

Is Logic Innate?

Stephen Crain & Drew Khlentzos

Arguments are presented supporting logical nativism: the conjecture that humans have an innate logic faculty. In making a case for logical nativism, this article concentrates on children's acquisition of the logical concept of disjunction. Despite the widespread belief to the contrary, the interpretation of disjunction in human languages is arguably the same as it is in classical logic, namely inclusive-*or*. The argument proceeds with empirical support for the view that the inclusive-*or* is the meaning of disjunction in human languages, from studies of child language development and from cross-linguistic research. Evidence is presented showing that young children adhere to universal semantic principles that characterize adult linguistic competence across languages. Several *a priori* arguments are also offered in favour of logical nativism. These arguments show that logic, like Socratic virtue and like certain aspects of language, is not learned and cannot be taught — thus supporting a strong form of innateness.

Keywords: disjunction, innateness, language acquisition, logic, semantic universals

1. Introduction

It is a contingent truth, in our view, that human language disjunction corresponds to inclusive-*or*, as in classical logic. In making our *prima facie* case for logical nativism, we will take advantage of this specific contingent fact about human languages, in the following ways. One way is to provide empirical evidence from studies of child language demonstrating that young children initially adopt the inclusive-*or* interpretation of disjunction despite the paucity of evidence for this interpretation in the primary linguistic data. Some of the relevant data demonstrating that children's interpretation is consistent with classical logic have been gathered in recent studies of two-year-old English-speaking children, and from studies of both English-speaking and Japanese-

This research was supported in part by Australian Research Council Grant FF0456432 to Stephen Crain, and ARC Grant DP0879842 to Stephen Crain and Rosalind Thornton. We thank two anonymous reviewers for helpful input, and we thank the following friends and colleagues for assistance and insights: Ivano Caponigro, Gennaro Chierchia, Takuya Goro, Andrea Gualmini, Martin Hackl, Britta Jensen, Thomas Lee, Luisa Meroni, Utako Minai, Anna Notley, Tanya Reinhart, Francesco Ursini, Peng Zhou, and, especially, Rosalind Thornton.



speaking 4–5-year-old children. The finding is that children demonstrate knowledge of the semantic principles that characterize adult linguistic competence, across these and other languages. It turns out that Japanese-speaking children differ from adult speakers, by adopting the inclusive–*or* interpretation of disjunction even in simple negative sentences where, for adults, disjunction is governed by an implicature of exclusivity because of its scopal relationship with negation. Japanese-speaking children apparently ignore the input from adults, and maintain an inclusive–*or* interpretation in simple negative sentences. The studies from child language form one empirical argument for logical nativism.

Another empirical argument for logical nativism is based on cross-linguistic research. We show that in typologically different languages (Japanese, Chinese and English), the interpretation of disjunction is consistent with classical logic, again because disjunction is interpreted as inclusive–*or*. Three putatively universal linguistic principles are proposed, all utilizing inclusive–*or*. It is noted, however, that these principles are manifested in complex structures in which disjunction combines (i) with negation, (ii) with the universal quantifier (e.g., English *every*), and (iii) with focus expressions (e.g., English *only*). In view of the complexity of these phenomena, it is unlikely that young children have relevant evidence in their primary linguistic experience to inform them that expressions for disjunction in human languages conform to classical logic. This brings the empirical findings from studies of children’s interpretation of disjunction in line with logical nativism. We contrast logical nativism with a learning-theoretical account of children’s acquisition of the interpretation of disjunction. The learning account maintains that children’s acquisition of the interpretation of disjunction is based on witnessing speakers’ use of disjunction in conformity with certain inference rules (introduction and elimination rules). We argue that the learning account is highly implausible because the hypothesized input turns out to be an unlikely source of children’s interpretation of disjunction. To bolster our empirical conclusions, we end the article by presenting two *a priori* arguments for logical nativism. One is, surprisingly, based on work by Quine. The other is, not surprisingly, based on work by Fodor.

2. Circumventing Subset Problems

To avoid prejudice, let us admit the possibility that disjunction, e.g., English *or*, may have the meaning associated with exclusive–*or* in human languages. We will indicate this meaning using the symbol \oplus . If a statement of the form ‘*A or B*’ is true on this interpretation (meaning $A \oplus B$), then exactly one, either *A* or *B*, is true. By contrast, we indicate the inclusive–*or* interpretation of disjunction using the standard wedge symbol \vee . In human languages in which disjunction means inclusive–*or*, a statement of the form ‘*A or B*’ (meaning $A \vee B$), is true if either *A* or *B* is true, or if both *A* and *B* are true.

Let us consider the learnability of disjunction in human languages. Suppose there is a class of adult languages L_1 with exclusive–*or* (\oplus -disjunction) as the unique interpretation of disjunction, and suppose there is another class of languages L_2 in which disjunction is uniquely inclusive–*or* (\vee -disjunction). Due to

the truth conditions associated with \oplus -disjunction and \vee -disjunction, any disjunctive statement that is true in L_1 will also be true in languages in L_2 (with \vee -disjunction). The converse relation does not hold, however, because $A \oplus B$ entails $A \vee B$, but not vice versa. In other words, statements with \oplus -disjunction are true in a subset of the circumstances corresponding to statements with \vee -disjunction — with respect to disjunction, $L_1 \subseteq L_2$.

