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Subject–auxiliary inversion errors and wh-question acquisition: 'what children do know?'*

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ABSTRACT

The present paper reports an analysis of correct wh-question production and subject–auxiliary inversion errors in one child's early wh-question data (age 2;3.4 to 4;10.23). It is argued that two current movement rule accounts (DeVilliers, 1991; Valian, Lasser & Mandelbaum, 1992) cannot explain the patterning of early wh-questions. However, the data can be explained in terms of the child's knowledge of particular lexically-specific wh-word + auxiliary combinations, and the pattern of inversion and uninversion predicted from the relative frequencies of these combinations in the mother's speech. The results support the claim that correctly inverted wh-questions can be produced without access to a subject–auxiliary inversion rule and are consistent with the constructivist claim that a distributional learning mechanism that learns and reproduces lexically-specific formulae heard in the input can explain much of the early multi-word speech data. The implications of these results for movement rule-based and constructivist theories of grammatical development are discussed.

INTRODUCTION

Many current rule-based theories of language acquisition are based on the assumption that in producing multi-word speech, children are manipulating syntactic categories such as subject, verb and auxiliary to produce rule-governed grammatical utterances. Rule-based theories of object wh-question acquisition make the additional assumption that children are applying the following grammatical movement rules to transform an underlying declarative sentence into a wh-question. First, the object of the sentence (*the apple* in *he is eating the apple*) is replaced by the wh-word (*he is eating what*?). Secondly, the object wh-word is preposed to the beginning of the sentence, moving into the specifier position of the complementizer phrase, CP (*what he*

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is eating). Thirdly, and most importantly for the present study, the subject (*he*) and the auxiliary (*is*) are inverted and the auxiliary moves into the head position of the complementizer phrase, CP (*what is he eating?*). This final transformation is known as the subject–auxiliary inversion rule. Once children begin to produce large numbers of correctly inverted wh-questions they are assumed to be doing so by applying the above grammatical rules to adult-like syntactic categories.

However, studies conducted in other areas of grammatical development have questioned the assumption that category-general rules underlie children's early multi-word speech. A growing body of research indicates that there is very little evidence that children's knowledge of how to use one lexical item in a particular construction generalizes quickly to other members of the same grammatical category or to other constructions (see e.g. Braine, 1976; Kuczaj & Brannick, 1979; Kuczaj & Maratsos, 1983; Ninio, 1988; Tomasello, 1992; Lieven, Pine & Baldwin, 1997; Pine, Lieven & Rowland, 1998). This evidence suggests that children's initial multi-word utterances reflect knowledge that is much more limited in scope than has previously been assumed. Similar results have been reported for very early wh-constructions. For example, Klima & Bellugi (1966) suggested that the early wh-questions of Adam, Eve and Sarah (Brown, 1973) could be identified as stemming from only two low-scope formulae: *what* + *NounPhrase* (+ *doing*) and *where* + *NounPhrase* (+ *going*). In addition, Fletcher (1985) noted that the earliest wh-questions with auxiliaries produced by one subject, Sophie, could be explained almost exclusively with reference to three formulaic wh-word + auxiliary combinations: *how* + *do*, *what* + *are* and *where* + *'s*. Despite these results, the possibility that this type of formula might play a part in later wh-question acquisition has not yet been considered. Instead, the assumption that children can only start to produce correct wh-questions in large numbers by using category-general rules has rarely been disputed.

The purpose of the present paper is to challenge the assumption that, in the production of correctly inverted wh-questions, young children are using category-general rules; specifically, the subject–auxiliary inversion rule. It reports an analysis of subject–auxiliary inversion errors in one child's early wh-question data, arguing that current movement rule accounts cannot explain the patterning of such errors in early production. Instead, an approach that takes account of the lexical-specificity of early multi-word speech, making no assumptions about the child's knowledge of grammatical categories or rules, provides a better fit to the child's wh-question acquisition data.

Subject–auxiliary inversion errors

Subject–auxiliary inversion (uninversion) errors were first reported by Bellugi and her associates in the late 1960s (Bellugi, 1965; Klima & Bellugi,

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1966; Bellugi, 1971). In an analysis of the wh-questions of Adam, Eve and Sarah, they described a number of 'uninverted' questions in which the auxiliary and the subject were not inverted as in the correct adult form. The children were using questions such as **what he can ride in?* and **what you will do?* at the same time as they were producing correctly inverted yes-no questions (e.g. *can I ride in it?*). Further research has revealed that although there seems to be no stage at which children produce only uninverted wh-questions and inverted yes-no questions as Bellugi suggested, children do produce uninverted wh-questions (e.g. **what you can do?*) at the same time as they are beginning to produce a large number of correctly inverted wh-questions (e.g. *what can you do?*) (e.g. Erreich, 1984; Labov & Labov, 1978; Stromswold, 1990).

The presence of such errors poses a problem for movement rule accounts which are based on the assumption that to produce inverted questions children must be applying a subject–auxiliary inversion rule. Movement rule-based solutions to the problem of uninversion errors have, therefore, to explain why children sometimes correctly apply the inversion rule and sometimes fail to apply it. Two existing movement rule theories will be considered in the present paper: deVilliers's (1991) ADJUNCT ANALYSIS and Valian, Lasser & Mandelbaum's (1992) OPTIONAL INVERSION RULE. Both are motivated by the need to draw a principled distinction between the questions the child produces with inversion and those in which s/he fails to apply the inversion rule. DeVilliers claims that the child distinguishes between two sub-categories of wh-words and Valian *et al*. suggest a distinction between two types of movement rules. In either case, if the child's data support the distinction made by the theory, this could count as evidence that the child is using a subject–auxiliary inversion rule to produce inverted wh-questions. However, if the child's pattern of inverted and uninverted questions cannot be explained by either hypothesis, another possibility has to be considered; that in producing correct wh-questions, children are acquiring lexically-specific wh-word + auxiliary formulae of the type seen in very early questions (e.g. *how* + *do*, *what* + *are*, *where* + *'s*).

DeVilliers's (1991) adjunct analysis

DeVilliers (1991) suggests that children produce non-inversion errors because they are misanalysing the wh-words in adjunct wh-questions. Adjunct wh-questions are questions in which the wh-word replaces the adjunct, rather than the argument, of the declarative sentence (e.g. the wh-question *how did Mary meet John* is an adjunct wh-question because the wh-word *how* replaces the adjunct *at a party* in the corresponding declarative *Mary met John at a party*). DeVilliers (1991) argues that because adjunct wh-words can occur in adjunct position in some adult wh-questions (e.g. *why hack at it like*

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that?, how come you have got some sweets?), children are misled into over-generalizing uninversion to other adjunct wh-questions.

