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Acquisition of semantic type flexibility: The case of conjunction*

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1. Introduction

Meanings of logical expressions have become one of the central topics in research on language acquisition. While there has been relatively little discussion of the learnability of functional meanings (cf. e.g. Clark 1996, 2011, Piantadosi et al. 2012), a lot of empirical work has focussed on the acquisition of semantic properties of coordinators such as English *and* and *or* (cf. e.g. Goro 2007, Crain 2012, Singh et al. 2016, Notley et al. 2016, Geçkin et al. 2016, Tieu et al. 2017). Yet, whereas the interaction of such elements with other logical operators has received a lot of attention, the semantic flexibility of coordinators – one of their central properties – has so far not been investigated at all: In many languages, they can combine with coordinates of various semantic categories, e.g. propositions, (1a), predicates of individuals, (1b), and individuals, (1c) (cf. Geach 1970, von Stechow 1974, Partee & Rooth 1983 a.o.).[1] Furthermore, conjunctive coordinations are ambiguous between so-called 'distributive' and 'non-distributive' interpretations (cf. Link 1983, 1984, Krifka 1990, Winter 2001): (1c) can either express that Martin and Winnie drank three bottles of beer each or (less plausibly) that they drank three bottles between them.

(1) a. Martin has a headache and Winnie feels nauseous.
b. Martin is very young and very tall.

*We wrote this squib for Martin Prinzhorn because he has always been interested in the foundations of natural language acquisition and because he is responsible for our own interest in the matter. We would like to thank Clemens Mayr for relevant remarks and comments – all remaining errors are our own. Nina Haslinger's work was funded by the Austrian Science Fund (FWF), project P 29240-G23 (*Conjunction and disjunction from a typological perspective*).

[1] Some analyses, most recently Schein (1997) and Hirsch (2016), assume that conjunction only operates on conjuncts of type t and that all instances of non-sentential coordination are derived by Conjunction Reduction (e.g. ellipsis). In this squib, we concentrate on semantic approaches to flexibility, because they seem to account for a wider range of attested construals of conjunction than approaches based on Conjunction Reduction – in particular, the latter do not consistently derive the correct truth-conditions for sentences involving 'non-distributive' interpretations. Some of the implications of Conjunction Reduction for acquisition are discussed by Ardery (1980) and Tager-Flusberg et al. (1982), among others.

c. Martin and Winnie drank three large bottles of beer.

The semantic literature offers various accounts of these two aspects of flexibility and how they could be tied to one another (cf. in particular Link (1983, 1984), Hoeksema (1983), Krifka (1990), Winter (2001), Champollion (2015)). In this squib we concentrate on the first aspect – cross-categorial application – and point out that existing semantic approaches potentially make different predictions about the order in which different construals of conjunction are acquired. Concentrating on the cross-categorial nature of English *and*, we formulate research questions for future experimental work on this issue on the basis of a preliminary study of the Brown corpus (Brown 1973).

2. Accounts of semantic flexibility and their predictions

Semantic analyses of conjunction differ as to which construals of conjunction they consider to be derived from a more basic lexical entry. In the following, we distinguish groups of analyses of cross-categorial application that differ in the strength of their predictions regarding acquisition. (For reasons of simplicity, we limit the discussion to the meanings of *and* for conjuncts of the logical types e (henceforth 'individual conjunctions', if e is the basic type of the conjuncts), t ('sentential conjunctions'), $\langle e,t\rangle$ ('predicate conjunctions') and $\langle\langle e,t\rangle,t\rangle$ ('quantifier conjunctions').) Crucially, these predictions rest on the premise that, if one lexical entry for conjunction is taken to be semantically derived from another, the derived entry should not be acquired earlier than the basic one. (Note that this assumption, even though implicit in much work on the acquisition of syntax, may be unwarranted for the acquisition of functional meanings. We are not aware of any recent explicit discussion of this issue in formal semantics.)

t-based theories. Gazdar 1980, Partee & Rooth 1983 a.o. derive the cross-categorial meaning of *and* from a basic operation $\wedge$ on truth values, defined as in classical propositional logic (2a). In (2b), this is illustrated for one-place predicates (predicates of primitives and generalized quantifiers). Since this approach only works for types that 'end in t', individual conjunction requires the application of a type-shift T mapping each individual to the set of its properties, a generalized quantifier (2c). (Winter (2001) and Champollion (2015) extend this approach to non-distributive interpretations of individual conjunction.)