Consider how learners decide whether the language they are exposed to is in L_1 or in L_2 . Suppose the learner guesses, without compelling evidence one way or the other, that the language spoken by members of the linguistic community is in L_1 (with \oplus -disjunction), but in fact the local language is in L_2 (with \vee -disjunction). Since $L_1 \subseteq L_2$ there will be positive evidence for the learner to extend their language to include statements with \vee -disjunction. The circumstances that inform learners that their initial hypothesis about the meaning of disjunction (\oplus -disjunction) was incorrect will be circumstances in which someone utters 'A or B' when both A and B are true. Grammatical change could take two forms. Learners could add to the truth conditions for disjunction, converting \oplus -disjunction into \vee -disjunction, or learners could add a second meaning to disjunction to their grammars, making disjunction ambiguous, with both \oplus -disjunction and \vee -disjunction.

There is a second learnability scenario, according to which learners initially guess (wrongly) that the local language is in L_2 (with \vee -disjunction) whereas, as a matter of fact, the local language uniquely uses \oplus -disjunction. Since $A \oplus B$ entails $A \vee B$, learners who made the wrong guess will only encounter evidence confirming their initial (wrong) interpretation, at least in the absence of negative semantic evidence. This is the familiar learnability dilemma that arises whenever an expression has two possible values, one yielding an interpretation that makes a sentence true in a superset of circumstances that correspond to the other interpretation. If the learner initially guesses the superset language, the evidence they encounter will always be consistent with this guess if the local language is actually the subset language. This is appropriately labeled the *Subset Problem*.

There are two potential ways to avoid the Subset Problem. One is to ensure that learners start out with the more restricted meaning, the subset interpretation. In the case of disjunction, the more restrictive meaning is \oplus -disjunction. As we saw, if it turns out that the local language (also) uses \vee -disjunction, then there will be positive evidence informing learners that their grammars need to accommodate \vee -disjunction. The other solution is to deny the existence of a Subset Problem. Essentially, this amounts to claiming that learners initially guess that the local language uses \vee -disjunction, and they are always correct because, as a contingent fact, all human languages use \vee -disjunction, and no languages use \oplus -disjunction. Of course, it is conceivable that some languages have two meanings of disjunction, i.e. both \vee -disjunction and \oplus -disjunction. However, if learners initially hypothesize \vee -disjunction as their initial interpretation of disjunction, then statements that correspond to the truth conditions associated with \oplus -disjunction will be covered whether or not the language also has \oplus -disjunction. In fact, if this learnability scenario is correct, then it is unclear why any language would need to express both kinds of disjunction, since learners' initial guess, \vee -disjunction, already handles the subset of circumstances

associated with \oplus -disjunction.

Despite these observations, the hypothesis that OR is uniquely \vee -disjunction in human languages is not widely accepted. Many linguists and philosophers think that at best, disjunctive words like English *or* are ambiguous between \oplus -disjunction and \vee -disjunction and, at worst, that disjunctive words in human languages uniquely mean \oplus -disjunction and not \vee -disjunction. Our own position is, following Grice (1975), that disjunction in human language is (exclusively) \vee -disjunction — inclusive-*or* (cf. Gazdar 1979, McCawley 1981, Pelletier 1972). In the next section we consider simple counter-evidence to this position. The counter-evidence takes two forms: (i) objections based on mutual exclusivity, and (ii) situational contexts where OR appears to violate de Morgan's laws, which are based on \vee -disjunction.

3. How Many ORs Are There?

There are many human language constructions that require inclusive-*or*, i.e. \vee -disjunction. In English, simple negative statements with disjunction (in the scope of negation) require this interpretation. So, *Max didn't order sushi or pasta* means that Max didn't order sushi and Max didn't order pasta. We will refer to this as the conjunctive interpretation of disjunction in the scope of negation. In classical logic, this interpretation follows from one of de Morgan's laws: $\neg(A \vee B) \Rightarrow (\neg A \wedge \neg B)$. The critical point is that this law assumes that disjunction is inclusive-*or*. To the extent that human languages yield conjunctive interpretations in negated disjunctions, then disjunction is inclusive-*or* in human languages. If the sentence *Max didn't order sushi or pasta* meant that Max didn't order sushi \oplus pasta, then the statement would be true if Max ordered both sushi and pasta, clearly the wrong result for simple negative sentences with disjunction in English (cf. Barrett & Stenner 1971).

But what about the corresponding positive sentence *Max ordered sushi or pasta*? For most English speakers, this means that Max either ordered sushi or he ordered pasta, but not both. This is not evidence that *or* is \oplus -disjunction, however. Following Grice (1975), we can account for the appearance that human languages express disjunction using exclusive-*or* as well as inclusive-*or* by invoking pragmatic norms of conversation, which sometimes eliminate one of the truth conditions of inclusive-*or*, namely the condition in which both disjuncts are true. In a nutshell, the Gricean account maintains that sentences of the form 'A or B' are subject to an implicature of exclusivity, i.e. 'A or B, but not both A and B'. The implicature of exclusivity arises due to the availability of another statement, 'A and B', which is more informative. 'A and B' is more informative because it is true in only one set of circumstances, whereas 'A or B' is true in those circumstances, but it is true in other circumstances as well. Due to the overlap of truth conditions, the expressions *or* and *and* form a scale based on information strength, with *and* being more informative than *or* (e.g., Horn 1969, 1996). A pragmatic principle *Be Cooperative* entreats speakers to be as informative as possible. Upon hearing someone use the less informative term on the scale, *or*, listeners assume that the speaker was being cooperative and they infer that the

speaker was not in position to use the more informative term *and*. Therefore, the speaker's use of the less informative term is taken by listeners to imply the negation of the more informative term: 'not both A and B'.