DeVilliers makes two claims about the acquisition process. The first claim is that the child will not correct her/his mistake until s/he starts to produce the same wh-word in embedded clauses (e.g. the child's production of *I know* ***why*** *you want it* triggers a reanalysis of *why* in matrix wh-questions).[1] Reanalysis occurs on a wh-word-by-wh-word basis which explains why individual wh-words show variation in the emergence of inversion. However, in making this assertion deVilliers goes further than her initial claim that '… adjunct questions initially begin as unmoved elements, generated in place at the front of the sentence' (deVilliers, 1991, p. 157). Nowhere in the paper does she explain why argument words (e.g. *what*, *who*) as well as adjunct words should be involved in the misanalysis. This is an important weakness since the basis of her theory is that because adjunct wh-questions can occur with post-subject auxiliaries in the adult grammar (e.g. *why hack at it like that?, how come he's going?*), this delays children in their correct analysis of adjunct wh-words.

A related problem for this claim comes from deVilliers's supporting data. She reports that the point at which children start to produce inverted questions with a particular wh-word correlates closely with the point at which they begin to produce embedded clauses with the same wh-word. However, more than correlation is required; the embedded clause must come first if its presence is to trigger the correct analysis of the wh-word in matrix questions. Valian, Lasser & Mandelbaum (unpublished manuscript) point out that in 7 of the 15 cases reported by deVilliers the inverted matrix question appears slightly earlier, not later, than the wh-word in embedded clauses. This result does not provide evidence that inversion always follows the appearance of the wh-word in an embedded clause. The failure to explain why argument wh-words should be misanalysed and the absence of data to show that inversion always follows embedding means there is little compelling evidence to support the first of deVilliers's claims.

DeVilliers's second claim is the one that will be investigated in the present paper. She argues that children treat adjunct and argument wh-words differently: argument words (e.g. *what* and *who*) are reanalysed early on but 'the analysis of adjuncts 'how' and 'why'…persists for some time' (deVilliers, 1991, p. 171).[2] However, the data deVilliers presents to support

[1] In order to produce an embedded clause, the child has to reanalyse the wh-word into its correct position in the specifier of the complementizer phrase. This triggers the correct analysis of the wh-word in a matrix question.

[2] Wh-questions with *where* may also be adjunct wh-questions. However, there is lack of agreement as to whether *where*, when it is used in wh-questions such as *where is it?*, should be considered an argument or adjunct (Stromswold, 1990, Valian, Lasser & Mandelbaum, unpublished manuscript). As a result, *where* wh-questions are excluded from this analysis.

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her argument only refer to *why* questions. No data are provided to show that adjunct *how* wh-questions are also delayed in reanalysis. One could argue that *how* may occur earlier in embedded clauses than *why*, and therefore be reanalysed earlier but, as Valian *et al*. (unpub.) have shown, deVilliers provides no data to support the idea that inversion always follows the production of embedded clauses. In addition, the reason deVilliers gives to explain why children could misanalyse adjunct wh-words (i.e. the presence in universal grammar of an alternative analysis of adjunct questions) relies on children distinguishing between adjunct and argument words, not between *why* and other wh-words. If adjunct *how* as well as *why* wh-questions are delayed in reanalysis the data will support deVilliers's theory. However, if the data show that only *why* is delayed in inversion then a distinction must be drawn between the child's treatment of the specific item *why* and other wh-words. This would suggest that it is simply the identity of the specific wh-word, not whether it is an adjunct or argument wh-word, that determines whether it occurs in inverted or uninverted questions. The first analysis in the present paper will test deVilliers's prediction that the adjunct wh-words *why* and *how* will occur more often and for a longer period with uninversion than the argument wh-words *what* and *who*.

Wh-word specific optional inversion rule – Valian, Lasser & Mandelbaum (1992)

If the results of the study reveal that a child treats *why* and other wh-words differently, this could be taken as support for the claim that children are operating with lexical items, not grammatical categories, to produce inverted wh-questions. However, this is not necessarily the case. Valian, Lasser & Mandelbaum (1992) present a movement rule theory that predicts lexical specificity in the wh-words the child uses with and without an inverted auxiliary. They hypothesize that uninversion errors occur because children are mistakenly applying an 'optional' inversion rule to wh-questions; a rule that allows the production of both inverted and uninverted wh-questions. Valian *et al*. (1992) suggest three reasons why a child may make this mistake. First, optional inversion in matrix object wh-questions is correct in some languages (e.g. French) and therefore optional inversion must be a possible grammatical principle that the child has to consider. Secondly, the child has evidence from yes-no questions in her/his input that optional inversion is possible in English. Thirdly, the child hears some wh-words with uninverted auxiliaries in subject (especially *who*) wh-questions and *how come* questions. S/he has to learn from exposure to inverted questions in her/his input, that matrix object wh-questions must always have inverted auxiliaries.

The important part of Valian *et al*.'s (1992) theory for the purpose of the present analysis is the assertion that each wh-word has its own properties which children have to learn individually. The fact that inversion is

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obligatory in object wh-questions is one of these properties. For some wh-words, the child will learn this very quickly so there will be little or no period of optional inversion. For other wh-words, the process takes longer and the period of optional inversion will be extended. A problem with this analysis is its failure to provide any explanation of why children should treat each wh-word differently, given the assumption that children know that each wh-word belongs to a wh-word category. Valian *et al*. suggest that children may be misled by wh-subject questions into thinking optional inversion is acceptable in English grammar but do not explain why children do not make this mistake with all wh-words. In addition, they do not explain why children do not overgeneralize the optional inversion rule to wh-subject questions as well, producing incorrectly inverted wh-subject questions.

Although these issues are problematic for Valian *et al*.'s theory, they do not directly address the question of whether there is evidence in the data that the child has an optional inversion rule. Like deVilliers, Valian *et al*. attempt to draw a principled distinction between the questions to which the child applies a correct rule and those to which s/he applies an incorrect rule. Unlike deVilliers's account, however, the theory predicts that the child operating with the wrong rule will produce inverted as well as uninverted forms. This makes the theory very difficult to test since it predicts all possible combinations of inversion and uninversion. A child who produces inverted and uninverted questions with all wh-words can be said to have an optional rule with all wh-words. A child who produces only inverted questions has 'hit upon' the correct rule. A child who produces uninverted questions with only a few wh-words has a mixture of optional and obligatory rules applied to different wh-words. It is difficult to see how to test the predictions of a theory that predicts every conceivable acquisition sequence.

One way to investigate whether the data support this theory is to examine the assumption that the child is applying a movement rule to an auxiliary CATEGORY.[3] The child may have reason to apply different inversion rules to different wh-words but has no reason, within the theory, to apply different rules to different auxiliaries. Inversion should not be affected by the auxiliary item itself, only by the wh-word with which the auxiliary is used. For example, a child with an optional inversion rule for *what* should produce inversion optionally with all members of the auxiliary category. When the child combines *are* with *what*, *are* should be equally likely to occur in pre- as post-subject position (e.g. the child should be equally likely to produce *what are you doing*? as **what you are doing*?). In other words, there should be

[3] Although Valian *et al*. (unpublished) suggest that children initially lack knowledge that tense must be lexicalized and knowledge of the range of modals, these two factors can only be used as an explanation of the production of wh-questions with missing auxiliaries. The presence of uninverted questions cannot be explained in these terms.

