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From Singleton to Exhaustive: the Acquisition of Wh-

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1. Introduction: What is the Acquisition Problem Here?

Wh-words in the world's languages exhibit extraordinary variation in morphology, privileges of movement, and pragmatic sensitivity. Their interpretation remains a complex challenge for linguistic theory so it is natural for it to be a challenge for children too. An extensive literature on syntactic acquisition of *wh* explores the finding that children at first choose partial movement in a variety of languages where it is not allowed by adults (de Villiers, Roeper, & Vainikka, 1990; Thornton, 1990; Abdulkarim, 2001, for a review). With respect to the quantificational properties of *wh*-questions, different languages have different properties and provide different cues to children for how they should be interpreted. Chomsky (1973) argued that *wh*-words were Names because they behaved like Names in binding theory, while Nishigauchi (1999) argued that English *wh*-expressions have a hidden universal quantifier *every* within them. In contrast, Chinese *wh*-words have an overt indefinite quantifier [*wh-something*] (Cheng, 1991).

Beck and Rullman (1999) and recent work in semantics have focused upon the properties of exhaustivity and maximality, while others have observed that the pragmatics of partition have to be taken into account (Higgenbotham, 1993). Furthermore, linguistic expressions can guide one's interpretations, whether an expression is to be understood either non-exhaustively or exhaustively. Expressions such as *for example* in English and the equivalent *zum Beispiel* in German can override the property of exhaustivity. By adding expressions such as *alles* in German or dialect forms of *all* ("who all") in English the speaker makes explicit that she demands an exhaustive answer (Reis, 1992; Beck, 1996).

Recent work in the semantics of quantifier acquisition (see Crain and Thornton, 1998) have focused on showing when children "know" the meaning of quantifiers like *every*. It is a natural first step to ask when the adult grammar is achieved — but it leaves untouched the acquisition problem: How does the child fix language-particular properties of grammar when the surface of language has many confusing, even contradictory clues

(see Roeper, 1999, and Yang, 2003, on the presence of multiple grammars in language)? In particular, by what acquisition stages, from an initial default state to the target state, does the child come to understand the exhaustivity in *wh*-expressions? Thus, our research question can be formulated as in follows:

- (1) How and when does the child first grasp the set properties of *wh*-expressions?

That is, how does the child realize that a *wh*-word does not refer to a single object, but to a set, and thus that an answer to a *wh*-question requires a listing of all the members of the set, whether it is a set of one or many.

Our goal is to characterize a child's initial semantic assumptions, the initial state prior to the acquisition or realization of quantificational relations. Our discussion however will provide only an empirical and descriptive account, which responds to the empirical evidence we present. We hope that this account will stimulate discussion of how a bridge to adult formal representations should be conceived.

1.1 The [+variable] Feature

In this paper we argue that at the initial stage the child may lack a specific feature which we call [+variable], and which is present in quantifiers like *every* as well. The basic idea is that the absence of an underlying variable makes it impossible for the child to recognize exhaustivity, which in turn depends upon the [+variable] property. Note that we use the term [+variable] to refer to the notion of a variable reading. This use is pre-theoretical and does not correspond directly to a semantic representation as an Operator-Variable chain, as sketched in Section 2 for the adult grammar.

We will examine what we call the singleton reading and the child's progress to an exhaustive reading of *wh*-questions. The child possesses a singleton reading when she assumes that the answer to a *wh*-question has a single answer, where an adult will give an exhaustive answer. Consider (2):

- (2) Who has a hat?

When this question is asked while looking at a picture of several people some of whom are wearing a hat, an adult will give a list of all people with a hat. If a person responds by naming or pointing to one person with a hat, she is said to have a singleton reading.

We take the notion [+variable] to be in contrast to the notion of a collective plural. The [+variable] property of quantified elements is distinguished from collective plural by the fact that it does not take scope, as illustrated in (3):

- (3)
 - a. Boys have noses.
 - b. #Who has noses?
 - c. #Every boy has noses.