Several challenges to this account of the 'not both' interpretation of disjunction have been offered, and we will briefly rehearse them now, indicating how Grice's account withstands the challenges. First, it has been observed that there are many circumstances in which the exclusive-*or* reading of disjunction is the only available reading, not just the preferred reading. Such cases are quite common in the input to children. Adults ask children many questions that make it clear that the disjuncts are mutually exclusive. Here are some examples from the input to Adam in the CHILDES database (MacWhinney 2000): *Was it a big one or a small one? — Did you find it or did Robin find it? — Is it a happy face or a sad face?* Assuming that English has inclusive-*or*, it might be suggested that such questions demand a second meaning for OR, expressing mutual exclusivity (e.g., Kegley & Kegley 1978, Richards 1978).

The force of this argument is weak. According to the truth conditions associated with inclusive-*or*, statements of the form 'A or B' are true in circumstances in which only A, or only B, is true. Contexts in which the disjuncts are mutually exclusive are therefore consistent with the inclusive-*or* reading of disjunction. Of course, such contexts are not consistent with all the truth conditions associated with inclusive-*or*, since faces cannot be both happy and sad at the same time. But, someone who poses the question *Is it a happy face or a sad face?* assumes that it was either happy or sad, and both of these truth conditions are consistent with inclusive-*or*. As we saw, the inclusive-*or* interpretation of disjunction is true in a superset of the conditions that are associated with exclusive-*or*, so any truth conditions that would be associated with an exclusive-*or* meaning (were this available to children) would be consistent with the inclusive-*or* interpretation of disjunction. So, if the basic meaning of disjunction is inclusive-*or*, there would be no need to coin a second term, or assign an independent meaning to OR, to be used in circumstances corresponding to exclusive-*or*.

A similar observation concerns the interpretation of disjunction in the presence of other logical operators, such as negation. An example is *Max did not order noodles — or (was it) rice?*. The idea is that the introduction of a pause, or by altering the prosody, one can indicate an exclusive-*or* reading, in direct violation of de Morgan's laws. Since de Morgan's laws depend on the inclusive-*or* reading of disjunction, such violations appear to call for a second meaning, i.e. one corresponding to exclusive-*or*. In our view, the issue here is one of scope, not ambiguity. The introduction of a pause, or a change in intonation, is taken by hearers as indicating that disjunction has scope over negation, and not the reverse. It is as though one had said: *It was noodles — or (was it) rice that Max didn't order*. De Morgan's laws are not operative when the scopal relation between negation and disjunction are reversed in this way, with disjunction having scope over negation.¹ In section 6, we offer an account of the 'inverse

¹ De Morgan's laws are not the only laws that fail for exclusive disjunction. The Distributive Law 'A or B and C is equivalent to A or B and A or C' is another notable failure. Thus,

scope' reading of disjunction that crops up in simple negative sentences in some human languages.

4. 'Weakening' as Evidence for Exclusive-or

There is a more serious potential challenge to the claim that the unique meaning of disjunction in human languages is inclusive-or. The challenge is predicated on the observation that the introduction rule for disjunction (known appropriately as 'Weakening') is typically judged to be unacceptable by adults. The introduction rule permits one to validly infer a statement of the form 'A or B' from a statement of the form 'A'. So, if one has evidence for A , one can logically infer A or B , regardless of the truth value assigned to B . This rule of inference is only valid if the disjunction operator in the statement 'A or B' is inclusive-or, since $A \vee B$ is a logical consequence of A , both when B is true and when B is false.

$$(1) \quad \frac{A}{A \vee B}$$

Similarly, $A \vee B$ is a logical consequence of B , regardless of the truth value of A .

$$(2) \quad \frac{B}{A \vee B}$$

If the meaning of disjunction is \oplus -disjunction, by contrast, the introduction rule of Weakening is not valid. On this interpretation of disjunction, exactly one disjunct can be true, so $A \oplus B$ cannot be inferred from evidence that A is true when B is also true. This contrasts with the formula using inclusive disjunction, $A \vee B$, which is true if both A and B are true. The upshot is, one way to explain why Weakening is not accepted by language users is to suppose that the meaning of disjunction in human languages is exclusive-or and not inclusive-or.

There is, however, another way to account for the observation that people do not find the introduction rule for disjunctive statements acceptable. This account appeals to the pragmatic norms people follow in discourse, as sketched above. It is simply odd, pragmatically, for language users to produce two statements, the first more informative than the second. This is exactly what happens with the simple introduction rule for disjunction. First, one encounters A , then A or B . But, someone who produces A or B implies that s/he was not in position to produce either A , or B . It is therefore, pragmatically infelicitous to find A followed by A or B .

To adjudicate between these accounts of the unacceptability of Weakening, we propose to recast the Weakening inference rule in a way that makes it acceptable to ordinary speakers, by reducing the pragmatic infelicity associated

whilst 'Either Annie or Bob and Chris will come to the party', A or $(B$ and $C)$, is true if *or* means \oplus when Annie and Bob turn up without Chris, the conjunction 'Annie or Bob and Annie or Chris will come to the party', $(A$ or $B)$ and $(A$ or $C)$ comes out false, since the first conjunct turns out false. Had Bob stayed away it would have been true.

with the inference rule. Adopting a similar perspective, McCawley (1981: 33) argues that Weakening is accepted if it is introduced in a sub-proof of a logical derivation, rather than in the main proof. We adopt a different strategy. It is possible to reduce or eliminate the pragmatic infelicity of Weakening simply by inserting a logical step between the statement *that A*, and the statement *that A or B*. The step is existential generalization. Existential generalization logically follows from certain statements *that A*, and it logically validates corresponding disjunctive statements *that A or B*. Crucially, by making the introduction rule for disjunction indirect, it becomes more palatable for English speakers. Here is a version of Weakening that people we have consulted find acceptable.