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overlap in the wh-word + auxiliary combinations that occur in inverted and uninverted questions. Only if this is the case, can we conclude that there is evidence that the child is even-handedly applying an optional inversion rule to all members of the auxiliary category.

A constructivist approach – lexical learning

By analysing the two movement rule theories outlined above it should be possible to answer the following question: does the evidence support the assumption that knowledge of how to apply the subject–auxiliary inversion rule to grammatical categories underlies early wh-question production? If the evidence does not support this assumption we suggest that the data may reflect lexically-specific knowledge that is much more limited in scope than has previously been assumed. The final section of the introduction details a preliminary account of how inverted wh-questions could be produced with reference to lexical knowledge rather than to a subject–auxiliary inversion rule.

There is a long history of research that indicates that young children's grammatical understanding may be best described in terms of lexically-specific knowledge. In an analysis of the corpora of 11 children, Braine (1976) concluded that children's early multi-word speech seemed to consist of limited scope formulae produced in order to realize specific kinds of meanings. He demonstrated that many of the children's early utterances seemed to be produced using 'constant + variable' patterns, in which individual words were used in a single position and combined with a variety of other words. For example, *more*, *all*, *no* and *other* were all used in a constant position, followed by a variety of different lexemes. More recently, constructivist researchers (e.g. Tomasello, 1992; Pine & Martindale, 1996; Lieven, Pine & Baldwin 1997; Pine & Lieven, 1997; Pine, Lieven & Rowland, 1998) have suggested that the nature of early multi-word speech may well be captured by a theory positing lexically-specific knowledge based around constant + variable patterns. For example, Pine & Lieven (1997) have reported that children's early determiner use seems to reflect low-scope lexically-specific knowledge of the type *that's a X*, *where's the Y* (where *X* and *Y* represent initially mutually exclusive groups of nouns or noun phrases). Such lexical specificity could be explained by hypothesizing that the high frequency determiners *a* and *the* are learnt in combination with vocabulary items and initially reproduced in the different lexically-specific frames in which they occurred in the input. The development of the determiner category would subsequently involve a gradual broadening of scope as the child built up knowledge of the number of, and overlap between, the lexically-specific frames in which determiners can appear; a process that would ultimately result in adult-like, abstract generalizations across different frames and determiners.

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In the case of wh-question acquisition, early correctly inverted wh-questions would be explained, not in terms of a subject–auxiliary inversion rule, but with reference to a small number of lexically-specific frames incorporating a constant or 'marker' combined with a variety of different lexical items or phrases. Non-inversion errors could be seen as examples of 'groping patterns' (Braine, 1976) in which the child is attempting to produce a question before s/he has acquired the knowledge necessary for its correct expression. These would only occur when the child has not learnt the relevant lexically-specific frame and/or marker with which to produce a correct question. Errors would disappear gradually as the child learns more correct frames and as the initially lexically-specific knowledge slowly generalizes across all members of the auxiliary category.

In order to test this hypothesis, we need to define the nature of the child's lexically-specific knowledge. This is difficult to do *a priori* as, unlike rule-based theorists, constructivists cannot rely on descriptions of the adult grammar to motivate predictions about the child's knowledge. It could be argued that the auxiliary and subject of the question should be examined since these are the elements involved in the inversion. However, since the account predicts that the child is producing wh-questions without knowledge of the inversion rule, we have no reason to anticipate that the relation between the subject and the auxiliary is the important one from the child's point of view. In addition, there are two reasons to predict that in the case of wh-question acquisition, the child's lexically-specific knowledge is likely to centre round wh-word + auxiliary combinations rather than auxiliary + subject combinations or, indeed, individual vocabulary items as has been suggested for other grammatical systems (e.g. Pine & Lieven, 1997; Pine *et al.*, 1998). First, there is evidence that the earliest wh-questions produced with an auxiliary can be explained with reference to three formulaic patterns that begin with a limited range of wh-word + auxiliary combinations (e.g. Fletcher, 1985). If later wh-questions are constructed in much the same way as these early formulae, the wh-word + auxiliary combinations would be predicted to serve the same function. Secondly, the range of possible wh-words and auxiliaries is more limited than the range of potential subjects and verb phrases, so the most likely constant in wh-questions is the wh-word + auxiliary combination. For the purpose of the present paper, therefore, we suggest that children's early inverted wh-questions are composed of formulaic wh-word + auxiliary combinations, combined with a variety of different noun phrase and/or verb phrase sequences.

The advantage of this account is that it allows us to explain the pre-subject positioning of the auxiliary in the child's correctly inverted wh-questions without having to credit the child with a subject–auxiliary inversion rule. Correctly inverted wh-questions will be produced when the child has learnt a wh-word + auxiliary marker around which to base her/his question frame.

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Uninversion errors will only occur when the child has not learnt the particular wh-word + auxiliary marker around which to base the question s/he wishes to ask. The third analysis in the present paper will test whether inverted and uninverted wh-questions occur with different populations of wh-words and auxiliaries to ascertain whether correctly inverted wh-questions are produced with reference to a few lexically-specific wh-word + auxiliary combinations and uninversion errors only produced when the child has no relevant wh-word + auxiliary specific knowledge with which to construct her/his question.

The final analysis addresses the question of why children learn some wh-word + auxiliary combinations before others. We suggest that the lexically-specific nature of early multi-word speech is consistent with the idea that children's early grammatical constructions reflect a process of 'functionally-based distributional analysis' of their input (Tomasello, 1992). Pine *et al.* (1998) have suggested that an information-processing system that is constrained by the limits which apply to human distributional learning (Braine, 1987, 1988) could reproduce the lexically-specific effects that have been reported in early multi-word speech data by learning how high frequency markers interact with the groups of lexical items with which they occur in the input. Although a preliminary explanation of the data rather than a well-specified account of language development, such an approach relies on there being a strong relationship between the nature of the lexically-specific patterns in the child's speech and the frequency with which such patterns occur in the child's input. Based on this suggestion, we hypothesize, first, that correctly inverted wh-questions will be produced when the child has learnt the appropriate lexically-specific wh-word + auxiliary combination from the input. For this to occur, the combination will have to be present in the mother's speech with sufficient frequency for the child to learn it. Secondly, if uninverted wh-questions are produced when the child has no appropriate model available, we would predict that the wh-word + auxiliary combinations that are necessary to produce the correct wh-questions are not of sufficiently high frequency in the input for the child to learn them. The final analysis in the present paper investigates the prediction that the wh-word + auxiliary combinations that the child uses in inverted wh-questions will be of significantly higher frequency in the child's input than the wh-word + auxiliary combinations that the child fails to use in order to test whether the data support the hypothesis that inverted questions can be produced with reference to high frequency wh-question models in the input, without knowledge of a subject–auxiliary inversion rule.