While (3a) can receive a distributive reading according to which a boy has one nose, (3b) and (3c) have the reading that each boy has several noses, which is pragmatically odd (here and in the following marked as #). In other words, *who* and *every* prevent a distributive reading, which can be captured by the presence of an underlying variable both in *who* and in *every*.

1.2 Exhaustivity and Specificity

Our conceptual scheme and experimentation is based on two concepts: specificity and exhaustivity each of which has been a focus of recent theoretical research. Work by Ihsane and Puskas (2001) adopts the definition of Enç (1991), who assumes that "... specificity involves a weak link, that of being a subset of or standing in some recoverable relation to a familiar object" (1991:22) (see also, among others, Cardinaletti and Starke, 1995; Knittel, 1998; and the references therein). This permits a distinction between definiteness and specificity, as stated below (Ihsane and Puskas, 2001: 40):

- (4) a. *Definiteness*: selects one object in the class of possible objects, whether or not it has been specified in the discourse.
- b. *Specificity*: relates to pre-established elements in the discourse

Given that definiteness and specificity are distinct, it follows that not all definite NPs are specific. Examples such as "John missed the train" show that the definite NP *the train* can be non-specific, referring to any, not pre-established train in the discourse.

In line with the observation that definite NPs can be specific or non-specific, Starke, building upon observations by Rizzi (1990) and Cinque (2002), has argued that *wh*-words are either specific or non-specific, with effects on their possible movement (Starke, 2000). Cinque (2002) observed the following contrast, illustrated in (5):

- (5) What did John know whether Bill weighed?
 His dog/*200 pounds

The specific form *his dog* can move over the adjunct, while the non-specific form *200 pounds* cannot.

Furthermore, we note this example from Roeper's corpus of child language — one of the rare instances of two *wh*-words in a sentence where this factor seems to allow a superiority violation (repeated twice so it was not a performance error):

- (6) Do you know what who is?

Here the child had a specific person with a specific costume in mind. The claim is that this unusual violation of superiority is possible because the child lacks a quantificational

property that would block it. Given this interpretation, (6) is no different from “Do you know what John is?”¹

For our purposes, we assume that a child initially responds to the question “Who has a hat?” as “Which one has a hat?” In other words, the child takes the adult’s question as presupposing the existence of a single such person.

Now what are the properties of specificity? It has been observed that it does not exclude quantification because *every* is specific in that it includes all members of a designated set. In contrast, the indefinite forms *a* and *some* are non-specific. Non-specific elements are necessarily of the [+variable] type. Therefore, one can say [-variable] necessarily arises in specific environments, as spelled out in (7).

- (7) a. specific = > [-variable] (i.e. singleton) or [+variable] as for *every*
b. non-specific = > [+variable]

We suggest that (7a) corresponds to the child’s initial assumption concerning the specificity of *wh*-questions, stated in (8).

- (8) Child’s initial default assumption: Questions are specific in nature.

2. Semantics of Exhaustivity

With respect to the semantic properties of *wh*- that the child must acquire, we follow Nelken and Shan (2004), and take the notion of exhaustivity to apply to *wh*-questions only. Furthermore, we assume that non-exhaustivity and exhaustivity of a *wh*-question are each reflected by a specific semantic representation. While non-exhaustive *wh*-questions involve existential quantification, exhaustive *wh*-questions involve universal quantification. We review non-exhaustive and two kinds of exhaustive *wh*-questions in turn and then consider various acquisition paths, drawing from Schulz and Reckling (2005).