Consider a domain containing two people, Max and Jon. Suppose that Jon laughs, so L_j (*Jon laughs*) is true. But if L_j is true, then it follows that ‘someone laughs’ is true, so $\exists x L_x$ is true. Yet, there are only two objects in the domain, Max and Jon, so the existential claim that ‘someone laughs’ is logically equivalent to the claim that ‘Jon laughs or Max laughs’. That is, from $\exists x L_x$, we can infer the truth of $L_m \vee L_j$. In short, we began with the statement L_j , and derived the disjunctive statement L_j or L_m . QED: Weakening holds for OR. Therefore OR is \vee -disjunction.

If disjunction is \oplus , it is not logically possible to begin with L_j and to derive $L_j \oplus L_m$ by following a sequence of steps that are each logically valid. To see this, suppose that Max laughs along with Jon. That is, $L_m \& L_j$ holds. Clearly then, L_j holds. As before this validates the existential claim $\exists x L_x$. But if L_m and L_j are both true, $L_m \oplus L_j$ is false. QED: Weakening does not hold for \oplus -disjunction.

The indirect argument from $L_j (= A)$ to $L_j \vee L_m (= A \text{ or } B)$ shows that the introduction rule for disjunction is sound after all. And this, in turn, means that disjunction is inclusive-or, at least for English speakers. So the fact that Weakening is judged unacceptable by most speakers in its simplest form (i.e. moving directly from A to $A \text{ or } B$) does not support the conclusion that human language disjunction is exclusive-or. Rather, as Grice (1975) proposed, Weakening is unacceptable simply because the conclusion is less informative than the premise. It is therefore jarring to encounter the premise immediately followed by the conclusion. However, by making the route from the premise to the conclusion indirect (via Existential Generalization), the validity of the Weakening introduction rule becomes apparent. In fact, this version of Weakening is an *a priori* argument that disjunction is inclusive-or, at least in English. What about in other human languages?²

² Jennings (2001) notes that if \oplus is to serve as an acceptable interpretation of *or* in English, then it cannot be a binary sentential connective since ‘Annie or Bob or Chris will come to the party’ is a perfectly acceptable, unambiguous sentence of English. Yet, bizarrely, if *or* means \oplus , then this statement will be true if all three turn up! If A, B, C are true, then $A \oplus (B \oplus C)$ turns out true since $(B \oplus C)$ will be false. In fact, as Reichenbach (1947) first observed, for \oplus an n -ary connective, $\oplus (\alpha_1, \dots, \alpha_n)$ will come out true if and only if an *odd* number of the

5. Weakening Reconsidered

Despite the logical proof we have given that English *or* is \vee -disjunction, it is widely believed that disjunction in human languages is exclusive-*or*, i.e. \oplus -disjunction (e.g., Lakoff 1971, Braine & Romain 1983). For example, although Braine & Romain (1983: 291) acknowledge the view that “equates *or* with standard logic”, they ultimately reject this view on the grounds that “coherent judgments of the truth of *or*-statements emerge relatively late and are not universal in adults”. They conclude that disjunction is more often than not, exclusive-*or* even for adults. In the last section, we presented an *a priori* reason for thinking that OR must have an inclusive reading in English. Moreover, we believe that the inclusive-*or* reading of disjunction is no quirk of English. Rather, we believe, the introduction rule for disjunction, Weakening, is valid in all human languages. In section 5 we present further arguments from cross-linguistic research for believing that all human languages allow an inclusive-*or* reading of disjunction. First, we reflect further on the *a priori* argument we offered for the claim that inclusive-*or* is the meaning of disjunction, based on the validity of one form of Weakening in English.

We began by considering the possibility that Weakening is invalid because, as many researchers have claimed, OR means exclusive-*or* (\oplus) in their idiolects, and Weakening is invalid for \oplus . To counter this, we offered a validation of Weakening which disproves this hypothesis. Here is a variant of our earlier argument. If it is valid, it proves that *or* is inclusive-*or*, not exclusive-*or*, in English.

- (3) (I) Jon laughs and Max laughs.
 (II) \therefore Jon laughs.
 (III) \therefore Someone laughs.
 (IV) \therefore Jon laughs or Max laughs.

Clearly, if it is valid to infer that *Jon laughs or Max laughs* from *Jon laughs and Max laughs*, then *or* is not \oplus -disjunction, since $A \oplus B$ is false if both A and B are true. By contrast, $A \vee B$ is true if both A and B are true, so if the argument is valid, then English *or* is \vee -disjunction. Anyone who thinks that the inference is not valid, in any language, however, owes us an explanation as to which step in the inference is unsound.

Let us consider the steps in turn. Consider first the inference from (I) to (II). This is the elimination rule for conjunction, Simplification. This inference is uncontroversial. To deny that Weakening holds in any human language, then, one must either say that (III) does not follow from (II), or that (IV) does not follow from (III). Presumably, to deny that *Someone laughs* follows from *Jon laughs*, one must deny that *someone* can mean ‘at least one person.’ Putting it another way, denying that (III) follows from (II) amounts to the claim that *someone* must mean

sentences α_i are true. As Jennings quips, there is no natural use of disjunction in human languages which counts A or B or C or D or E true just in case either one or three or all five of the disjuncts are true.

'exactly one person.' That claim cannot be right, however. The reason is that (II) *Jon laughs* is derived from the hypothesis that (I) *Jon laughs and Max laughs*. Since (III) *Someone laughs* is supposed to follow from (II) *Jon laughs* by existential generalization, that sentence also must rest upon the same hypothesis, (I) *Jon laughs and Max laughs*. But we patently cannot conclude from the hypothesis that both Jon and Max laugh that exactly one of them laughs. So *someone* cannot mean 'exactly one' and must, as required, mean 'at least one'. So we think the transition from (II) to (III) is incontestable in any language.