To summarize, the present paper will investigate whether there is evidence in one child's data to support the assumption that early wh-questions are produced using the subject–auxiliary inversion rule. Two attempts to explain subject–auxiliary inversion errors with reference to the subject–auxiliary

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inversion rule are examined. DeVilliers's (1991) adjunct analysis predicts that adjunct wh-words *why* and *how* will be more likely to occur with non-inversion errors than argument wh-words *what* and *who*. Valian, Lasser & Mandelbaum's (1992) optional inversion rule predicts that because the child is operating with the auxiliary category there will be overlap in the wh-word + auxiliary combinations that occur with and without inversion. If the data support either of the above predictions, the evidence would appear to support the view that the child is producing wh-questions by applying a subject-auxiliary inversion rule. If, however, the wh-questions that occur with inversion can be defined in terms of lexically-specific markers (wh-word + auxiliary combinations) combined with a variety of lexical items, and if the distinction between inverted and uninverted questions can be predicted by the difference between high and low frequency wh-word + auxiliary combinations in the child's input, then we suggest a different explanation. A distributional learning mechanism that acquires and reproduces lexically-specific wh-word + auxiliary combinations which have been heard in the input could provide an answer to the question of how children learn to produce correctly inverted wh-questions without access to a subject-auxiliary inversion rule.

METHOD

The analyses were performed on the longitudinal data from one child – Adam from the Brown corpus (Brown, 1973) made available on the CHILDES database (MacWhinney & Snow, 1985, 1990). Fifty-five hours of Adam's data are available, including a large number of both inverted and uninverted questions. Given the nature of the analyses in the present paper (i.e. assessing evidence for lexical specificity) longitudinal data from one child were considered more reliable than cross-sectional data from several children. The use of such data reduces the possibility that any lexical specificity in the child's speech is due to sampling constraints.

Child data

All matrix object (argument and adjunct) wh-questions (i.e. questions that require inversion according to adult grammatical rules) were extracted from the 55 one-hour transcripts recorded when Adam was between the ages of 2;3.4 and 4;10.23. Mean length of utterance (MLU) ranged from 2·14 morphemes at the beginning to 4·54 morphemes at the end. Six different wh-words were used by Adam – *how*, *what*, *why*, *which*, *where* and *who*. In line with Klee's (1985) interpretation, the period of high uninversion was defined as beginning when Adam's MLU reached 3 morphemes (measured by two consecutive tapes with a MLU over three morphemes), and ended when Adam's MLU (in two consecutive tapes) reached 4 morphemes. This period corresponded to transcripts 19–36 (MLU 3·24–4·10) and will be referred to

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as the 'uninversion period'. Although uninverted questions were produced before and after this period, defining the period in this way makes it possible to control for the child's developmental level across analyses.

All analyses were conducted on types, not tokens, to ensure that the presence of highly frequent but rote-learned phrases (e.g. *how do you do?*) would not influence the results. Two tokens were defined as the same type if the wh-word, auxiliary, subject, verb and, if present, prepositional phrase were identical. For example, '*what is he doing?*' and '*what is he doing in that car?*' were counted as two types, but '*what is he doing?*' and '*what is he doing, Mummy?*' as one type.

Certain utterances were removed from the dataset. These included partially intelligible or incomplete (e.g. interrupted or trailing off) utterances, utterances with parts marked as unclear or questionable, quoted utterances, routines and utterances where the child's meaning was unclear (e.g. if it was unclear whether the utterance was a matrix question or an embedded question fragment then the question was discarded). Full or partial repetitions or imitations of the five previous utterances were excluded, as were questions with double auxiliaries (e.g. **what can he can do?*) and those with a missing subject (e.g. **what can do?*). Questions with the copula were also removed from the dataset. All matrix object questions were coded for inverted, uninverted or missing auxiliaries. Questions with missing auxiliaries were not included in the individual analyses.

Input data

Maternal utterances from the ten transcripts of tapes recorded immediately prior to the 'uninversion' period were extracted (transcripts 9–18). These tapes, produced before the tapes that were used for the child data analyses, were chosen to minimize the likelihood that any similarities found between the mother's and the child's data could be due to context-specific effects or the impact of the child on the mother's speech. All fully transcribed wh-questions were coded as 'matrix object question' or 'other'. All wh-questions with the copula were excluded. Two utterances were excluded, one with a missing subject and one with a missing auxiliary. Analyses were, again, performed on types not tokens.

RESULTS

Overview of the acquisition of inversion

The dataset (transcripts 1–55) was divided into nine data points, the first eight consisting of six consecutive transcripts, the final data point consisting of seven consecutive transcripts. Figure 1 details the percentage of wh-questions produced by Adam with inverted, uninverted and omitted

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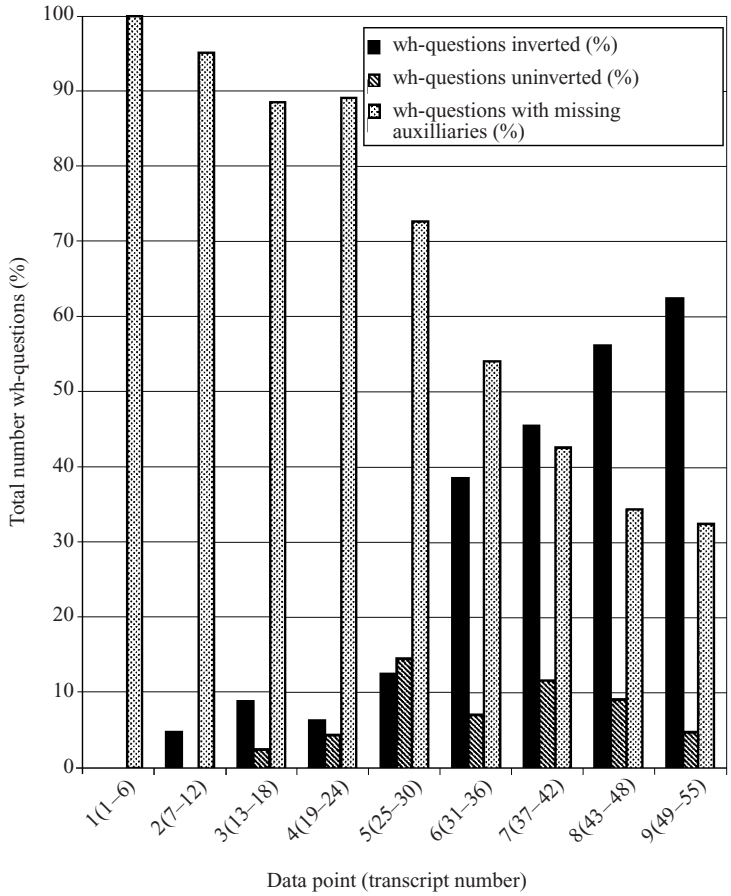