(2) a. $[\![and_t]\!] = \lambda p_t.\lambda q_t.p \wedge q$
b. $[\![and_{\langle a,t\rangle}]\!] = \lambda P_{\langle a,t\rangle}.\lambda Q_{\langle a,t\rangle}.\lambda x_a.P(x) \wedge Q(x)$
c. $[\![$ [T *Martin*] *and* [T *Winnie*]$]\!]$ = $\lambda P_{\langle e,t\rangle}.P(\text{Martin}) \wedge P(\text{Winnie})$

Accordingly, predicate conjunction or individual conjunction should not precede sentential conjunction developmentally, since the latter reflects the "basic" meaning in (2a).

Theories assuming an *e*/*t* ambiguity. While t-based theories derive individual conjunctions from sentential conjunctions via type-shifting, Link (1983), Hoeksema (1987), Schwarzschild (1996) a.o. posit a primitive meaning for *and* in individual conjunctions: the operation $\oplus$ that forms pluralities of individuals from individuals,

(3). This meaning is independent of the meaning for *and* in predicate and sentential conjunctions, which is analogous to that of t-based theories, i.e. (2a,b).

(3) $[\![and_e]\!] = \lambda x_e.\lambda y_e.x \oplus y$

As the meanings of *and* for type e and types 'ending in t' are independent of each other, such theories make no predictions w.r.t. the relative acquisition order of these two operations – but still predict that predicate conjunction won't precede sentential conjunction.

***e*-based theories.** In analogy to t-based theories, Krifka (1990) and Heycock & Zamparelli (2005) try to derive a cross-categorial meaning for *and*, but take the plurality-forming operation $\oplus$ in (3) as basic (rather than the truth function $\wedge$). This meaning is then generalised to all types 'starting with e', including $\langle e,t\rangle$, (4). Sentential conjunction, which does not involve a type starting with e, is still assigned the meaning in (2a).

(4) $[\![\text{and}_{\langle e,t\rangle}]\!] = \lambda P_{\langle e,t\rangle}.\lambda Q_{\langle e,t\rangle}.\lambda x_e.\exists y_e, z_e.x = y \oplus z \wedge P(y) \wedge Q(z)$

As individual conjunction reflects the 'basic' meaning, such accounts predict that it should not be acquired after predicate conjunction. However, they make no predictions concerning the relative order of either individual and sentential conjunction or predicate and sentential conjunction, as the two meanings in (2a) and (4) are independent of each other.

Theories with type-independent lexical entries A final class of theories, including Keenan & Faltz (1985) and Schmitt (2013), does not consider one particular instance of *and* as basic and the other ones as derived from it, but rather posits that the meaning of *and* is defined primitively for all semantic domains – either as set-intersection (Keenan & Faltz 1985) or as generalised plurality-formation (Schmitt 2013). Such theories make no predictions concerning the relative order of acquisition since they do not assume any derived meanings of *and*.

Interim Summary The following summarises those predictions that involve an asymmetry in the order of acquisition of different semantic categories ('a $\leq$ b' stands for 'b is not acquired before a').

(5)
a.	sentential conjunction $\leq$ predicate conjunction		t-based, e/t ambiguity
b.	sentential conjunction $\leq$ individual conjunction		t-based
c.	individual conjunction $\leq$ predicate (starting with e) conjunction		e-based

3. Production data

As Martin likes to point out, the value of spontaneous-speech samples for investigations of children's grammatical competence is limited since 1) non-adult performance may be the result of extra-grammatical processing factors and 2) lack of spontaneously produced examples does not show that the child has *not* acquired a certain linguistic feature. Ultimately, the predictions of the different semantic approaches therefore need to be tested experimentally. However, there are two preliminary questions which are relevant for the design of such experiments and *can* be investigated using spontaneous speech samples. First,

when do children begin to produce conjunctions of different semantic categories? Second, to what extent do conjunctions of different semantic categories emerge in a fixed order?[2]