This leaves the final step, from (III) to (IV), as the remaining inference to challenge. Supporters of the exclusive-*or* interpretation of *or* are already committed to denying the inference of (IV) from (III). But it is hard to see how this inference could be denied. For it is just bluntly true that, in the circumstance where Jon and Max are the only members of the domain, *Someone laughs* is logically equivalent to *Jon laughs or Max laughs*. This is the human language counterpart to the relationship between quantificational operators and logical connectives in classical logic: The existential quantifier is disjunctive, and the universal quantifier is conjunctive. In classical logic, in a domain with two objects, a and b , $\exists xPx$ expands to $Pa \vee Pb$; and $\forall xPx$ expands to $Pa \& Pb$. The same relationship holds in human languages. So in a domain with two people, Jon and Max, the sentence *Someone laughs* can likewise be expanded to the sentence *Jon laughs or Max laughs*. Anyone informed that the former sentence is true can infer that the latter is also true.

None of this is surprising to anyone who thinks, as we do, that first order logic is the innately given logic of human languages. For the reason that *Someone laughs* can be expanded to *Jon laughs or Max laughs* is because the underlying logical form of the first sentence just is $\exists xLx$ and the underlying logical form of the second sentence just is $Lj \vee Lm$, so that if there are only two objects j and m in our universe of discourse, the existential formula can be replaced at the level of logical form by its disjunctive expansion $Lj \vee Lm$. For logical nativists, the logical entailments that hold between the sentences of a human language just are the formal ones holding between the logical forms corresponding to those sentences, so there is no problem of trying to find a human language analogue for logical concepts and relations.

Interestingly, human languages can even wear the relation between quantificational operators and logical connectives on their sleeves. Japanese is one such language. In Japanese, the disjunction operator is *ka* and the conjunction operator is *-mo*. These logical operators appear in quantificational expressions in Japanese, such that 'someone' is formed using the expression for disjunction, and 'everyone' is formed using the expression for conjunction. That is, the equivalent of English 'someone' in Japanese is *dare-ka* and the equivalent of English 'everyone' in Japanese is *dare-mo*.

We have seen that, by itself, the inference of *Jon laughs or Max laughs* (A or B) from *Jon laughs* (A) gives us pause, but it seems compelling when viewed through the intermediary of existential generalization. It is very hard to see how this could just be a quirk of English, however, since the reasoning that justifies Weakening makes no use of semantic properties unique to English words. Rather any language that contains an existential quantifier and a disjunction operator

will vindicate it.³ To disprove the hypothesis that inclusive disjunction must be an admissible interpretation of disjunction in any human language, it would have to be shown that there is a language L_n for which either:

- (i) Existential generalization fails (the inference from II to III), or else
- (ii) Existential quantification over a finite domain of named objects produces an existential claim that is not logically equivalent to a finitary disjunction (the inference from III to IV).

Any such human language L_n would be logically unsound. The upshot is that human language disjunction must have an inclusive–*or* interpretation on pain of logical incoherence.

6. Linguistic Universals with inclusive–*or*

So far, we have produced an *a priori* argument supporting the hypothesis that all human languages allow an inclusive interpretation of disjunction. If sound, this argument establishes that OR, meaning \vee -disjunction, is a universal feature of human languages. There is considerable empirical evidence that confirms this hypothesis. One source of this evidence is from cross-linguistic research.

For a start, it is universally the case that negated disjunctions adhere to de Morgan's law for negated disjunctions: $\neg(A \vee B) \Rightarrow (\neg A \wedge \neg B)$. In human languages, this law applies universally only when negation is in a 'higher' clause than disjunction. An example is given in (4) where the clause that contains disjunction, *...John speaks French or Spanish*, is embedded in the clause with negation, *Mary didn't say...*. Semantically, the critical observation is that (4) generates a conjunctive entailment, as indicated in (4a); it does not have the 'disjunctive' truth conditions indicated in (4b).

- (4) Mary didn't say John speaks French or Spanish.
 - a. Mary didn't say John speaks French and she didn't say he speaks Spanish.
 - b. *Mary didn't say John speaks French or she didn't say he speaks Spanish.

Remarkably, when (4) is translated into Japanese, Chinese, Russian, and so forth, its variants in these other languages also carry conjunctive entailments. Here are examples from Chinese (5) and Japanese (6). In both languages, these negated disjunctive statements generate a conjunctive entailment.

³ We are not claiming that every human language must contain a word corresponding to the existential quantifier and a word corresponding to disjunction. The concepts of existential quantification and disjunction could be made available to language users indirectly, e.g., using negation and universal quantification, as in *Not everybody laughed*.

(5) *Chinese*

Mali meiyou shuo-guo Yuehan hui shuo fayu huozhe xibanyayu.

Mary not say-PAST John can speak French or Spanish

瑪麗沒有說過約翰會說法語或者西班牙語

'Mary didn't say that John speaks French or Spanish.'

(6) *Japanese*

Mary-wa John-ga French ka Spanish-wo hanas-u-to iwa-nakat-ta.

Mary-TOP John-NOM French or Spanish-ACC speak-PRES-COMP say-not-PAST

'Mary didn't say that John speaks French or Spanish.'

