Input and first language acquisition: Evaluating the role of frequency

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ABSTRACT

This paper addresses the relationship between the frequency of morphological, lexical and syntactic forms in the input and children’s language acquisition. The problem of obtaining reliable frequency measures under different sampling regimes is discussed. Since children are not simple associationist processors onto which the frequency of hearing or producing a string maps directly, a number of factors that interact with frequency are reviewed: form-function mappings, neighbourhood relations and multiple cues. These factors raise the problem of the level of granularity at which we test for a frequency-based explanation which can only be established through empirical research. Studies showing a relationship between the relative frequency of forms in the input and children’s errors, including morphological errors, optional infinitive errors and accusative-for-nominative errors in English are discussed. The final section of the paper deals more briefly with some counter-arguments to the importance of frequency effects in the learning of grammar.

1. Introduction

Psycholinguistic research demonstrates adult language processing to be sensitive to frequency effects at all levels of language processing (Bod et al., 2003; Bybee and Hopper, 2001; Ellis, 2002) and this is also true in studies of children’s production and comprehension. The frequency of experiencing an event affects such diverse aspects of behaviour as our speed of recognition, our ability to recognise or recall whether we have encountered an event before and our ability to encode novel but similar items. Most importantly for accounts of learning, frequency affects how strong a response pattern is by comparison with other possible response patterns. Experimental studies (e.g. Bates and MacWhinney, 1987) and connectionist and computational simulations (e.g. Morris et al., 2000; Chang et al., 2006; Chater and Manning, 2006) can provide considerable insight into the ways in which frequencies of forms and constructions may interact to produce learning outcomes.

Information is not just either ‘present’ or ‘absent’. Events for which people have no explicit memory can influence subsequent recall (Roediger, 1990) and people can recognise items that they cannot recall (Mcdougall, 1904; Anderson and Bower, 1972). Tip of the tongue phenomena indicate the graded nature of representations (Brown, 1991). Experiments show that the more frequent a word, the more degradation to the visual or auditory signal subjects can take and still recognise it (Howes and Solomon, 1951; Howes, 1957). All of this suggests that representations (patterns of response to an event) are not either ‘there’ or ‘not there’—their strength is related to the frequency with which they have been experienced. However, frequency is not the only factor on which the strength of a particular representation depends and, in addition, given the highly preliminary nature of our understanding of language comprehension and production, we often do not know the right level of analysis for a frequency-based prediction (Ambridge, 2010).
From a usage-based perspective, children build their grammars initially out of the phonological–lexical strings that they learn from the input rather than analysing that input in terms of pregiven, more abstract, linguistic categories. But of course children are not simple associationist mechanisms onto which the frequency of hearing or producing a string maps directly. This is a ’straw man’ characterisation of usage-based approaches. Most importantly what children say and how they say it is affected by what they want to say and this, in turn, will have effects on both intake and production. In addition relative frequencies compete, for instance where there is no one-to-one form to function mapping, and the consistency of form-function mappings will interact with the absolute frequencies of either the form or the function (Bates and MacWhinney, 1987, 1989). Frequencies also interact with a number of other factors in affecting learning. Neighbourhood effects in phonology (Marchman et al., 1997; Allbright and Hayes, 2003) and the semantic or prosodic salience of items in the input can enhance or reduce frequency effects of the basic form (Theakston et al., 2005). High token frequencies can entrench particular phonological strings while high type frequencies can lead to the creation of slots in strings and categorisation (Bybee and Scheibman, 1999). Finally, as the child’s grammar develops more abstraction, what counts as a token and what as a type will change and so, therefore, will the scope of the child’s productivity.

Although there are a variety of theoretical positions on how to characterise the nature of representations under a usage-based view, in my view the most helpful way to think about this is in terms of a developing network of form-meaning mappings (Langacker, 2000; Croft, 2001). Initially these may be forms and meanings of very limited scope. Thus what’s that? might be an undifferentiated phonological string mapped to a meaning something like ‘show me that you can name that object’. Note that the phonological string is not yet connected to anything that ‘tells the child’ that it contains a wh-word, the copula BE and a demonstrative, and that the meaning is characteristic of test questions in child-directed speech (CDS) though not of the usual adult use of this question. The network builds up associations between strings that are close in their form-meaning mappings. Very high token frequencies will result in a highly entrenched string, while high type frequencies in a particular position in a string, in interaction with the range of these types, will allow the formation of a slot. This slot is then more ‘abstract’ in the sense that it is not lexically-specific: an example is the noun phrase slot that English-speaking children develop (e.g. I want X, Where’s X, Lieven et al., 2009). Thus the starting point from a usage-based perspective is that frequencies at the lexical-phonological level in the input will affect the course of learning.

There are two crucial points about the way in which I envisage this network working. First frequency will interact with neighbourhood relations in the network and these will change with development. This has implications for what should be counted. The second point is that how the network responds in any particular situation will depend on the interaction between the incoming information and its current level of ‘knowledge’. Thus a small child asked What’s that? may only have one way to respond on the basis of the form-meaning mappings in the network, while depending on the context an older child or adult might have many options including, Yes, What IS that? or Is it an X?, which indicate that connections have been built in the network between constructions with the non-contracted copula in both wh- and inverted yes-no questions. It is important to note that as soon as children move beyond the rote-learning of specific forms, they can be productive. What changes is the scope of that productivity.