Methods We attempted to address these questions by analysing child utterances containing *and* in the corpus discussed by Brown (1973), which is available via CHILDES (MacWhinney 2000) and contains spontaneous speech collected over several years from three English-speaking American children. We only used the odd-numbered transcripts in the database and extracted all child utterances containing *and*. Utterances that were uninterpretable even with the linguistic context in the transcripts were excluded, as were utterances in which *and* occurred utterance-initially and the first conjunct was not provided in a child utterance immediately preceding *and*, and elliptical conjunctions, i.e. non-sentential coordinate structures not embedded in a larger constituent (e.g. *for you and me* was included but *you and me* was not). Finally, we excluded clear imitations and repetitions. The remaining coordinate structures were assigned the categories *sentence* (with subcategories *declarative / non-declarative*), *VP*, "*other predicates*" (e.g. conjunction of PPs, or of nouns within a DP), and *DP* (with subcategories for *definite*, *indefinite* and *quantificational* DPs).[3]

For each child, the transcripts were grouped into samples such that all samples except the last one contained roughly similar numbers of utterances. (6) shows how many instances of the individual syntactic/semantic categories occurred in each sample.[4] In the case of VP conjunction, we made a distinction between examples in which the coordinate structure directly combines with the subject and those in which it is embedded under an additional item such as an auxiliary or modal verb. The former group was classified as "ambiguous" since, given that child English allows null subjects, the conjuncts could be analyzed as having semantic type t as well as $\langle e,t\rangle$. The column "other" in (6) contains other ambiguous examples, coordinations with conjuncts of different categories and some categories that were very rare, such as quantificational DPs.

[2]These questions concern the cross-categorial nature of conjunction; our corpus data were uninformative about the distributive/non-distributive distinction due to the rarity of unambiguous instances of non-distributive conjunction.

[3]Our analysis included 404 of Adam's 765 tokens of *and* (53%), 78 of Eve's 209 tokens (37%) and 237 of Sarah's 567 tokens (41%). Note that we did not exclude all instances of utterance-initial *and*.

[4]The last sample from Sarah was omitted from (6) since it contained less than 200 utterances.

(6) *Absolute frequencies of different types of* and*-conjunction in the Brown corpus*[5]

child	sample	sentence		predicate			DP		other	total	total
		decl.	other	VP unambig.	VP ambig.	other	def.	indef.		conj.	utterances
Adam	2 (2;6-2;8)	0	0	1	0	0	0	0	0	1	2555
	3 (2;9-2;10)	0	0	0	0	0	0	0	1	1	2109
	4 (2;11-3;1)	0	0	4	3	5	1	0	5	18	2871
	5 (3;2-3;4)	38	0	7	3	1	1	3	10	63	2854
	6 (3;5-3;8)	37	1	8	5	6	5	1	8	71	2136
	7 (3;8-3;11)	29	5	5	1	3	7	1	12	63	2139
	8 (4;1-4;4)	34	0	10	6	6	10	2	12	80	2606
	9 (4;6-4;10)	21	2	7	1	6	4	2	9	52	2249
	10 (5;2)	31	3	3	1	5	4	0	8	55	1089
Eve	2 (1;10-1;12)	2	0	1	2	0	1	2	4	12	1321
	3 (2;1-2;2)	21	0	0	1	3	22	1	5	53	1488
	4 (2;3)	3	0	1	2	2	5	0	0	13	579
Sarah	1 (2;3-2;7)	0	0	0	0	0	0	0	1	1	1894
	2 (2;7-2;11)	1	0	0	0	0	0	0	0	1	1898
	3 (3;0-3;3)	4	0	0	1	0	1	0	1	7	1819
	4 (3;4-3;7)	11	0	1	2	2	5	1	5	27	1868
	5 (3;8-4;0)	18	0	0	3	0	0	0	9	30	1911
	6 (4;1-4;4)	28	0	1	2	4	2	3	10	50	1963
	7 (4;5-4;7)	31	1	4	5	6	2	3	6	58	1906
	8 (4;8-5;0)	20	1	7	1	6	1	7	18	61	1971

Discussion The data in (6) do not provide clear evidence for the hypothesis that coordinations of different semantic categories appear in a fixed order. From Adam's data, it appears that he began to use non-elliptical *and*-conjunctions productively around age 3. In his sample 4, predicate conjunction predominates, although there is one clear instance of DP conjunction and some of the ambiguous examples grouped as "other" examples could be interpreted as DP or sentential conjunctions. Already in sample 5, however, many instances of sentential conjunction as well as several DP conjunctions appear. A comparison of samples 3 and 5 suggests that he began using conjunctions of all the semantic categories discussed above within a few months (with the potential exception of quantifier conjunction, since indefinite DPs can be analyzed as non-quantificational (Heim 1982)). The data suggest that Adam may have acquired predicate conjunction slightly earlier than the other categories, a prediction not made by any of the semantic theories discussed above.

