllabic affixes are likely to be influenced by metrical structures, such as foot structure.

For instance, children acquiring Sesotho are more likely to produce noun class prefixes such as *mo-* when they are part of a disyllabic foot (e.g. [mo-tho]$_{Ft}$ 'person'), then when the nominal stem already consists of a two-syllabic foot (e.g. (mo)-[sa.di]$_{Ft}$ 'woman') (cf. Song, Sundara & Demuth 2009). As these examples illustrate, phonology is likely to exert a strong influence on the production and acquisition of inflectional morphology – an influence which, however, has been somewhat neglected in the past and awaits further research in the future.

Conclusion

For more than 50 years, the investigation of how inflectional markers are acquired by children has attracted researchers all over the world who have targeted this question from a variety of linguistic viewpoints. The research conducted over the past decades has furthered our knowledge on how inflected forms are identified and segmented in the input, how the grammatical information encoded in inflectional markers is extracted and represented, how the acquisition of inflectional morphemes is constrained by phonological characteristics of a language and how the acquisition of inflectional affixes interacts with the acquisition of syntactic structure. An impressive amount of data from languages all over the world has been collected in the wake of this research. A focus of studies conducted during the last 15 years has been on exploring how characteristics of the input a child receives influence the acquisition of inflected forms. Most of this research has been conducted within the constructivist paradigm of language acquisition which assumes that input characteristics, such as the frequency of specific forms and constructions in the input and the typological characteristics of a language's inflectional systems, determine the acquisition process (cf. Ambridge & Lieven 2011, Bittner, Dressler & Kilani-Schoch 2003a, Stephany & Voeĭkova 2009). Whether input characteristics strictly determine the acquisition of inflectional morphology is, however, a matter of debate. Interactions between the build-up of phonological structure and the production of inflectional markers or between the acquisition of inflectional affixes and resulting consequences for syntactic structures indicate that more is going on in the mind of a language learner than what could be accounted for by input

characteristics alone. A deeper understanding of the steps and processes involved in the acquisition of morphology and of their interaction with other domains of cognition and grammar can only be achieved if we target the processes and representations that are operative in the child's mind during acquisition. Given the wealth of inflectional systems to explore and the interlacing of inflectional morphology with other domains of cognition and grammar, investigations of the acquisition of inflectional morphology will continue to play a central role in language acquisition research.

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