In what follows, I first review evidence for frequency effects in acquisition. In section 2, I discuss the interaction between frequency and sampling. Section 3 covers a number of factors that interact with frequency: form-function mappings, neighbourhood relations and multiple cues. These factors raise the problem of the level of granularity at which we look for frequency effects and this is discussed in section 4. Section 5 addresses the role of frequency in the explanation of children’s errors. In the final section of the paper I deal more briefly with some specific counter-arguments to the importance of frequency effects in the learning of grammar.

2. Input frequency effects

Many naturalistic studies of children’s speech have found that the more frequently children hear a particular word or construction, all things being equal, the earlier they acquire it. For example, de Villiers (1985), Naigles and Hoff-Ginsberg (1998) and Theakston et al. (2004), have all shown that order of emergence of particular verbs is significantly correlated with the frequency of use in language addressed to the children. In addition, all these studies found that the range of constructions with which adults used the verbs in talking to children was also correlated with the syntactic diversity of these verbs in the children’s language. In the development of auxiliary syntax, Lieven (2008) has shown correlations between the frequency of low-scope, auxiliary frames in CDS and their order of emergence while Wilson (2003), Theakston et al. (2005) and Pine et al. (2008) have shown frequency effects on the provision of obligatory auxiliaries and copulas. Note that these two latter studies measured the correlations only after the child had produced examples of each form, so lack of obligatory provision was not because the children did not know the forms. Another example is the study by Rowland and Pine (2000) of one child’s development of correct wh-inversion. The study showed that the child produced correctly inverted wh–auxiliary sequences that were highly frequent in the input whereas for lower frequency sequences, he made non-inversion errors. The authors suggested that having learned a number of lexically specific patterns from the input, the child was starting to abstract over them to form a more general category of wh–auxiliary sequences but that this process was not complete as indicated by his production of some sequences in both correct and non-inverted order (an example of what Braine, 1976, called ‘groping patterns’).

Frequency effects are not confined to the early stages of language development. Huttenlocher et al. (2002) have found correlations between relative syntactic complexity in the speech of parents and the children’s development of complex syntax as well as between the relative complexity of teacher’s speech and children’s syntactic development. Naturalistic and
experimental studies focussing on specific constructions have also found effects of input frequencies on children's development, for instance, finite complement structures and relative clause constructions. Early matrix clauses in utterances with finite complements are also the most frequent in the input and it is clear that children use these initially in non-fully subordinated structures (Diessel and Tomasello, 2001; Diessel, 2004; Kidd et al., 2006; Brandt et al., in press). In studies of both German and English relative clauses (Diessel and Tomasello, 2000; Kidd et al., 2007) children first produce the most frequent type of relative construction and find producing less frequent relatives much more difficult. Although differences in children's performance on subject and object relatives have been explained in terms of differences in the underlying structure of these constructions, in fact when children are presented with the types of object relatives that they actually hear in the input they are equally good at interpreting them as for subject relatives (Brandt et al., 2009; Arnon, 2010). This undermines a structural explanation for these differences and supports an input frequency explanation. Here we see a gradual emergence of fully-fledged syntax, preceded by a stage of lower-scope learning that is influenced by frequency.

The effects of frequency on children's linguistic representations have also been shown experimentally. A number of the studies in the previous paragraph are experimental and we will see more examples in later sections of the paper. Here I just give two. In 'weird word order' experiments using high, medium and low frequency verbs, English- and French-speaking children presented with scenes described in non-canonical word orders (Subject-Object-Verb) were significantly more likely to correct to canonical word order with high frequency verbs (Renard Canard pousse, 'Fox duck pushes') than with verbs of lower frequency (Renard Canard percute 'Fox duck rams') Matthews et al., 2005, for English, Matthews et al., 2007 for French). Grammaticality judgements also show frequency effects. Children and adults judge an argument-structure over-generalisation involving a frequent verb (e.g. 'He disappeared it) as more ungrammatical than one with a less frequent verb (e.g. 'He vanished it) (Theakston, 2004; Ambridge et al., 2008a,b). These results are hard to explain within the framework of an early and highly abstract grammar involving 'all-or-nothing' representations, whether these are acquired instantaneously or stochastically. However they fit well with a view of language learning as a process of developing a network of interconnected representations that will change with development, showing more or less abstraction as a function of the relative degree of entrenchment of various parts of the system and the requirements of the particular communicative or linguistic task in hand.