Questions such as (9a), called “mention-some” questions, are non-exhaustive: Any assertion of a bathroom’s location such as (9b) qualifies as a complete answer (Groenendijk and Stockhof, 1984; Beck and Rullmann, 1999; Nelken and Shan, 2004). This question type is represented by existential quantification (9c):

- (9) a. Where is a bathroom around here?
b. There's one down the hall.
c. $\exists x. \Box p$ (where $\Box p$ = it is common ground or known that p
(Nelken and Shan, 2004)

¹ It is related to claims by Grohmann (p.c.) that superiority violations in German are possible only in D-linked environments where, again, specificity is satisfied.

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A complete answer is a single individual as in this dialogue.

Note that while an exhaustive answer such as (10a) is pragmatically odd, naming a few relevant locations such as in (10b), i. e. a plural, but not exhaustive answer, is acceptable.

- (10) a. #There's one down the hall, one upstairs on the first floor, one in the kitchen...
b. Down the hall, in the kitchen.

This observation is relevant for the experimental study presented below because there the plural represents a clear response option. As mentioned in Section 1, it is notable that the singleton reading can be marked by a modifier such as *for example* (Beck and Rullmann, 1999).

- (11) a. Who for example is wearing a hat?
b. John.
c. #John, Mary, Jill, Ben, ...

It is possible that adverbial markers play a role in triggering this option for the child's understanding of *wh-*. In particular, once exhaustivity is acquired, then the presence of *for example* has the effect of selecting one or few from the set.

Weak exhaustivity can occur with single *wh*-questions such as (12a). Here, a complete answer consists of an exhaustive list of all individuals sharing the property of wearing a hat (12b) (Groenendijk and Stockhof, 1984; Beck and Rullmann, 1999; Nelken and Shan, 2004).

- (12) a. Who is wearing a hat?
b. John, Mary, Jill, Ben, ...

Importantly, neither a singleton nor a plural answer is correct, as shown in (13).

- (13) a. #John.
b. #John and Mary.

In fact, in a legal environment, failure to be exhaustive would be a form of perjury. (14) does not permit a "for example" answer.

- (14) Who was in the car the night of the murder?

Following Nelken and Shan (2004), exhaustive *wh*-questions can be represented as in (15).

- (15) $\forall x_n p \rightarrow \Box p$

Besides single *wh*-questions, paired *wh*-questions can also receive an exhaustive reading. A complete answer to a question such as (16a) consists of an exhaustive list of

all pairs of individuals and objects who stand in an eating relation to each other. Imagine a situation, in which John, Mary, and Jill are eating. John is eating a banana, Mary an apple, and Jill an orange. Then, the complete answer is (16b), but none of the other alternatives, given in (16c) to (16f).

- (16) a. Who is eating what?
 b. John is eating a banana, Mary an apple, and Jill an orange.
 c. #John is eating a banana.
 d. #John and Mary.
 e. #An apple.
 f. #Fruit.

Based on the representation of exhaustive single *wh*-questions, exhaustive paired *wh*-questions can be represented as follows (cf. Schulz and Reckling, 2005):²

- (17) $\forall x_n y_m. p \rightarrow \Box p$

Our experiments look precisely at how this property is captured. We also ask the question of how an extra marker might facilitate acquisition of the exhaustivity property.

3. Acquisition Hypotheses

From an acquisition perspective, the instantiation of [+variable] on *wh*- is a prerequisite for successful acquisition. There is evidence that children with Specific Language Impairment (SLI) fail to understand pairing, which has been attributed to the absence of the [+variable] property (see Finneran, 1993; Roeper and deVilliers, 1993; Roeper, 2004). The acquisition path for normally developing children may be more complex, which will be better understood when the conditions for single-pair readings are better understood. Perhaps all children move through a single-pair stage, which would naturally follow the singleton stage. It is in effect a singleton answer for double *wh*-. Our current hypothesis is that there is an implicational hierarchy as spelled out in (18).