Fig. 1. Percentage of WH-questions with inverted, uninverted and missing auxiliaries as a proportion of total number of WH-questions produced in the child's data

auxiliaries at each of the 9 points between the ages of 2;3.4 and 4;10.23 (MLU 1·83–4·97). From the graph it is possible to see that the proportion of Adam's questions with missing auxiliaries decreases over time as the proportion of correctly inverted questions increases. Uninversion errors, however, show a different pattern. Adam does not start to make uninversion errors consistently until his mean length of utterance exceeds three morphemes (the uninversion period: data points 4–6, transcripts 19–36, MLU 3·24–4·10, Age 2;11.28–3;8.14). The proportion of uninversion errors produced rises to a peak in this period, (14·6% of all wh-questions at point 5, transcripts 25–30, mean MLU 3·82). At this peak, Adam produces slightly more uninverted questions than inverted questions (12·6% of all wh-

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TABLE 1. *Number of wh-words that occur with inverted and uninverted auxiliaries during the uninversion period (data points 4–6, transcripts 19–36, MLU 3·24–4·10, age, 2;11.28–3;8.14) and % as a proportion of the total number of times each wh-word occurred with either form*

Wh-word	Number inverted	Number uninverted	Inverted (%)	Uninverted (%)	Total
What	55	15	78.6	21.4	70
Who	4	0	100	0	4
How	41	7	85.4	14.6	48
Why	3	33	8.3	91.7	36
Which	2	1	66.7	33.3	3
Where	11	4	73.3	26.7	15
Total	116	60	65.9	34.1	176

TABLE 2. *Number of times* ***how/why*** *and* ***what/who*** *occur with inverted and uninverted auxiliaries during the uninversion period and % of total number of times each occurred with either form*

Wh-word	Number inverted	Number uninverted	Inverted (%)	Uninverted (%)	Total
What/Who	59	15	79.7	20.3	74
How/Why	44	40	52.4	47.6	84
Total	103	55	65.2	34.8	158

questions are inverted, 14·6% uninverted) although many fewer than questions with omitted auxiliaries (72·8% of all wh-questions). The number of uninverted questions decreases after Adam's MLU reaches four morphemes, although there is a later, smaller peak where uninversion errors account for 11·7% of all Adam's wh-questions (data point 7, transcripts 37–42, mean MLU 4·17). At no stage in development does the proportion of uninverted questions account for more than 14·6% of all wh-questions.

Table 1 details the number of inverted and uninverted questions that occurred with each wh-word during the uninversion period (data points 4–6, transcripts 19–36, MLU 3·24–4.10, Age 2;11.28–3;8.14).

Six wh-words were produced with an auxiliary – *what*, *who*, *why*, *how*, *which* and *where*. Only *who* was never produced with an uninverted auxiliary. All wh-words were produced more often in inverted than uninverted questions except *why* which was produced 91·7% of the time with an uninverted auxiliary. This result is consistent with previous analyses which show that *why* is the wh-word most likely to occur in an uninverted question (e.g. Erreich, 1984; Klee, 1985; Labov & Labov, 1978; Stromswold, 1990).

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DeVilliers's (1991) *adjunct analysis*

To test the prediction made by deVilliers's (1991) theory that the adjunct wh-words *why* and *how* should show a greater amount and a longer lasting period of uninversion than argument wh-words *what* and *who*, two analyses were performed. The first examined whether during the uninversion period (MLU 3·24–4·10, data points 4–6, transcripts 19–36) Adam produced more uninverted questions with adjunct words than with argument words. The number of inverted and uninverted question types with *why* or adjunct *how* was compared with the number with *what* or *who* (see Table 2). Argument *how* questions (e.g. *how big*, *how long*, *how many*) were excluded from the analysis. Together, the adjunct words *why* and *how* show significantly more uninversion than *what* and *who* ($\chi^2 = 12{\cdot}97$, d.f. = 1, $p < 0{\cdot}001$), which seems to support the prediction of deVilliers's theory. However, from Table 1, it is possible to see that although *why* occurs more often in uninverted questions than any other wh-word (only 9·3% of *why* questions are inverted), *how* occurs more often in inverted form than *what* (85·4% of *how* questions are inverted but only 78·6% of *what* questions). DeVilliers's theory predicts that both *why* and *how* should occur more often uninverted than argument wh-words so a further test was carried out with *why* removed to test if *how* occurred significantly more often in uninverted questions than *what* and *who*. The result was not significant (χ^2 *how* × *what*/*who* = 0·67, d.f. = 1, p = n.s.). The initial significant difference between adjunct and argument words is due to the fact that *why* but not *how* shows a greater amount of uninversion (χ^2 *why* × *what*/*who* = 50·19, d.f. = 1, $p < 0{\cdot}001$). Contrary to the predictions of deVilliers's theory, the adjunct word *how* does not occur less often with inversion than the argument words *what* and *who*.

The second analysis investigated whether *how* and *why* occurred in uninverted questions for a longer period of time than *what* and *who*. The number of questions with *what*, *why* and adjunct *how* that occurred in inverted form expressed as a proportion of the total number of times each wh-word occurred with either an inverted or uninverted auxiliary at each of six data points was calculated (data points 4 9, transcripts 19–55, see Fig. 2). *Who* was not included as there were not sufficient *who* questions at each data point for analysis. The first three data points (transcripts 1–18) were excluded because there were not enough questions overall in these transcripts for analysis.

Only *why*, not *how*, shows a greater delay in inversion than *what* (see Fig. 2). Eighty percent of *why* questions occur with inversion only after data point 8, (transcripts 43–48, mean MLU 4·61). *How* and *what* both occur over 88% of the time with inversion consistently after data point 6 (transcripts 31–36, mean MLU 3·88). Contrary to deVilliers's prediction, the adjunct word *how* does not show a greater delay in reanalysis than the argument word *what*. It