As these examples illustrate, when negation appears in a higher clause than the clause that contains disjunction, i.e. not ${}_s[A \text{ or } B]$, such statements exclude the possibility of both *A* and *B*, in typologically different languages (cf. Szabolcsi 2002, Goro 2004). Notice that in the Japanese example (6), the statement takes a different form, $[A \text{ or } B]_s \text{ not}$, as compared to English and Chinese, $\text{not } {}_s[A \text{ or } B]$. This is because Japanese is verb-final and negation is attached to the verb. Nevertheless, the Japanese example has the same truth conditions as the examples from English and Chinese. It makes no difference that the disjunction operator *ka* precedes negation in Japanese, whereas *or* and *huozhe* follow negation in the English and Chinese examples. This shows that the interpretation of disjunction does not depend on linear order; what matters is constituent structure. In any event, we have derived one candidate for a linguistic universal (influenced by the work of Anna Szabolcsi and Takuya Goro): *When disjunction appears in a lower clause than negation, negated disjunctions license a conjunctive entailment.*

It is implausible to suppose that children learn that disjunction is inclusive-*or* in human language based on their exposure to sentences like those in (4), (5), and (6). Such sentences are too rare to ensure that every language learner is exposed to a sufficient quantity of them to guarantee convergence on the target grammar.⁴ The conjunctive interpretation of disjunction is licensed only if disjunction words are interpreted as inclusive-*or*, as in de Morgan's laws of classical logic. De Morgan's laws apply, of course, if and only if the negation operator is acting upon disjunction. To illustrate, consider the following two sentences, and their associated logical forms, where 'Dx' stands for *x is a delegate*, 'Sx' for *x ate sushi*, 'Px' for *x ate pasta*, and 'Ix' for *x became ill*.

(7) Not every delegate who ate sushi or pasta became ill.

$$\neg \forall x[(Dx \ \& \ (Sx \vee Px)) \rightarrow Ix]$$

(8) Not every delegate who became ill ate sushi or pasta.

$$\neg \forall x[(Dx \ \& \ Ix) \rightarrow (Sx \vee Px)]$$

⁴ As we discuss in section 5, a similar cross-linguistic generalization does not extend to simple negative sentences with disjunction, such as *Ted didn't eat sushi or pasta*. In simple negative statements, some languages license conjunctive interpretations (e.g., English, German), but other languages do not (e.g., Japanese, Chinese).

The role the disjunction ‘ $Sx \vee Px$ ’ plays in both of these formulae might look the same prior to analysis, but there is a significant difference. In the formula in (7) disjunction appears in the antecedent clause of a negated conditional, whereas in (8) it appears in the consequent clause of a negated conditional. Thus, when we come to reduce each formula further, as in (7’) and (8’) respectively, we see that disjunction is no longer in the scope of negation in (7’), but it is in the scope of negation in (8’).

(7’) Not every delegate who ate sushi or pasta became ill.

$$\begin{aligned} & \neg \forall x[(Dx \ \& \ (Sx \vee Px)) \rightarrow Ix] \\ & \Leftrightarrow \exists x \neg [(Dx \ \& \ (Sx \vee Px)) \rightarrow Ix] \\ & \Leftrightarrow \exists x[(Dx \ \& \ (Sx \vee Px)) \ \& \ \neg Ix] \end{aligned}$$

(8’) Not every delegate who became ill ate sushi or pasta.

$$\begin{aligned} & \neg \forall x[(Dx \ \& \ Ix) \rightarrow (Sx \vee Px)] \\ & \Leftrightarrow \exists x \neg [(Dx \ \& \ Ix) \rightarrow (Sx \vee Px)] \\ & \Leftrightarrow \exists x [(Dx \ \& \ Ix) \ \& \ \neg (Sx \vee Px)] \\ & \Leftrightarrow \exists x [(Dx \ \& \ Ix) \ \& \ \neg Sx \ \& \ \neg Px] \end{aligned}$$

Thus negation acts directly on a disjunctive clause only in (8). The reason is that in negating conditionals we affirm the antecedent and deny the consequent, since this represents the sole condition under which conditionals are false. So if the disjunctive clause appears in the antecedent of a conditional, as in (7), it does not get negated, whereas if it appears in the consequent, as in (8), it does get negated. In human languages, then, disjunction is negated if it appears in the predicate phrase of a negated universally quantified statement, but disjunction is not negated if it appears in the subject phrase of a negated universally quantified statement. Consequently, disjunction licenses a conjunctive entailment in the predicate phrase of a negated universally quantified statement, as in (8), but not when disjunction appears in the subject phrase of such a sentence, as (7) shows. So to say *Not every delegate who ate sushi or pasta became ill* is to say that at least one of the delegates who ate sushi or pasta remained unaffected, and to say *Not every delegate who became ill ate sushi or pasta* is to say that some delegate who became ill didn’t eat sushi and didn’t eat pasta (so these foods are ruled out as the source of the illness). De Morgan’s laws are thus preserved at the level of logic and also at the level of semantic interpretation in human languages.

We just noted that disjunction licenses a conjunctive implication in the predicate phrase in negated universally quantified statements. This is in striking contrast to sentences with the universal quantifier in pre-subject position, but without negation. In such cases, disjunction licenses a conjunctive implication in the subject phrase, but not in the predicate phrase. As (9) shows for English, when disjunction is in subject phrase of a sentence with the downward entailing expression *every*, the sentence yields the entailments (9a) and (9b). Therefore, the English statement in (9) generates the conjunctive interpretation indicated in (10), which is simply the conjunction of the two entailments (9a) and (9b).

- (9) Every student who speaks French or Spanish passed the exam.
 a. every student who speaks French passed the exam
 b. every student who speaks Spanish passed the exam
- (10) Every student who speaks French passed the exam and every student who speaks Spanish passed the exam.