- (18) specific \rightarrow [-variable] (i.e. singleton)
 non-specific \rightarrow [+variable] \rightarrow exhaustivity \rightarrow paired-list readings

We argue that the singleton reading results from the default assumption [specific] that children initially make. Does the move to exhaustivity and pairing involve a complex path, or a quick triggering sequence? It is possible that the realization of the [+variable] property instantly follows from the discovery of non-specificity, which in turn instantly invokes exhaustivity when linked to *wh*-, which instantly invokes exhaustive pairing when two *wh*-expressions are involved. This acquisition path would correspond to the

² Interesting exceptions to (16) case have been found in Portuguese and Slavic languages where movement leads to Single-Pair readings (see Boskovic, 2002, and Vignjevic, 2005, for discussion).

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strongest hypothesis according which all steps in (18b) happen at once. Alternatively, the properties delineated in (18b) could be acquired not simultaneously but after sufficient specific triggering experience.

In summary, we have identified the following three components of the successful acquisition of exhaustivity:

- (19) a. Discourse context carrying multiple instances
- b. The hidden [+variable] (in correspondence with the universal quantifier *every*)
- c. Lexical markers of singleton and exhaustive readings

From the above discussion, we can derive two competing acquisition hypotheses:

- (20) H-1: Pragmatic Hypothesis:
The singleton reading for *wh*-questions is natural, corresponding to the lexical marker *for example*, but plural reading is acceptable.
- (21) H-2: Formal Feature Hypothesis:
The language learner begins with the concept of [specific] which allows a singleton reading. Then, she acquires non-specificity, which requires a [+variable] feature. When the [+variable] feature is linked to *wh*-, then exhaustivity is automatic, in principle instantly blocking the plural reading.

The pragmatic hypothesis would crucially allow the child to pass through what one can call a “plural” stage, illustrated in (22).

- (22) singleton → several (plural) → exhaustive

Note that this acquisition path might also be consistent with a cognitive hypothesis, according to which the child realizes the presence of several relevant entities. By contrast, the Formal Feature Hypothesis (21) would not allow at any phase in acquisition a plural stage to exist.

4. The Acquisition Studies

4.1 Experiment 1

Previous experiments with normally developing children provided evidence that exhaustivity emerges between the ages of 4 to 6 years (for German, see Penner, 1994, 1996; for English, see: Roeper and de Villiers, 1991, 1993). Crucially, these experiments involved one, two, or three individuals sharing the property in question. Given the limited number of response options in the experimental design, the fact that plural responses have not been observed could be merely an artifact of the experimental stimuli. Therefore, in the following experiment, administered to English and German speaking children, we systematically varied the numbers of the individuals in order to test whether a larger number of response options would elicit a plural response. Imagine a situation, i. e. in our

case a picture, in which five out of six children are wearing a sweater. We ask the following question:

(23) Who is wearing a sweater?

Will the children respond with a singleton answer (24a), an exhaustive answer (24b), or with a plural answer (see (24c), (24d), (24e))?

- (24) a. One child.
b. Five children.
c. Two children.
d. Three children.
e. Four children.

Adults know that in this situation, only an exhaustive answer such as (24b) is sufficient. If the child entertained the pragmatic option, thus also allowing plural answers, then she would respond with any of the five options given in (24).

Subjects:

There were 115 normally developing (ND) German and English children in four age groups from 4;0 - 7;11 years as in Table 1.

Table 1. Participants in Experiment 1

Language	German	English
Age		
4-years	22	4
5-6 years	21	15
6 years	16*	12
7 years	16*	11

*These groups are from the comparison with SLI children reported first in Schulz and Penner, 2002. See also Roeper et al. 2002.