3. Frequency and sampling

One important reason for complementing naturalistic studies with experimental studies is that research using speech corpora raises the problem of sampling. Most corpora sample a small proportion of children's waking and talking lives. This makes for two methodological problems. First is that infrequent forms may be missed. When a correlation is found between the frequency of a form in the input and the order in which it appears in the child's speech, the form may, in fact, have been said much earlier by the child and just not been sampled. Also some other form might actually have been produced even earlier thus changing the order of emergence (Rowland et al., 2008). One approach to this problem is to collect much denser corpora allowing researchers to check frequency and order of emergence. However, with the exception of the 'Speechhome' project (Roy et al., 2009), even the densest corpora collected so far are only sampling an estimate of 7–15% of the child's waking day (Tomasello and Stahl, 2004). A second is to attempt to collect everything the child says but it will be readily appreciated that this is not possible beyond the very earliest stages of language acquisition (Dromi, 1987). However it is possible to target particular forms and attempt to collect as wide a sample as possible using a 'diary' methodology, though this can only be done by caretakers who spend almost all their time with the child. Examples are overgeneralisation errors (Bowerman, 1988), utterances with verbs (Tomasello, 1992; Naigles et al., 2009) and wh-questions (Rowland, 2007).

The second problem is that it is only possible to draw a reasonably firm conclusion that the child's language is of more limited scope than the adult's when the adult's speech corpus is controlled to match the relevant features of the child's. For example, studies of young children's provision of correct verbal morphology, Pizzuto and Caselli (1992) for Italian, and Rubino and Pine (1998) for Portuguese, found that this was not fully productive across all parts of the system but the sampling regimes were quite thin, potentially giving rise to the problems raised above. However Aguado-Orea (2004) used richer corpora (from two Spanish-speaking children) and a more sophisticated methodology to investigate two Spanish children's productivity with agreement morphology on the verb. He directly compared adult and child productivity by counting the number of inflections per verb, controlling for the number of tokens produced and only for verbs and inflections used by both adult and child. He found that there was a significant difference between each child and his/her parents. Although at first sight this result might not seem that surprising, it is, in fact, a powerful demonstration precisely because adult and child were compared on exactly the same verbs and inflections and on the same number of tokens.

4. Factors that interact with frequency

4.1. Form to function mapping

As suggested by Slobin (1985), learning is helped by a one-to-one mapping between a form and its function and this then interacts with frequency. Cameron-Faulkner et al. (2007) studied the development of negative constructions with verbs in a dense corpus collected from one child and his mother. No and not occurred with roughly equal frequency in the mother's
speech, *no* almost exclusively in single word utterances and *not* in multiword utterances. Initially, all negative utterances with verbs were produced by the child with an ungrammatical **no + verb**\(^1\) schema. Three months later, *not + verb* (also frequently ungrammatical) began to account for an increasing proportion of the utterances and continued to do so for the next 6 months. By 3;0, **no + verb** had disappeared and *can’t + verb* and *don’t + verb* accounted for just under 20% of the utterances. At 3;3, **not + verb** had virtually disappeared, *can’t + verb* and *don’t + verb* accounted for an increasing proportion, and other **auxiliary + n’t + verb** structures began to appear: the child’s system was now a limited version of the adult’s. The authors suggested that the child first produced *no* in his multiword utterances, because he had already been using it in single word utterances, probably following his mother’s frequent and salient use in single word negation. Not as the most frequent negator in the mother’s multiword utterances was produced next. However, the speed with which the child moved from **no + verb**, to *not + verb* and then finally to the adult forms using *can’t*, *don’t*, etc., was related to the range of negators that the mother used for any particular semantic function. Thus, if a particular function was consistently mapped by just one form, the child used this form earlier than if the function is expressed by several forms, in which case he seemed to utilise his all-purpose construction (**no + verb** earlier, *not + verb* later). This pattern of development seems to accord well with Bates and MacWhinney’s (1989) definitions of cue validity and reliability in which the frequency of a form interacts with its consistency to allow learning to take place at greater or lesser speed, an issue that we return to below.