It is worth noting, again, that the same linguistic phenomena are manifested across human languages. When (9) is translated into Japanese or Chinese (and any other language, as far as we know), the corresponding statements also generate conjunctive interpretations. This is illustrated in (11) and (12). Example (11) shows that the Chinese disjunction operator *huozhe* licenses a conjunctive interpretation when it appears in the subject phrase of the universal quantifier *meige*. Example (12) provides the corresponding sentence in Japanese.

(11) *Chinese*

Meige hui shuo fayu huozhe xibanyayu de xuesheng dou
every can speak French or Spanish DE student DOU
 tongguo-le kaoshi.
pass-PERF exam
 'Every student who speaks French or Spanish passed the exam.'

(12) *Japanese*

Furansugo ka supeingo-wo hanas-u dono gakusei-mo goukakushi-ta.
French or Spanish-ACC speak-PRES every student pass exam-PAST
 'Every student who speaks French or Spanish passed the exam.'

In view of this cross-linguistic generalization, a second universal principle is postulated (influenced by the work of Gennaro Chierchia): *Disjunction licenses a conjunctive interpretation when it appears in the subject phrase of the universal quantifier.*

In the next section, we report the findings of a study showing that children know this universal principle. But more importantly, children also know where disjunction does not license a conjunctive interpretation in human languages. Interestingly, when disjunction is in the predicate phrase of a sentence with the universal quantifier, it no longer generates a conjunctive interpretation. This is illustrated in (13), which has been formed from (9) simply by swapping the contents of the subject phrase and the predicate phrase.

- (13) Every student who passed the exam speaks French or Spanish.
 a. # every student who passed the exam speaks French
 b. # every student who passed the exam speaks Spanish

In (13), the predicate phrase (*speaks French or Spanish*) contains disjunction, but a conjunctive interpretation is not licensed, because neither of the relevant entailments, (13a) or (13b), are valid inferences from (13). This asymmetry

between the subject and predicate phrase of the universal quantifier extends to human languages around the globe and, again, experimental investigations have revealed that children are aware, at an early age, that disjunction generates a conjunctive interpretation in the subject phrase of the universal quantifier, and children are also aware that disjunction does not generate a conjunctive interpretation in the predicate phrase of sentences with the universal quantifier.

The question naturally arises: how do children figure out that human languages interpret OR in one way in the subject phrase of the universal quantifier, and a different way in the predicate phrase? As Chierchia (2004: 94) remarks “All the action concerns meaning. Morphology or distributional patterns play no role”. Chierchia concludes that the “generalization under discussion yields a particularly strong version of the poverty of stimulus argument. It is thus interesting to find out when exactly the child starts acting in an adult like manner [...]” (*ibid.*). Since poverty of stimulus arguments are the bread and butter of both linguistic nativism and logical nativism, it is important to find out if knowledge of the asymmetry in the interpretation of disjunction in sentences with the universal quantifier emerges early in language development, albeit without decisive evidence from experience. We return to this in the next section.

First, we offer further confirmation that disjunction is inclusive–*or* in human languages. This confirmation comes from studies of how speakers interpret disjunction in sentences with certain focus operators, e.g., English *only*, Japanese *dake*; Chinese *zhiyou*. The semantic contribution of such focus operators is quite complex. Consider the statement in (14).

(14) Only Bunny Rabbit ate a carrot or a green pepper.

This statement expresses two propositions. Following common parlance, one proposition is called the *presupposition* and the other is called the *assertion*. Simply deleting the focus expression from the original sentence yields the presupposition: *Bunny Rabbit ate a carrot or a green pepper*. For many speakers, there is an implicature of exclusivity (‘not both’) in the presupposition (see section 3). The second proposition is the assertion. To derive the assertion, the sentence can be further partitioned into (i) a *focus element* and (ii) a *contrast set*. Focus expressions such as *only* are typically associated with a particular linguistic expression somewhere in the sentence. This is the focus element. In (14), the focus element is *Bunny Rabbit*. Typically, the focus element receives phonological stress.

The assertion is about the contrast set. The members of the contrast set are individuals in the domain of discourse that are taken by the speaker and hearer to be alternatives to the focus element. These individuals should have been introduced into the conversational context before the sentence was produced; their existence is presupposed. In the present example, the contrast set consists of individuals being contrasted with *Bunny Rabbit*. The sentence would not be felicitous in the absence of such alternatives to Bunny Rabbit. The assertion states that the members of the contrast set *lack* the property being attributed to the focus element. In *Only Bunny Rabbit ate a carrot or a green pepper*, the assertion is the following claim: *Everybody else (being contrasted with Bunny Rabbit) did not eat a*

carrot or a green pepper. The critical observation is that disjunction is in the scope of (local) negation in the assertion: ... *did not eat a carrot or a green pepper*. Because disjunction appears in the scope of negation, it licenses a conjunctive interpretation: *Everybody else didn't eat a carrot and everybody else didn't eat a green pepper*. As far as we know, disjunction generates a conjunctive interpretation in all human languages when it appears in the assertion of sentences with certain focus expressions. So, Chinese sentences license a conjunctive interpretation when the disjunction operator *huozhe* appears in the scope of the focus expression *zhiyou*, and Japanese sentences license a conjunctive interpretation when the disjunction operator *ka* is in the scope of the focus expression *dake*. Therefore, a third linguistic universal has been postulated (based on joint work with Takuya Goro and Utako Minai): *Disjunction generates a conjunctive interpretation in the assertion of certain focus expressions in all human languages*.