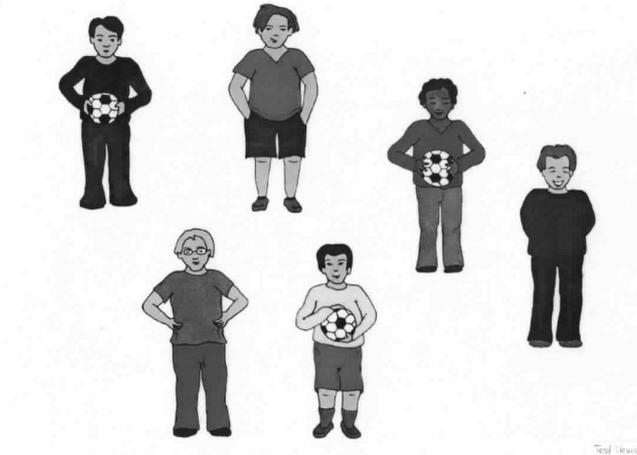
Materials and Procedure:

There were eight color drawings each featuring six individuals, where two to five of them had the specified property: wearing jackets, holding soccer balls, wearing glasses, etc. as shown in Figure 1.

Figure 1. Sample stimulus for Experiment 1

Prompt: "Who is holding a soccer ball?"

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After a pretest to confirm that the children knew the vocabulary to describe the pictures, could answer simple *wh*-questions, and grasped the notion of categories, children were shown the test stimuli. There were two orders of presentation balanced across children and groups. Control stimuli, which elicited a true singleton response, were interspersed among the trials.

Results:

The results clearly suggest that all children pass through a singleton stage around age 4 and 5.

Four-year-olds produced singleton readings in these proportions, with a difference between English and German to which we will return:

English: 79%
German: 52%

The exhaustive reading was distinctively present by 6 years in both groups, with again a notable contrast between English and German for the 5-year-olds.

Table 2. Percent Exhaustive responses by Language Group

Age	German	English
5 years	80%	27%
6 years	85%	75%
7 years	84%	74%

Crucially, the number of plural answers was extremely small: 6%. Therefore, despite the fact that the plural option, were it viable, would be pragmatically much easier, children

almost never choose it. They proceeded directly from the singleton to the exhaustive reading. This result supports Hypothesis 2, which claims that a particular feature of [+variable] is linked to *wh*-, equivalent to a hidden every as Nishigauchi (1999) suggests.

4.2 The Mechanism of Acquisition: Exhaustivity Trigger

Now let us ask: What triggers exhaustivity? One view is that some aspect of “experience” points the child in the right direction. One could imagine contexts where a person points out “but she is not the only one with a sweater”. This kind of explanation, however, introduces many social variables and would lead one to expect to see more individual variation in its acquisition than is actually observed. One might expect that children vary between 4 and 8 years for the acquisition of this property as they do for many lexical items. In addition, it offers no clue as to why the German children appear to be a little ahead of the English ones.

So let us advance an hypothesis that incorporates other smaller points of variation between the languages.

- (25) Language Hypothesis:
Children learning a language that allows explicit exhaustivity markers will acquire exhaustivity first.

That is, the presence of a further marker, like *all* or *alles* in German could trigger the [+variable] property in the *wh*-word.

There are two important features of this notion of trigger that should be mentioned. First it could, in principle, not trigger that property but remain as a required feature for a non-singleton reading. Second *all* is a collectivity marker and therefore not completely equivalent to the property being triggered which allows distributivity. It does not have the same scope relations which we discuss below. This is probably the crucial property of triggers, namely, that they bear a partial relationship to what they trigger. We know that forms of *all* appear with 2-year olds while every N is not really productive until 5 years, except for adverbial uses like *everyday*, or fixed forms like *everything* or *everybody*. Thus, the collective form of exhaustivity appears much earlier than the (distributive) every form.

The presence of *all* in American dialects and in German, as illustrated in (26):

- (26) a. Who all is coming?
b. Wer kommt alles?
‘Who is coming all?’

does contradict the singleton assumption, and therefore it knocks out one assumption and in a sense points toward the right assumption: Plural or quantification is allowed in *wh*-expressions. A further experience might then be needed to guarantee that the response to

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a *wh*-questions is indeed exhaustive and not simply plural. It is possible that such an experience occurs, but it is also possible that UG simply states that a property of questions is the presence of universal quantification and not plural. It is precisely a conclusion of that sort which our evidence supports.