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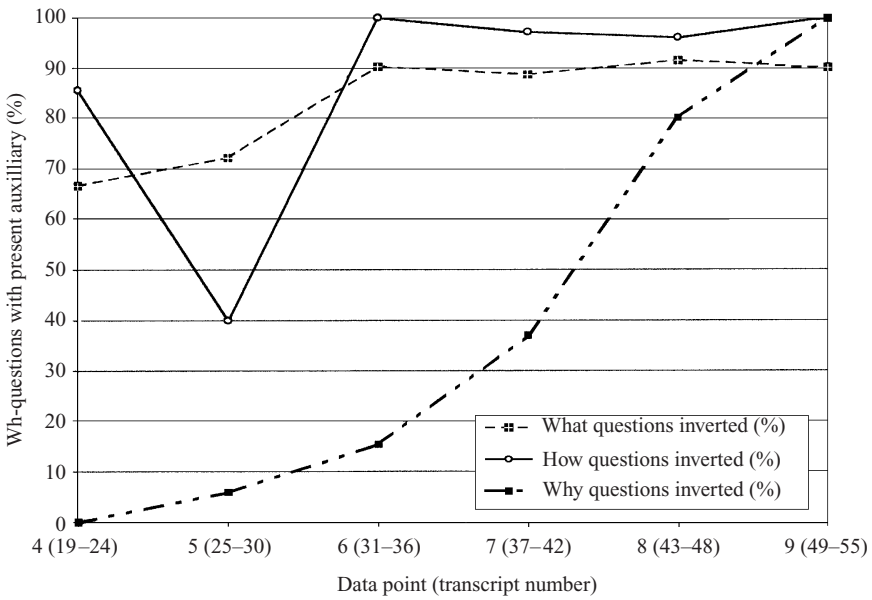


Fig 2. Percentage inverted *What*, *Why* and adjunct *How* questions at each data point. The inversion rate for each wh-word is expressed as a percentage of the total number of wh-questions that occur with that wh-word and contain an auxiliary (inverted or uninverted). The graph refers only to data points 4–9 (transcripts 19–55, age of child 2;11.28–4;10.23, MLU 3·24–4·97).

is not possible to distinguish between argument and adjunct wh-words in the way deVilliers's theory predicts.

Wh-word specific optional inversion rule – Valian, Lasser & Mandelbaum (1992)

To test the prediction that for each wh-word that shows optional inversion, there will be overlap in the auxiliaries that are used inverted and uninverted, data were taken only from the period defined as the 'uninversion period' (data points 4–6, mean MLU 3·24–4·10, transcripts 19–36). Although Adam continued to produce uninversion errors after this point, analysing only the wh-questions produced in a single developmental period (MLU 3–4) reduces the possibility that any overlap found is due to the child changing from an optional to an obligatory pattern during the test period.

Table 3 details each wh-word that was produced by the child, the auxiliaries that occurred with each wh-word and whether each auxiliary occurred in inverted or uninverted form. The wh-word inversion rates presented in Table 1 were used to ascertain which wh-words showed optional inversion. During the period, *what*, *how*, *why*, *which* and *where* showed

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TABLE 3. *Total number of wh-word + lexical auxiliary combinations that occur inverted and/or uninverted during the uninversion period*

Wh + aux combination	Number inverted	Number uninverted	Total
how can	**2**	**4**	**6**
how can't	0	3	3
how could	1	0	1
how did	5	0	5
how do	19	0	19
how does	14	0	14
what am	1	0	1
what are	14	0	14
what're	1	0	1
what is	4	0	4
what'is	**1**	**1**	**2**
what was	1	0	1
what can	0	7	7
what did	2	0	2
what do	27	0	27
what does	2	0	2
what have	1	0	1
what'has	1	0	1
what may	0	1	1
what shall	0	1	1
what should	0	2	2
what will	0	3	3
where'is	1	0	1
where could	1	0	1
where did	1	0	1
where do	3	0	3
where does	3	0	3
where had	1	0	1
where shall	1	0	1
where should	0	2	2
where will	0	2	2
which does	2	0	2
which should	0	1	1
who are	1	0	1
who're	2	0	2
who do	1	0	1
why is	**1**	**1**	**2**
why'is	0	3	3
why can	0	3	3
why can't	0	10	10
why couldn't	0	1	1
why did	0	1	1
why didn't	0	2	2
why do	2	0	2
why don't	0	6	6
why doesn't	0	3	3
why 'has	0	1	1
why might	0	1	1
why won't	0	1	1
Total	116	60	176

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optional inversion. Only *who* was never produced in an uninverted question. For each of the five wh-word that showed optional inversion, the number of times each lexical auxiliary was used in inverted and uninverted form was calculated. A lexical auxiliary was defined as any different form of a particular auxiliary (for example, *is*, *are* and contracted '*s* were counted as three lexical auxiliaries) in order to distinguish between overlap caused by the application of an optional inversion rule and overlap due to the child using one form of an auxiliary (e.g. *is*) in inverted questions and another (e.g. *are*) in uninverted questions.

There were 46 different wh-word + auxiliary (wh + aux) combinations and 172 different question types, 112 in inverted and 60 in uninverted form. Contrary to the predictions of Valian *et al.*'s theory, only three of the 46 combinations occurred in both inverted and uninverted form; *how* + *can*, *what* + '*is*, *why* + *is*. These three overlapping combinations only accounted for 10 (5·8 %) of the 172 different question types. If the 19 combinations that only occurred once and could not, thus, show any overlap are removed the three combinations still only account for 6·5 % of the 153 different question types. Although the lack of overlap could be due to sampling constraints, this seems unlikely given the number of questions included in the sample (172 different wh-question types, 46 different wh + aux combinations). In addition, if this was the case, one might expect that the combinations that occur most often in Adam's speech would be the ones most likely to show overlap. However, not one of the six combinations that occurred seven or more times showed any overlap (*what do* occurred 27 times, *how do* occurred 19 times, *what are* and *how does* occurred 14 times, *why can't* occurred 10 times and *what can* occurred seven times in inverted form but never in uninverted form). The results do not support the prediction of Valian *et al.*'s theory.

A constructivist approach – lexical learning

The first prediction to be tested was that inverted and uninverted wh-questions involve different pairs of wh-words and auxiliaries. Table 3 details the wh-word and auxiliary pairs that the child used in inverted and uninverted form. Only three of the 49 wh-word and auxiliary pairs showed optional inversion, *how* + *can*, *what* + '*is*, *why* + *is*. These accounted for 10 of the 176 different wh-question types produced by Adam in total (5·7 %). The data uphold the prediction in that almost all inverted and uninverted wh-questions are produced with different wh-word and auxiliary pairs.