### 4.2. Neighbourhood relations

One approach to the learning of inflectional morphology sees the child as ‘analysing’ the ambient language into pregiven categories such as tense and agreement (Hyams, 1986; Wexler, 1998; Legate and Yang, 2007). The alternative sees patterns of tense and agreement as emergent from stored forms: Word forms relate via a network of connections between shared phonological and semantic features. Productivity (rule-like behaviour) results from the relationship between a new item and the already existing network of connections. The extent to which a given set of connections is productive will depend on its type frequency (the number of items reinforcing that pattern of connections) and restrictiveness (the range of features shared by the pattern that will affect its application to new items, Bybee, 1985, 1995). In this approach, children start by using unanalysed inflectional forms which will be more or less strongly represented in their lexicons as a function of their token frequency in the speech that they hear. Morphological schemas develop, initially restricted to a small number of similar items, but gradually becoming more abstract and more productive (i.e. applicable to more items sharing fewer features). Type frequency (the number of items which fit a particular schema) will affect how rapidly this occurs. Note that what is entered into the measurement of type frequency will change as the child’s system develops and that will depend on developing patterns of ‘similarity’ but that these are, in principle, discoverable through empirical research. A long-standing debate in the literature that reflects these different positions is over the learning of the English past tense. In the classic version of the ‘dual route’ model, the past tense for regular verbs is formed by a rule while irregulars are learned by rote. By contrast the ‘single-route’ model maintains that all verbs, regular and irregular, are learned by the same process. All accounts of the learning of the English past tense build in a role for frequency effects irrespective of the side of the debate from which they come: the more frequent an irregular past-tense form is, the less likely it is to be over-regularised (Pinker and Ullman, 2003; Prasada and Pinker, 1993; Marchman et al., 1997, 1999; Maratsos, 2000; Maslen et al., 2004). However there is still a major difference between single and dual route models, with the latter based on the idea that the grammar contains rules with irregulars listed (Claassen, 1999; Pinker and Ullman, 2003). This should give rise to ‘all-or-nothing’ behaviour - a verb is either regular or irregular. In single-route models of learning instances are entered into a network and the network builds up. Behaviour with a particular verb is predicted from its frequency, phonological neighbourhood relations and, in some cases, semantics (Ramscar, 2002). Maslen et al. (2004), following Maratsos (2000), showed clearly in a study using dense data from one child, that over-regularisation rates depended critically on the frequency of the irregulars in the input. Thus learning the correct irregular is not a matter of one-trial learning—it is being learned but over-regularisation can only be resisted when it is sufficiently frequent. Rule-like behaviour therefore interacts with frequency. Further, children often go through a stage where they produce both the correct irregular and the over-regularised form (Ramscar and Yarlett, 2008) indicating that they ‘know’ both forms. The correct past tense of the irregular is reinforced by incoming tokens and the over-regularised form is reinforced through its neighbourhood relations with similar sounding forms that take a regular past tense. An example is *throw*, which could be over-regularised because it is phonologically similar to a number of verbs that take the regular past tense (*show-showed, flow-flowed, sew-sewed*). This is clearly compatible with the idea that both forms are being ‘reinforced’ and incompatible with the idea that repeated presentation does not add new information or change the representation (Rooper, 2007, this issue).

However, English is not a good language for studying the learning of inflectional morphology because there is very little. Other languages provide better tests but have been studied less. Reports of morphological learning in languages with rich morphology suggest that very early correct marking is pervasive. When we look more closely, we find frequency effects both for correct learning and for errors—as is the case for the learning of English past tense and plural marking. It is difficult to see how a rule-based model can be made to account for more complex inflectional systems, for example the Polish system of noun declensions which shows a number of different inflectional forms per noun, substantial allomorphy and a complex set of factors governing the choice of endings in which some inflections are rule-like and for others there is no clear

\(^{1}\) Bold face denotes a schema.
predictability as to why a particular stem takes a particular ending. Yet in tests of productivity with nonce nouns, Dąbrowska (2004) shows that rule-like inflections are not necessarily easier to learn or produce than those for which precise criteria for choosing the proper ending cannot be listed. When we consider what the speaker has to know how to switch between one case and another, how is this to be characterised if some inflections are operated by rules and others are not (Krajewski et al., in press)? A schema-based approach that accommodates neighbourhood relations as well as type and token frequencies seems to stand a better chance of accounting for such a system.

Experimental studies on children and adults (e.g. Dąbrowska and Szczerski, 2006; Dąbrowska, 2004) confirm that although the acquisition of inflectional endings indeed starts early, children develop productivity with inflections more or less gradually and are sensitive both to type and token frequencies and to semantic and phonological factors. These factors continue to exert an influence even into adulthood with not all adults showing full mastery and this is related to their language experience (Dąbrowska, 2008).

Indefrey (2002) found a similar result for the weak noun declension in German. Nouns from this declension, which involves masculine nouns ending in schwa (–e), are inflected with –en in the accusative and dative. Adults and children were presented with existing nouns and nonce labels for novel creatures and ask to form the accusative. Since there are only about 100 of these nouns it is possible to learn all of them by rote or to abstract the rule. If the participants in the experiments had abstracted the rule, then they would successfully inflect the nonce nouns; if not, they would be variably successful with the existing nouns but fail on the novel nouns. Indefrey found that in every group from the three-year-olds up to adults there were some participants who were rule-learners and some who were rote-learners. What changed between groups were the proportions of each: the youngest age group of children had only one rule-learner, the ‘high education’ group of adults had only two rote-learners. Thus there are graded representations of inflectional morphology both in development and between adults.

It is clear from these and other studies that factors other than frequency play an important role and also that identifying the level at which to look for frequency effects in the acquisition of a complex system is a major challenge. For instance, Dąbrowska and Szczerski (2006) found a significant correlation between the frequency of a given inflection and children’s performance on elicitations of the correct form of a given case, and this correlation was higher for younger children. On the other hand, results from one of the studies in Dąbrowska (2004) suggest that similarity plays a more important role than frequency. Similarly, Ševa et al. (2007) found that despite the very different frequency of diminutives in Russian and Serbian, their effect on the rate of gender agreement errors was similar. The authors argue that it is phonological closeness and inflectional consistency that is producing this result rather than the frequency of diminutives in the language.