We have now advanced to another prediction:

- (27) a. Children will impose exhaustivity when *alles* is present.
b. *alles* will trigger exhaustivity in other *wh*-contexts

It is quite possible that exhaustivity via *alles* does not need universal quantification, but is achieved via some other means, so the term exhaustive does not apply in the same way to exhaustive *wh*. It is therefore, again, a trigger for a UG notion, which involves more than the triggering information — which is in keeping with the classical notions of biological triggers. It would be natural to suppose that the scope-marking properties of *wh*- are additionally triggered at the same moment, but our first experiment does not examine this question, so a second experiment was undertaken that included questions of the type (26b).

4.3 *alles*-Experiment

Reckling (2005) examined normally developing and SLI children's comprehension of exhaustive single and paired *wh*-questions and of *wh-alles*-questions such as (28).

- (28) Wer trägt alles einen Hut?
Who wears all a hat?
'Who all is wearing a hat?'

Subjects:

Twenty normally developing (ND) and 20 SLI-children (Mean Age = 5;4 years)

- Test sentences: (a) Who is wearing all a hat?
wer trägt alles einen Hut?
(b) Who is wearing a hat?
(c) Who is wearing what?

Results:

ND 5-year-olds:

- wer* (who) cases => 97% correct exhaustive.
wer alles (who-all) =>100% correct exhaustive
4 children make errors with *wer* (who)

SLI 5-year-old children

- wer* (who) 75% correct exhaustive
wer-alles (who-all) 91% correct exhaustive

The SLI results are particularly interesting. It is clear that they give exhaustive answers in the *alles*-condition without always extending it to *wh*-questions with the lexical marker *alles* absent. The significant contrast with the normally developing children ($p = .023$) on *wh*-answers, but not on *wh-alles*-questions indicates this ($p = .087$). Looking at the individual data, note that 25% of the SLI children did not give consistent exhaustive answers, while 75% of the SLI children and all the normally developing children supplied exhaustive responses in a consistent manner. These results suggest that the information for triggering is present in normally developing children, but may not be active in SLI children.

The second important conclusion is that for the normally developing children one can plausibly argue that the presence of an overt trigger in the standard dialect could play the role of accelerating the move to exhaustivity. *All* does not occur in an analogous way in English sentences. This would account for the difference between English and German children.³

5. Conclusions

We suggest that children begin first with a notion of [+specificity] that allows *wh*-words to be interpreted as singleton. This corresponds to an option in the adult language, answers to the so-called “mention-some” questions, but children apply it uniformly where adults do not.

Second the move from singleton to exhaustive does not follow a cognitively natural hypothesis that would make plural an intermediate stage, but leads directly to exhaustivity. This is what one expects of an efficient language acquisition device that is looking for domains where exhaustivity is necessary. Third we found that cross-linguistic differences reveal the role that explicit markers can play in accelerating the move from a default assumption to the adult grammar.

In sum, the acquisition path for *wh*-acquisition is inevitably complex. Although all stages are defined by UG, the initial state involves default assumptions that are

³ It remains an open question whether the children who grasp the exhaustivity property of *wh*- will immediately grasp its scope-taking character. Strauss et al. (2003) found that there was a correlation between children who understood every and those who grasped the exhaustive pair-list reading of double questions. This directly supports Nishigauchi's suggestion that there is a hidden every in *wh*-. What needs to be determined is whether children understand that the following sentence is false where there is a picture of three boys:

(27) Does every boy have three heads?

and the answer to:

(28) Who has three heads?

is “nobody”. It is possible that this realization is automatic or that it requires a further triggering experience.

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pragmatically and cognitively natural, the singleton stage, but not logically necessary. Therefore acquisition research offers a unique angle on the contents and organization of Universal Grammar.

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