Some may argue that this result could be explained in terms of the child selectively applying the subject–auxiliary rule to some auxiliaries and not others. For example, from Table 3 it seems that some auxiliaries (e.g. *can* and the negatives, e.g. *don't*, *can't*, *won't*) almost always occur in uninverted wh-questions, and others show a strong tendency to invert (e.g. *do*, *did*, *does*). In

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order to check that the results presented above were not an epiphenomenon of auxiliary-specific, rather than wh + aux-specific learning, an additional analysis was conducted to ascertain whether the distinction between inverted and uninverted combinations could be more accurately described in terms of specific auxiliaries. Table 4 details the auxiliaries used in both inverted and

TABLE 4. *Total number of auxiliaries that occur inverted and/or uninverted during the uninversion period*

Auxiliary	Number inverted	Number uninverted	Total
am	1	0	1
are	15	0	15
-'re	3	0	3
can	**2**	**14**	**16**
can't	0	13	13
could	2	0	2
couldn't	0	1	1
did	**8**	**1**	**9**
didn't	0	2	2
do	52	0	52
don't	0	6	6
does	21	0	21
doesn't	0	3	3
had	1	0	1
-'has	**1**	**1**	**2**
have	1	0	1
is	**5**	**1**	**6**
-'is	**2**	**4**	**6**
may	0	1	1
might	0	1	1
shall	**1**	**1**	**2**
should	0	5	5
was	1	0	1
will	0	5	5
won't	0	1	1
Total	116	60	176

uninverted wh-questions by Adam during the uninversion period (data points 4–6, mean MLU 3·24–4·10, transcripts 19–36). The table shows that six of the 25 auxiliaries produced showed overlap between inverted and uninverted use (24%, -'*is*[4] *is*, *did*, *shall*, *can* and -'*has*), accounting for 41 of

[4] The CHAT convention for contraction is used (MacWhinney & Snow, 1985, 1990). The auxiliary is written in full (e.g. *is*, *has*, *does*) but -' indicates a contracted auxiliary. Therefore, -'*is* indicates a contracted *is*, -'*has* indicates a contracted *has*, and -'*does* indicates contracted *does*.

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TABLE 5. *Total number of wh + aux combinations that occur inverted and/or uninverted during the uninversion period and their frequency in the input sample*

Inverted wh + aux	Number in input sample	Uninverted wh + aux	Number in input sample	Inverted & uninverted wh + aux	Number in input sample
how could	0	how can't	0	why is	1
what was	0	what can	0	how can	3
what have	0	what may	0	what'is	7
what'has	0	what shall	0		–
where'is	0	what should	0		–
where had	0	where should	0		–
where shall	0	which should	0		–
which does	0	why'is	0		–
who are	0	why can	0		–
who're	0	why can't	0		–
who do	0	why couldn't	0		–
how does	2	why doesn't	0		–
what am	2	why 'has	0		–
what is	2	why might	0		–
where could	2	why won't	0		–
what're	4	where will	1		–
where do	4	what will	3		–
how did	5	why didn't	3		–
where does	6	why did	6		–
why do	13	why don't	22		–
how do	14				–
what does	18				–
what did	19				–
where did	22				–
what are	25				–
what do	37				–
Total	175		35		11

the 176 different wh-questions asked (23·3 %). This is compared to only three of the 49 wh-word and auxiliary pairs. It would, therefore, seem that, although some auxiliaries show a strong inversion or uninversion bias, the identity of the auxiliary used does not predict the inversion/uninversion distinction as well as the identity of the wh + aux combination.

The final analysis tested the prediction that the child may be producing correctly inverted wh-questions by reproducing wh + aux combinations that have been learnt from high frequency combinations in the input. We predicted that the inverted wh + aux combinations the child uses will be of higher frequency in the input than the wh + aux combinations the child fails to use (i.e. that occur divided by a subject in uninverted questions). All inverted wh-questions were extracted from the ten-hour input sample. As

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this is only a sample of the mother's data, we cannot expect to be able to identify all the wh + aux combinations that the mother uses. However, from 10 one-hour transcripts we should be able to distinguish the relative frequency of different wh + aux combinations in the mother's speech in order to investigate whether the combinations the child uses tend to be more frequent in the input sample than those the child fails to use.

Table 5 details the wh-words and auxiliaries the child uses in inverted and uninverted questions together with the number of times each occurs (correctly inverted) in the input sample. The three wh + aux combinations that occurred in inverted wh-questions and, divided by a subject, in uninverted questions were present in inverted form in the input sample. These were excluded from the analysis. In line with the predictions of the hypothesis, the wh + aux combinations the child uses are more frequent in the mother's input than those the child fails to use (i.e. that occur divided by a subject in uninverted wh-questions) (Median = 2 versus Median = 0, Mann-Whitney U = 164·5, n1 = 20, n2 = 26, $p < 0{\cdot}05$ 2-tailed).

DISCUSSION

The purpose of the present study was to investigate whether there was any evidence in one child's early wh-question data that the child was using a subject–auxiliary inversion rule to produce correctly inverted wh-questions. The first two analyses investigated the claims of two movement rule-based theories that the child was applying the subject–auxiliary inversion rule to produce correctly inverted questions but was failing to apply this rule when producing uninversion errors. The data do not support the predictions of either theory. DeVilliers's (1991) adjunct analysis predicts delayed acquisition of inversion with the adjunct words *how* and *why* but in Adam's data only *why* occurs later and less often with inversion than the argument words *what* and *who*. The data do not support the hypothesis that the child is distinguishing between adjunct and argument words. Valian *et al*.'s (1992) optional inversion rule can explain both the fact that *why* is more likely to occur uninverted than other wh-words and the fact that uninversion is not restricted solely to *why* questions. However, since Valian *et al*. only distinguish between different wh-words, not different auxiliaries, their theory would predict optional inversion equally with all auxiliary verbs. It cannot explain why Adam's inverted and uninverted questions can be divided into two sets of lexically-specific question formulae, with little overlap between the wh + aux combinations that occur in inverted and uninverted questions.

This finding poses a problem for all movement rule accounts which, while acknowledging the existence of lexically-specific effects at the earliest stages of multi-word speech, do not attribute any role to lexically-specific knowledge in the development of more complex grammatical relations, such as wh-

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questions. Although the present study is based on only one child and will need to be replicated before strong conclusions can be drawn, it suggests that in order to make claims about the child's category-general knowledge of movement rules, rule-based theorists must support their conclusions with positive evidence for category-general, as opposed to lexically-specific, knowledge in children's data. In addition, future movement rule theories of wh-question acquisition need to be able to explain why inverted and uninverted questions include different wh-word and auxiliaries, and why inverted wh + aux combinations are very similar to the type of lexically-specific markers seen in children's initial wh-questions (Fletcher, 1985) and to those reported in the literature on the early acquisition of other grammatical structures (e.g. Braine, 1976; Kuczaj & Maratsos, 1983; Ninio, 1988; Tomasello, 1992; Pine & Martindale, 1996; Lieven, Pine & Baldwin, 1997; Pine, Lieven & Rowland, 1988).

The final analyses examined an alternative, constructivist account of wh-question acquisition which suggests that children could produce correctly inverted wh-questions without access to the subject–auxiliary inversion rule by learning how high frequency markers (in the case of wh-questions, wh + aux combinations) interact with the groups of lexical items with which they occur in the input. This account predicted that inverted questions in the child's data would be produced with the wh + aux combinations that had occurred with high frequency in the child's input. Uninverted questions would be produced when the child had no high frequency model on which to base the question. The data supported this prediction. First, there was very little overlap between the wh-words and lexical auxiliaries present in the child's inverted and uninverted wh-questions and second, the wh-words and auxiliaries that were produced in correctly inverted questions by the child were significantly more frequent in the input sample than the wh-words and auxiliaries that occurred in uninversion errors.