In a recent study of Polish-speaking children’s ability to switch between case inflections which, after all, is what speakers have to do all the time, neither the frequency of the source form nor that of the target could account for the different rates at which children switched from one inflection to another (Krajewski et al., in press). Krajewski et al. presented children with short picture stories in which a strange monster was first presented in a construction taking one inflection (for instance locative or dative) and the child then had to describe what happened to the monster in a subsequent picture requiring a different inflection (for instance, genitive). Children’s success at this task depended on the similarity between source and target forms (e.g. no change, dropping an ending, changing the number of syllables) and of the direction of the switch (going to nominative from locative or dative was sometimes more difficult than going to genitive from locative or dative, despite the much greater frequency of the nominative form). Given that studies on adults show frequency effects throughout the system, why would young language-learning children not show these effects from the start? Krajewski et al. suggest that it may be the frequency of a particular transition from one inflection to another that matters rather than the frequency of any particular inflection. This frequency measure may be less important at later stages, when the system is more developed, since children will increasingly experience a whole diversity of transitions in various directions. Both these suggestions clearly require experimental testing.

We can see that assessing the role of frequency in the learning of inflectional morphology must involve much more than simply counting the form in the input and its provision in the child’s speech. The nature of the network of associations into which any new item is entered will vary developmentally with important consequences for what should be counted. However it should also be clear that while a usage-based, schema theory of inflectional learning has a long way to go, the ability to deal with graded representations, with developmental change and with varying forms of similarity relations all make it a more convincing candidate than a dual route model.

4.3. Multiple cues

Just as with inflectional morphology, a central question in the learning of syntax is which cues may be having frequency effects at what stage in development. In their cue competition model, Bates and MacWhinney (1989) showed that frequency interacts with consistency in form–function mapping (see also Kempe and MacWhinney, 1998) and they developed methods for counting the strength of different cues in the input. Chan et al. (2009) used this method to compare Cantonese, German and English children’s use of animacy and word order cues to the identification of subject and object in active transitive sentences containing novel verbs. Children aged 2;6, 3;6 and 4;6, acted out three types of sentences (see Table 1): those in which the preverbal NP was animate and the postverbal NP was animate (the AVI, ‘prototype’ condition, see Næss, 2007);

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1 Most singular German nouns are not marked accusative and dative. This is marked on determiners, possessive pronouns and adjectives.

2 Since there are only about 100 of these nouns it is possible to learn all of them by rote or to abstract the rule. If the participants in the experiments had abstracted the rule, then they would successfully inflect the nonce nouns; if not, they would be variably successful with the existing nouns but fail on the novel nouns. Indefrey found that in every group from the three-year-olds up to adults there were some participants who were rule-learners and some who were rote-learners.
those in which both NPs were animate (the AVA, ‘word order only’ condition) and those in which the preverbal NP was inanimate and the postverbal NP was animate (the IVA, ‘conflict condition).

Results revealed interesting cross-linguistic similarities and differences. With the AVI sentences where animacy contrasts and word order coalesce, even the youngest two-year-olds in all three languages were above chance in choosing the first animate noun as the agent. With the IVA sentences where semantic and syntactic cues conflict, the same children aged 2;6 – again across language groups – did not use either cue systematically, preferring neither the first inanimate nor the second animate noun as the agent on group performance measures. Later in development, older children showed preference for word order over animacy, choosing the first inanimate noun as the agent, with the Chinese children depending for longest on animacy rather than word order. With the AVA sentences where the animacy contrast was neutralized and only the word order cue was present, children acquiring English showed the earliest and greatest reliance on word order, followed by children acquiring German and then children acquiring Cantonese.

These results demonstrate that children’s SVO word order productivity corresponds closely with how systematic the input is in providing consistent cues for the schematisation of an abstract SVO schema. English input properties are the most conducive, since the argument NPs are often available and consistently aligned. Cantonese input properties are the least conducive among the three languages, since argument NPs are often dropped. German input properties are between English and Cantonese–the NPs are not as consistently aligned as those in English (22% of transitives in the input have OVS word order, see below), while they are available more often than in Cantonese. This suggests that acquisition, for instance of the role of syntactic word order, is not an ‘all-or-nothing’ reflection of an early-set, abstract parameter but emerges through development in relation to what the child is hearing.

A related study on the cues of word order and case-marking in German (Dittmar et al., 2008) demonstrates the way in which experiments can be a guide to the level of granularity at which frequency should be measured. Here children aged 2;7, 5 and 7-years old were presented with active transitives containing novel verbs and two animate nouns in three conditions: the ‘consistent’ condition, with nominative case-marking on the preverbal NP and accusative case on the postverbal NP; the ‘word order only’ condition, with no case-marking on either NP; and the ‘conflict’ condition, with accusative case on the preverbal NP and nominative case on the postverbal NP which is grammatical in German (see Table 2). The two-year-olds were only correct in pointing to a matching picture in the consistent condition (i.e. with a preverbal agent and nominative case-marking) where both cues supported each other. Five-year-olds used word order by itself to choose the preverbal NP as agent, but were at chance in the conflict condition. Only seven-year-olds behaved like adults by correctly relying on case marking over word order when the two cues conflicted. These findings suggest that children do not begin by attending to single cues, but rather they learn the most frequent form which has all cues present and have difficulty whenever there is deviation from it.