Interestingly, the data from the other two children do not show an analogous asymmetry between predicate and other conjunctions. In Sarah's case, the first instances of conjunction – in samples 2 and 3 – are mostly sentential, with a single instance of definite DP conjunction in sample 3. (The ambiguous "other" example and the ambiguous VP example in sample 3 can also be interpreted as sentential, among other possible interpretations.) In sample 4, multiple instances of predicate and individual conjunction appear. One could hypothesize that Sarah acquired sentential conjunction around age 3, with the other categories appearing a few months later. However, given the small number of instances in her early samples and the fact that conjunction of declarative sentences was the most frequent category in our data, the apparent asymmetry may also be a sampling effect. Finally, Eve acquired coordination considerably earlier than the other two children, around age 2.[6] Her

[5]Here we only counted tokens of *and* corresponding to interpretable, non-elliptical, non-discontinuous conjunctions. The last column gives the number of child utterances in each sample.

[6]Oddly, the description of her data in CHILDES distinguishes between age "1;12" and "2;0", so we are not sure at what exact age the last transcript from sample 2 was collected.

data do not reflect any clear asymmetries between the semantic categories: While sample 1 contains no interpretable, non-elliptical instances of conjunction, sentential, predicate and DP conjunction all appear more than once in sample 2.[7]

(6) suggests that indefinite DPs appeared slightly later than definites in the Adam and Sarah corpora. However, only the Sarah corpus really provides evidence for this asymmetry since Adam produced several elliptical utterances consisting of indefinite DP coordinations earlier than the first example counted in (6).

In summary, some of the data suggest that individual children may have acquired conjunctions of one category before another, but these asymmetries are not consistent across children.[8] Further, for all three children, conjunctions of our different semantic categories (again, with the exception of quantifier conjunction) appeared within a few months.

4. Earlier studies of the acquisition of conjunction

Existing acquisition studies on the flexibility of coordinators generally focus on *syntactic* flexibility, i.e. their ability to combine with conjuncts of different syntactic categories. However, at least some of these studies are informative for the semantic questions addressed here, and the results of the studies we are familiar with, upon closer scrutiny, are consistent with our findings.

Corpus-based work Several corpus studies of conjunction in child language have aimed to test the developmental predictions of the hypothesis that all non-sentential conjunctions are transformationally derived from sentential conjunctions. The findings are somewhat inconclusive. Lust & Mervis (1980) divide their corpus (children aged 2;0-3;1) into "stages" defined by MLU (cf. Brown 1973) and claim that sentential conjunctions are acquired earlier than phrasal conjunctions – but their Figure 2 (p. 286) shows the frequencies of these categories to be very similar at the first two stages. Most of their early examples of phrasal conjunction appear to involve DP conjunction (Table 3, p. 288).[9] Bloom et al. (1980) found that in their data set, phrasal and sentential conjunction occurred at about the same time except for one child who exhibited phrasal conjunction first (p. 250) – however, the latter conclusion is debatable. Finally, Tager-Flusberg et al. (1982), who also studied Brown's 1973 corpus, concluded that phrasal conjunction appears before sentential conjunction.[10] We are not sure what accounts for the difference between their findings and ours, as it is not always clear which criteria they used to select the relevant data points from the set of all utterances containing *and*. However, their criticism of the Lust & Mervis (1980) study (p. 213) suggests that they may have excluded more "uninterpretable" or am-

[7] Tager-Flusberg et al. (1982) comment on the unusually high frequency of definite DP conjunction in her data. They point out that Eve uttered the individual conjunction *Fraser and Cromer* – the names of the linguists who taped her speech – many times and may have used this string as an unanalyzed lexical item.

[8] At present, it is not clear to us whether the observed asymmetries correlate with the children's input.

[9] In their data set, which is quite small (32 phrasal coordinations), many examples of coordination were excluded because the coordinate structures were not "embedded in a full sentence".

