J. Child Lang. **42** (2015), 294–297.
doi:10.1017/S0305000914000658

Frequency effects and processing

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Ambridge *et al.* (this issue) document the pervasive influence of input frequency on language acquisition, raising the question of how and why effects of this sort arise in the first place. I focus here on this matter.

An explanatory account of frequency effects needs to address two related issues: Why do such effects exist, and why is their impact tempered rather than absolute? A promising strategy for approaching these questions is to incorporate the study of input frequency and its effects into a more comprehensive research program dedicated to understanding processing cost, its underlying causes, and its role in shaping the course of linguistic development.

In recent work (O'Grady, in press), I have suggested that two quite different sets of factors help determine processing cost. On the one hand, there are internal pressures, such as constraints on working memory, that favor particular patterns over others for reasons of computational efficiency. Detailed proposals along these lines can be found in the work of Hawkins (2004), Reinhart (2006), O'Grady (2015), and many others. On the other hand, processing cost is also sensitive to external factors that arise from experience, including the frequency with which the routines used by the processor are activated – a key factor in facilitating their operation (e.g., Townsend & Bever, 2001, p. 175; Paradis, 2004, p. 28; Bybee & McClelland, 2005, p. 382; among others). The impact of these internal and external influences, sometimes alone and sometimes in interaction with each other, can be discerned in a broad range of developmental phenomena, giving rise to three sorts of situations.

First, there are aspects of development whose course seems to be shaped entirely by the facilitatory effect of frequency on various types of processing activity, including lexical access, the retrieval of irregulars, the implementation of agreement, sensitivity to transitional probabilities, and the like. Ambridge *et al.* document many examples of such effects.

Second, there are instances of development whose course is determined largely, if not entirely, by internal pressures, without regard for input frequency. As I have suggested elsewhere (O'Grady, 2013, in press), one example of this can be seen in how children go about interpreting patterns to which they have had little or no prior exposure. In experimental studies of comprehension, for instance, four-year-old Korean children prefer the *all* > *not* interpretation of the rarely occurring construction in (1), apparently because the alignment of scope with word order reduces processing cost.

(1) Mary-ka motun sakwa-lul an mekessta.
Mary-SUBJ all apple-DIROBJ not ate
'All the apples were left uneaten by Mary.'
NOT: 'Mary ate only some of the apples.'

Also telling are instances of development that run against the grain of experience, with constraints on working memory overwhelming input frequency. A possible example of this type comes from children's early success at interpreting reflexive pronouns (*himself, herself*) compared to plain pronouns (*him, her*), which occur a hundred times more frequently in maternal speech. The key factor, it seems, is that whereas reflexive pronouns require a local antecedent, plain pronouns often have to look to a more distant NP for their interpretation (O'Grady 2015, in press).

Third, there are cases where processing cost (and, therefore, acquisition) is shaped by the interaction of frequency effects with internal factors. Most developmental phenomena arguably fall into this category, although this may not always be evident. The acquisition of relative clauses in English is a case in point.

Early work on this topic reported a strong advantage for subject relative clauses over their direct object counterparts in both production and comprehension.

(2) a. Subject relative clause:
the boy [that _ chased the girl]
b. Direct object relative clause:
the boy [that the girl chased _]

As Ambridge *et al*. note, however, subsequent work uncovered an important qualification: the direct object relative clause pattern exemplified in (2b), with an animate head noun such as *boy*, is highly infrequent in the input. Crucially, when children are tested on patterns that are more commonly heard (e.g., those like *the book* [*that I read* _], with an inanimate head noun and a pronominal subject), the subject relative clause advantage disappears. This finding is consistent with the tenets of a frequency-based account of processing cost: an animate noun is a much better predictor of a subject relative clause than of a direct object relative clause.

But other aspects of relative clause development are not so easily explained in this way. For example, drawing on data from an elicited production task, Kim (2014) reports that five-year-old English-speaking children commonly avoid the opportunity to produce direct object relative clauses by constructing a passive pattern instead – even when the head noun in INANIMATE.

(3) a. Targeted pattern – direct object relative clause with an inanimate head:
the book [that the girl put _ on the box]
b. Produced pattern (20%) – passivized subject relative clause:
the book [that _ was put on the box]

More than just input frequency must be involved here, as direct object relative clauses are two to twenty times more common than passivized subject relative clauses in spoken-language corpora (Roland, Dick, & Elman, 2007, p. 355). Indeed, there are strong signs that internal pressures are at work, since passivization has the effect of eliminating an argument (the agent phrase), of reducing the distance between the clause-internal gap and its filler (the head of the relative clause), and of heightening the topicality of the relativized element (by making it a subject) – all of which help reduce processing cost (O'Grady, 2011).[1]

More broadly, we can see in the relative clause facts a general illustration of how a theory of development might be structured. Internal factors such as constraints on working memory and external factors such as frequency of occurrence are joint contributors to a single larger effect – processing cost – that is ultimately responsible for the developmental profile associated with language acquisition.

The proposed tripartite taxonomy of developmental phenomena is at best a small step forward, of course. Even if it is correct to treat frequency effects as processing effects, there is still the question of how they interact with internal pressures to yield particular patterns of development in those many cases where both types of factor are relevant. One possibility, which I favor, is that input frequency straightforwardly determines development, unless its influence is overridden by internal processing pressures (as indeed it often is). But how can we identify those pressures and their effects? The answer involves a paradox: the best way to understand the precise role of input frequency in language acquisition is to focus on cases of development where it has no effect, thereby making available for direct study the internal pressures to which it is ultimately subordinate.

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[1] The advantages of passivization in Kim's experiment are further enhanced by the fact that her test items were designed to elicit relative clauses with a lexical subject. Both experimental and corpus studies suggest that direct object relative clauses with a lexical subject are more difficult than those with a first- or second-person pronominal subject, presumably because of the ease with which the referent can be processed in the latter cases.

https://doi.org/10.1017/S0305000914000658 Published online by Cambridge University Press

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