5. Identifying the right level of granularity

The consistent form in German is also the most frequent (SVO order with overt case-marking). However, if we compute the strength of the cues on the two standard measures of input in the Competition Model—cue availability (how often the cue is available in relevant sentences) and cue reliability (how reliable the cue is, when it is present, in indicating the correct interpretation), the success of predicting these results depends on precisely what is counted. Counting only full SVO sentences and all case-marked forms, word order shows no advantage in availability (87% versus 86% for case marking), and indeed its cue reliability, as standardized computed, is lower (79% versus 100% for case marking). This is because if overt case-marking is present, it is 100% reliable while 22% of German transitives in CDS have OVS word order. This would suggest that the 5-year-olds should do better on the conflict, OVS sentences where case-marking is available than on the SVO, word order only, sentences. But the reverse is the case: they do as well on the word order only condition as on the consistent condition and are at chance on the conflict condition.

However, it may be that German children do not use the word order cue as the positional relation between the two nouns in the sentence (first noun = agent; second noun = patient) but as the positional relation between the noun and the inflected

### Table 1
Sentence types used in Chan et al. (2009).

<table>
<thead>
<tr>
<th>Sentence type</th>
<th>Example</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animate-Novel verb-Inanimate (AVI)</td>
<td>The horse tams the telephone</td>
<td>‘Prototype’</td>
</tr>
<tr>
<td>Animate-Novel verb-Animate (AVA)</td>
<td>The cow tams the giraffe</td>
<td>‘Word order only’</td>
</tr>
<tr>
<td>Inanimate-Novel verb-Animate (IVA)</td>
<td>The cup meeks the cat</td>
<td>‘Conflict’</td>
</tr>
</tbody>
</table>

### Table 2
Sentence types used in Dittmar et al. (2008).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Example</th>
<th>Translation + Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistent</td>
<td>Der Hund wieft den Löwen</td>
<td>The masculine nominative dog is weefing the feminine lion masculine accusative</td>
</tr>
<tr>
<td>Word order only</td>
<td>Die Katze wieft die Ziege</td>
<td>The feminine cat is weefing the feminine goat</td>
</tr>
<tr>
<td>Conflict</td>
<td>Den Tiger wieft der Bär</td>
<td>The masculine accusative tiger is weefing the masculine nominative bear</td>
</tr>
</tbody>
</table>

Table 2 Condition Example Condition
verb (noun before verb = agent; noun after verb = patient). That would mean that the word order cue is also available in fragment sentences (which were not included in the first count) and hence more often available (100%) than case marking (89%). A second possibility is that German children do not use case marking in a completely general way. They may, for instance, know the mapping for ich (1st sing-NOM), mich (1st sing-ACC), du (2nd sing-NOM) and dich (2nd sing-ACC) without having a full knowledge of how all the forms fit into fully abstract case-marking system, particularly since the German case marking system is complex with no one-to-one mapping between gender, number and case. If children at a particular age have not yet discovered that all these forms mark the same case, then cue reliability should not be counted at such a high level of abstraction. That is, the children were tested on the particular case markers der and den used as determiners (masculine nominative and accusative) which appear in only 21% of all transitive sentences, and their comprehension of these may not benefit from their experience with case marking using pronouns, which would mean that the cue availability of these particular forms is not particularly high. But, of course, as children learn to connect the different case-equivalent forms (e.g. the nominative forms for nouns of different genders, as well as the nominative form for personal pronouns of the same gender), the cue availability of case marking will go up (even if the input stays exactly the same). Calculating the cue availability of case marking in this more item-based way results in the availability of case marking being much lower (21%) than that of word order (87%) even when assuming that word order is not available in fragment sentences. Both approaches to calculating the cue availability of word order and case marking result in the conclusion that availability might indeed be higher for word order than for case marking. This suggests that young German children rely on different input parameters at different stages of development; specifically, they rely more on cue availability (basically frequency) early in development and more on cue reliability later in development (see Sokolov, 1988; McDonald, 1986 for similar findings).

Thus the frequency of a particular form or construction in the input does not necessarily map directly onto order of learning by children since frequencies can interact with other features of the input, for instance distributional regularities. These features may act independently of frequency or frequency may still be having an effect but at a different level of granularity. This can only be discovered by hypothesising that a particular level (for instance, meaning) might be important on theoretical grounds and then testing for this through empirical research.