[10] Oddly enough, their Fig. 6.3 on p. 212, which is supposed to show the relative frequencies of phrasal and sentential conjunction, only includes sentential conjunctions that involve redundancy and hence could undergo Conjunction Reduction. However, they say on p. 211 that "sentential coordinations with or without potential deletion" appeared considerably later than phrasal coordinations.

biguous examples from their analysis than we did. For instance, it seems that they excluded sentential conjunctions in which both conjuncts contained a referential pronoun if it was unclear whether the pronouns coreferred.

Experimental work Syntactically oriented experimental studies also lack definitive evidence for asymmetries between semantic categories. Ardery (1980) and Tager-Flusberg et al. (1982) report some relevant results of experimental studies on conjunctions of different syntactic categories, although those studies were motivated by the Conjunction Reduction debate and hence did not explicitly consider the semantic properties discussed in this paper. In Ardery's study, English-speaking children (mean age: 3;11) had to act out simple SVO sentences involving different syntactic subtypes of coordination. There were four categories on which more than 90% of the participants met her criteria for comprehension: sentences with intransitive verbs (type t), two kinds of VPs (both type $\langle e,t\rangle$) and definite DPs in object position (type e or $\langle\langle e,t\rangle,t\rangle$ depending on one's analysis). These results do not support an acquisition asymmetry between these simple semantic types. Interestingly, Ardery's participants performed less well on conjunction of transitive verbs (type $\langle e,\langle e,t\rangle\rangle$) and of definite DPs in subject position. She proposes a syntactic processing explanation for this asymmetry, but a semantic explanation cannot be ruled out at this point.[11] Similarly, an elicited production study by Tager-Flusberg et al. (1982), in which English-speaking children (age ≥ 3) were asked to describe pictures, did not find a developmental asymmetry between phrasal and sentential conjunction – rather, the types of conjunction produced depended on the non-linguistic context.

More recently, comprehension studies have focused on the interaction between conjunction and other logical operators in different languages (Goro 2007, Crain 2012, Notley et al. 2016, Geçkin et al. 2016). The conjuncts in these studies were either type e expressions or expressions that could be interpreted as being of type e or $\langle\langle e,t\rangle,t\rangle$ (indefinite DPs or nominals unmarked for definiteness). The results of these experiments are compatible with the hypothesis that the participants had adult-like knowledge of the lexical meaning of type e conjunction. Several studies found a non-adult interpretation of negated conjunctions, but this can be attributed to independent properties of child grammars such as the scope of coordinate structures w.r.t. negation or, alternatively, the interpretation of distributivity markers such as English *both*. The children who participated in these experiments were usually a bit older than the children in corpus-based work (mean age $>$ 4;0). Unfortunately, these studies do not allow us to draw any conclusions about sentential or predicate conjunction.[12]

[11] Tager-Flusberg et al. (1982) performed a similar comprehension experiment. Their findings, which they say are compatible with those of Ardery (1980), are harder to interpret since they do not give percentages of correct answers for the individual conditions, and the variables in their statistical analysis are only indirectly based on syntactic categories, with the exception of a sentential/phrasal distinction. The latter distinction had a statistically significant effect; however, this is unsurprising as their examples of phrasal conjunction included some cases of non-constituent conjunction which is known to be particularly hard for children.

[12] They are also uninformative about the order in which distributive and non-distributive construals are acquired, since inherently distributive predicates were used.

5. Summary and implications for experimental work

On the basis of the spontaneous speech we surveyed and the predictions of the semantic theories reviewed above, we propose the following research questions for a future experimental study of the *comprehension* of conjunctions of different semantic categories in child English.

(7) a. Do very young children (age $\leq$ 3) show adult-like comprehension of conjunctions of different semantic categories in sentences without other logical operators?
b. Do some children go through a developmental stage (probably before age 3) at which they are competent on some, but not all of the three main semantic categories we studied (e.g. individual conjunctions before sentential conjunctions)?
c. If so, are these asymmetries predicted by any of the semantic analyses surveyed in Section 2?
d. Do we find the same asymmetries across children?

The spontaneous-speech analysis leads us to expect a positive answer to questions (7a-b) and a negative answer to questions (7c-d). If these hypotheses could be confirmed, we could conclude at least that semantic analyses of type flexibility (i.e. derived meanings for *and*) by themselves are not sufficient to account for the acquisition patterns. However, given the small number of examples in our early samples, the observed asymmetries may well be sampling effects or artifacts of our way of classifying the data.

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