The present study supports the hypothesis that children will only produce correctly inverted wh-questions when they have been able to learn the relevant wh + aux combinations necessary to produce the question from the input. The results add to a growing body of evidence that suggests that children's early multi-word speech may reflect low scope lexically-specific knowledge, not abstract category-general rules (see e.g. Braine, 1976; Ninio, 1988; Tomasello, 1992; Lieven, Pine & Baldwin, 1997; Pine, Lieven & Rowland, 1998). This evidence seems to support the suggestion that a distributional learning mechanism capable of learning and reproducing the lexically-specific patterns that are modelled in the input may be able to explain much of the early multi-word speech data. However, there is obviously a need to develop a more detailed model than that suggested in the present paper; a need illustrated by the two issues that are considered in the remainder of this discussion.

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The present paper has focused on wh+aux combinations as high-frequency markers but, as discussed in the introduction, this is a decision based on the grounds, first, that a child's earliest wh-questions may be explained with reference to patterns beginning with a few wh+aux combinations (Fletcher, 1985) and, secondly, that the limited range of possible wh-words and auxiliaries makes these more likely constants than verbs and/or subjects. However, there is no reason why only wh+aux combinations should function as wh-question markers for the child. In fact, it is much more likely that these markers will vary depending on the nature of the input. For example, all maternal *why don't* questions were in fact *why don't you* questions. A possible explanation for why Adam only produced UNinverted *why don't* questions is that he may have picked up a *why don't you* formulae from the input that was not suitable for use in most of his *why don't* questions. A *why don't you* formula would only be a suitable template for one of Adam's six *why+don't* questions. The same type of explanation could be applied to the three wh-words and auxiliaries used in both inverted and uninverted wh-questions. These examples illustrate that the lexically-specific knowledge of language-learning children may take different forms depending on the patterning of the child's input. In order to take effects such as these into account, there is a need for a well-specified distributional learning mechanism that makes strong predictions about the nature of the lexically-specific knowledge such a mechanism would produce, and about the exact relationship between the child's knowledge and the frequency distribution of the child's input. Only with such a model will it be possible to determine how much of early multi-word speech data can be explained in terms of input-driven lexically-specific knowledge and how much must be attributed to other factors such as the phonological salience of items in the input and/or semantic and syntactic constraints.

Secondly, although this paper has concentrated on explaining how children could produce inverted wh-questions without access to a subject–auxiliary inversion rule, the issue of why children produce uninversion errors, given that such utterances are never heard in adult data, is relevant. The literature seems to show that uninversion is most predominant with *why* and with negative auxiliaries (e.g. Bellugi, 1971; Brown, Cazden & Bellugi, 1969; Labov & Labov, 1978), a fact that the present study supports. Some have suggested that children will produce uninversion errors with *why* because the concept of *why* is hard to acquire (Ravem, 1974) or because *why* is a wh-sentential that does not simply stand for a missing constituent but involves clarification of the semantic relations in the whole sentence (Wooten, Merkin, Hood & Bloom, 1979). Others have suggested that children will have problems inverting negative auxiliaries, perhaps because negatives are syntactically more complex to construct (Bellugi, 1971). However, we suggest that *why* and negatives are more likely to occur in uninverted wh-

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questions simply because they are of lower frequency in the child's input. From Table 4 we can see that Adam produced 33 uninverted *why* questions. Only 10 of these questions contained wh-words and auxiliaries that had been modelled together in the input sample (30·3 %). Six of these 10 wh-questions occurred with *why don't*. If we remove these on the assumption that the child may have picked up a *why don't you* instead of a *why don't* pattern from the input (see discussion above), only four of the child's 33 uninverted *why* questions are modelled in the input (12·1 %).

The same explanation can be applied to the uninversion bias with negatives. Although all five of the child's negative auxiliaries (*can't*, *couldn't*, *doesn't*, *didn't*, *don't*) were used uninverted, three of these were absent from the input sample (*can't*, *couldn't*, *doesn't*). The other two were *why didn't* (which only occurred three times in the input sample) and *why don't* (see discussion above). From these results, we suggest that the reported uninversion bias for *why* and negatives may be an epiphenomenon of input frequencies.

In fact, these kinds of uninversion error can be seen as instances of 'groping' patterns, (Braine, 1976) said to be produced when the child attempts to construct a question for which s/he has not yet acquired the necessary knowledge. There is some evidence that the child may be adding a pre-subject wh-word to a declarative utterance, either one that has just occurred in his input (e.g. after the mother says '*you don't throw things*', the child asks '**why you don't throw things?*', Brown, Cazden & Bellugi, 1969) or one that s/he has constructed. For example, twelve of Adam's 60 (20 %) uninverted forms followed a mother's declarative sentence that modelled the same auxiliary in post-subject position (within the previous five mother utterances). Such an explanation would be compatible with the lexically-specific nature of children's knowledge as presented here and in other studies (e.g. Braine, 1976; Ninio, 1988; Tomasello, 1992; Pine & Martindale, 1996; Lieven, Pine & Baldwin, 1997; Pine, Lieven & Rowland, 1988) and could account for other types of errors. Auxiliary omission could be explained by positing that the child adds a pre-subject wh-word to an auxiliaryless sentence (e.g. *you like cakes* would become **why you like cakes*?); double auxiliary errors would be made when the child adds a wh + aux combination to a declarative sentence (e.g. *you don't like cakes* becomes **why don't you don't like cakes*?). However, once again, these sorts of suggestion are difficult to test empirically in the absence of a well-specified distributional learning model that would predict the exact relationship between the child's wh-questions and the child's input.

In conclusion, the present study found no evidence in one child's data to support the claim that the child was operating with a subject–auxiliary inversion rule applied to grammatical categories to produce inverted questions. Instead, when analyses are performed that make no prior

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assumptions about the nature of the child's knowledge, the pattern of apparent inversion and uninversion is best explained in terms of lexically-specific knowledge based on high-frequency patterns in the input. At the very least, these results suggest that future movement rule-based theories must account for lexical specificity in early wh-questions and that analyses must be applied which discriminate between positive evidence for category-general and lexically-specific knowledge in the child. In addition, the results provide some support for the claim that a learning mechanism which pays attention to the distributional patterning of the input could produce correctly inverted questions without access to a subject–auxiliary inversion rule. However, the problem of how to establish the exact nature of the child's lexically-specific knowledge argues strongly for the need to develop a well-specified model that makes explicit and detailed predictions about the nature of the distributional learning mechanism involved (see Gobet & Pine, 1997 for a preliminary attempt to build such a model). The development of such a model will make it possible to derive more precise, testable predictions about the exact nature of the child's knowledge and its relationship to the patterning of the input.

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