A good example of the interaction of frequency with other factors is the study of optional infinitive (OI) errors, utterances that lack finiteness marking (e.g. He going, He go). Young Spanish-speaking children make few OI errors while German and Dutch speaking children show very high rates, with Dutch rates even higher than German. If children simply learn the non-finite forms directly from all non-finite forms in the input, one might think that the different rates of OI errors between children learning these different languages would be related to the relative frequency of compound finites in the input, with the children initially using only the non-finite form of the main verb. However this is not the case since the rate of compound finites in the Spanish input lies between those for German and Dutch (German 22%, Spanish 25%, Dutch 31%). In fact, Freudenthal et al. (2007) have shown that it can be accounted for by the relative frequency of utterance final, non-finite verbs (Dutch 82%, German 65%, Spanish 26%) which results from the verb-second rule in Dutch and German (see also Wijnen et al., 2001). Thus the suggestion is that the child’s processing mechanism may be differentially picking up forms at the ends of utterances and it is this that gives rise to the different rates of OI errors. Again this highlights the importance of having a theory of learning which can interact with the raw frequencies in the input that the child is experiencing.

6. Explaining errors

If relative frequencies in the input simply mapped directly onto children’s learning then, of course, they could never explain errors. But, in fact, a number of studies (including the one above on OI errors) have been able to account for systematic errors in children’s syntactic development by focussing their frequency counts at the right level of granularity.

In the Aguado-Orea (2004) study of two Spanish children’s early development of verbal morphology (discussed above) the children’s errors were analysed. Aguado-Orea found that although the overall error rate of person-marking on the verbs for the two children was low at around 4.5%, there were pockets of very high error-rates (for instance the marking of 3rd person plural was wrong 31% of the time for one child and 67% for the other). If the data was analysed verb by verb, the error rate went up inversely with the relative frequency of each verb form. Thus the overall error rate for the 58 verbs requiring 1st person was 4.9%. However quiero (want-1st-SING) and puebo (can-1st SING) accounted for around 60% of the children’s 1st person usage. Once these two correctly marked (and likely rote-learned) verb forms were taken out, the error rate climbed to 10.4% and largely involved the use of the 3rd person singular inflection instead of the correct 1st or 2nd person singular inflection. The 3rd person singular inflection was the most frequent form in the speech addressed to the children and thus, in these early stages, the children were incorrectly using this inflection when they did not know the correct form. Two important implications follow from these results. First that, despite an overall low error rate, agreement morphology is actually being learned gradually, with pockets of high error and this is related to input frequencies. Second is the importance of the level of abstraction at which one counts the frequency of a form: Errors are low if one treats AGREEMENT as a category but much higher when one looks at the system in terms of either marking for PERSON or at individual forms.

In a study with a somewhat similar logic to Freudenthal et al. (2007) study on OI errors, Kirjavainen et al. (2009) investigated whether complex utterances in the input (Let me do it) might explain the origin of English-speaking children’s first person, pronoun case errors, where accusative pronouns are used in nominative contexts (me do it). Naturalistic data from 17 two-to-four-year-olds was searched for 1psg accusative-for-nominative case errors and for all 1psg preverbal
pronominal contexts. Their caregivers’ data was also searched for 1psg preverbal pronominal contexts. The data show that the children’s proportional use of me-for-I errors was correlated with their caregivers’ proportional use of me in 1psg preverbal contexts. Furthermore, the verbs that children produced in me-error utterances appeared in complex sentences containing me in the input more often than verbs that did not appear in these errors in the children’s speech. Of course there is no direct mapping from me used as a subject in the input (which never happens), but children do appear to be learning and using lexical strings from the input in which me appears before the verb. For at least one of the children, this becomes a productive pattern: she uses the *me + V* pattern very often using verbs with which me has not appeared in her input. This is interesting since it indicates a process of abstraction from the input (which will, of course, eventually become of very low, or non-existent, frequency as the frequency of competing correct forms builds up). Theakston et al. (2003) showed a similar effect of input in an experimental study in which children were taught novel verbs either in utterances with complex verb phrases in which the verb was unmarked (*Will it tap?*) or with the verb in third person singular (*It tamps*). Children who only heard the verbs in the unmarked condition were significantly more likely to produce them with OI errors.

A final example the way that frequency and lexical specificity can interact to explain errors comes the well-attested non-inversion errors that English-speaking children make with the syntax of questions (e.g. *Why can’t she do it*?). These have been explained in terms of relatively abstract structures (Stromswold, 1990, the wh-word is mis-analysed as unmoved and generated in place: Santelmann et al. (2002): problems with the main verb inversion of copula BE and DO-support). However, children are significantly less likely to make errors with question frames that are frequent in the input (Rowland and Pine, 2000; Rowland, 2007). Non-inversion errors occur on low-frequency strings and children can show patterns of alternation between correct and incorrect inversion while the system is developing. In an experimental study, Ambridge et al. (2006) showed that lexically-specific strings of particular wh-words and particular auxiliary forms could account better for the pattern of errors than either the particular wh-word alone or the auxiliary independent of number (i.e. DO rather than *do* vs. *do*). The learning of high frequency strings can also lead to error. When a declarative chunk (*she can’t X*) is high frequency, relative to a question frame (*what can’t*), the child is most likely to use the declarative chunk and put a question word on the front (e.g. *what + she can’t X*), giving an error. When the declarative string is of low frequency (*she does X*), this does not happen. (Ambridge and Rowland, 2009). These results indicate that the development of English question-syntax is closely tied up with the frequency and form of lexically-specific strings that children hear.

7. Arguments against the importance of frequency effects

The question of the level of granularity at which we measure is, as I have pointed out, a major issue for empirical research as is determining other factors that may be playing a part in learning. Because children develop grammar, the forms that are entrenched early on will be of lower scope and less abstract. As development proceeds, frequency effects have to be measured across a more abstract set of categories. So, if we take the example of learning the relationship between various forms of the verb GO, Roep (this abstract) is right to say that the meaning of go may be different to that of *went* initially, indeed that is just what Theakston et al. (2002) have shown. The children in this study started out with semantically limited meanings for the different forms of GO, instantiated in very limited syntactic frames (e.g. *gone* is the only form to appear in a wh-question for many weeks and is produced initially only with the meaning of disappearance: *going* appears first with adverbials and initially denotes movement) and this was related to the frequency with which they heard this particular form-meaning mapping in the input. Even at age 3:0, the children did not seem to be operating with an adult-like representation of GO, though there was increasing flexibility in the use of different forms across different constructions suggesting that connected representations of the various forms were developing. In principle, it should be possible to test this using a priming methodology. The prediction would be that priming would not occur across different forms of the same verb at very young ages but would be possible at older ages and, of course, with adults.

However in saying that frequency effects are initially lower-scope and less abstract than later in development, it is important to note that these lower scope categories are not those of a pregiven and parameterised universal grammar. For instance, Freudenthal et al. (2010) show that while Legate and Yang’s ‘Variational Learning Model’ (2007) can explain cross-linguistic effects at the level of TENSE, it cannot explain lexical effects that are found for particular individual tense-marked forms. Another example is that in the learning of wh-questions, it is the relative frequencies of strings of the form ‘*What does ...*’ or ‘*Why can’t ...*’ which correlate with children’s provision of correct inversion in both naturalistic and experimental data (Rowland and Pine, 2000; Ambridge et al., 2006; Rowland, 2007; Ambridge and Rowland, 2009), not categories such as TENSE, AGREEMENT, WH-WORD or AUXILIARY). We can only identify what these categories are and how they change with development by empirical investigation but we should not assume *a priori* that they are operating at the level of a highly abstract grammar.

Finally there are the ‘poverty of the stimulus’ arguments that maintain that children learn structures that are either not present or very infrequent in the input and that this suggests that they must have pregiven knowledge of, for instance, constituency and recursion (Crain and Nakayama, 1987). But this assumes that children could only learn a structure from that exact same structure in the input. In fact, of course, children’s knowledge of constituency develops, for instance building up from the provision of bare nouns to more complex NPs (Lieven et al., 2009). Thus while a 2;6 -year-old might not understand that *The boy who is smoking* forms a constituent which agrees with the verb, they may well already be developing the rudiments of verb agreement with simpler NPs (i.e. understand that *he, the boy and the nice little boy all fill the same functional slot of ‘referent’). Lewis and Elman (2001) and Reali and Christiansen (2004) have shown that the models in their
studies can learn to predict the correct structure of yes/no questions with a relative clause (Is the boy who is smoking crazy?) even when there are no constructions of this type in the model's input. The models do this by learning the distributional probabilities of frequent chunks and Ambridge et al. (2008a,b) show that such an analysis also predicts when children will make errors on these types of questions.

8. Conclusions

I would not, for one moment, wish to suggest that the usage-based approach has all the answers. At the empirical level much remains to be explained (just one example is that not all non-nominative subject errors, such as my do it, can be explained by the learning of lexical strings). The development of abstraction and of the interaction between different parts of the grammar in arriving at the adult system is very under-theorised. However Roeper's argument against the importance of frequency is that it can’t change the information in a representation because this is either present or absent (Roeper, this issue, 2007). But frequency has its effect because it reinforces one representation in contrast with another. Thus we get the types of graded responses I have outlined above. If repeated presentations do not add new information, most of these results would be inexplicable. We do have to measure at the right level of granularity – this will change with development – and empirical research is the only way to find out what this is at any point. Because the child’s system changes and becomes more abstract, frequency effects should be at more phonologically and lexically-specific levels to start with, changing to broader scope categories with developmental time. This makes the question of precisely what to measure in the input and how it relates to the child's developing system, a central issue in explaining the course of language development. I have suggested both that the right level of granularity for measuring frequency needs to be identified and that frequency interacts with other critical explanatory factors, communicative importance to the child and neighbourhood relations to take two at somewhat opposite ends of the scale—but ignoring the pervasive effects of frequency in an account of language development will make it far more difficult to identify what these non-frequency factors might be and whether, and/or how, they interact with frequency. Dismissing frequency effects because the level at which to analyse them may not be immediately apparent is surely premature.

Acknowledgements

I had a great deal of help with this paper from Ben Ambridge (see also Ambridge, 2010). I am also grateful to an anonymous reviewer and to Colin Bannard, Silke Brandt, Grzegorz Krajewski, Caroline Rowland, Anna Theakston and Michael Tomasello for insightful comments on an earlier version. Interpretations and errors are, of course, all my own.

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