This rests our case for concluding that all languages adopt the same meaning of OR, namely inclusive-*or*. We cited three structures that, across languages, invoke inclusive-*or*. In all three cases, moreover, it seems implausible that children learn that disjunction is inclusive-*or* based on their exposure to sentences with these structures. These joint observations are relevant for the long-standing 'nature versus nurture' controversy. A linguistic property that (i) emerges in human languages without decisive evidence from experience and (ii) is common to all human languages is a likely candidate for innate specification. A third hallmark of innateness, early emergence, will be discussed in section 7. First, though, we wish to consider one way in which languages vary in the interpretation they assign to disjunctive statements, in simple negative sentences. Since evidence of cross-linguistic variation often accompanies arguments against innateness and for an experience-dependent account of language development, it is important to show that cases of language variation do not weaken the case for logical nativism. Experience matters, of course. As child speakers grow up, they must eventually learn to use disjunction in the same way as adults do. But, as we will show, the cross-linguistic variation at issue is not compelling evidence that disjunction is exclusive-*or* in any human language.

7. Variation in the Interpretation of Disjunction

It is worth asking why we didn't derive a universal principle invoking simple negative sentences such as *Max didn't eat sushi or pasta*, with negation and disjunction in the same clause. After all, this sentence also licenses a conjunctive entailment that Max didn't eat sushi *and* Max didn't eat pasta, at least in English. Why was it necessary to add the proviso that negation had to be in a higher clause than disjunction in order to ensure that a conjunctive interpretation was generated? The problem is that, if we translate the simple English sentence *Max didn't eat sushi or pasta* into certain other languages, including Japanese, Russian, and Hungarian, the corresponding sentences in these languages do not generate a conjunctive interpretation. As example (15) illustrates, adult speakers of Japanese interpret (15) to mean that the pig didn't eat the carrot or the pig didn't eat the green pepper. Despite the appearance of the disjunction operator *ka* under

local negation in the surface syntax, *ka* is interpreted as if it has scope over negation.

(15) *Japanese*

Butasan-wa ninjin ka pi'iman-wo tabe-nakat-ta.
pig-TOP carrot or green.pepper-ACC eat-NEG-PAST
 'The pig didn't eat the carrot or the pig didn't eat the green pepper.'
lit.: 'The pig didn't eat the carrot or the green pepper.'

Pursuing a suggestion by Szabolcsi (2002), Goro (2004) proposed that languages are partitioned into classes by a 'parameter'. According to this parameter, the disjunction operator is a *positive polarity item* (like English *some*) in one class of languages, but not in another class of languages (including English and German, among others). By definition, a positive polarity item must be interpreted as if it were positioned outside the scope of negation (OR > NEG), rather than in the scope of negation (NEG > OR). The Japanese setting of the parameter is (OR > NEG), so a paraphrase of (15) would be: *It is a carrot or a green pepper that the pig didn't eat*. On this setting of the parameter, negation does not take scope over disjunction, so no conjunctive interpretation is generated. On the English setting of the parameter (NEG > OR), disjunction is interpreted under negation, so (15) would be paraphrased in English as *The pig didn't eat a carrot or a green pepper*. In this case, a conjunctive entailment is generated.

Based on considerations of language learnability, Goro made an intriguing prediction — that young Japanese-speaking children would initially generate a conjunctive entailment in simple negative disjunctive sentences, in contrast to adult speakers of Japanese. The prediction was based on the observation that the two settings of the parameter are in a subset/superset relation. Setting aside the implicature of exclusivity, on the Japanese/Russian setting of the parameter, (15) is (logically) true in three different sets of circumstances; when the pig didn't eat a carrot, but did eat a green pepper, when it didn't eat a green pepper, but did eat a carrot, and when it didn't eat either one. These are the circumstances associated with the inclusive-*or* interpretation of disjunction when disjunction takes scope over negation (OR > NEG). On the English/German setting of the parameter, negation takes scope over disjunction (NEG > OR). On this setting, (15) is true in just one set of circumstances, namely ones in which the pig didn't eat either a carrot or a green pepper. This parameter setting also invokes the inclusive-*or* interpretation of disjunction. This means that disjunction has the inclusive-*or* interpretation on both settings of the parameter. What changes, according to the setting of the parameter, is the scope relations between disjunction and negation.

Notice that one setting of the parameter (NEG > OR; English/German) makes the statement of (15) true in a subset of the circumstances corresponding to the other setting (OR > NEG; Japanese/Russian). The *semantic subset principle* dictates that, whenever parameter values are in a subset/superset relation, the *language acquisition device* compels children to initially select the subset value (Crain, Ni & Conway 1994). The semantic subset principle anticipates that the subset reading (NEG > OR; English/German) will be children's initial setting (i.e. the default). Based on this line of reasoning, Goro (2004) predicted that children

learning Japanese would initially interpret (15) in the same way as English-speaking children and adults. The prediction was confirmed in an experimental investigation of 4- and 5-year-old Japanese-speaking children by Goro & Akiba (2004). They found that young Japanese-speaking children consistently licensed a conjunctive entailment in response to statements like (15). This empirical finding reinforces the conclusion that human languages invoke the inclusive-*or* meaning of disjunction, as in classical logic (Crain, Goro & Thornton 2006).

According to the parameter under consideration, there are two classes of languages. In one class, which includes Japanese and Chinese, disjunction is a positive polarity item; in the other class, which includes English and German, disjunction is not a positive polarity item. By definition, a positive polarity item must take scope over negation. English *some* meets this definition of a positive polarity item, as (16) illustrates. If *some* were to be interpreted within the scope of negation, then the sentence would mean Ted didn't eat *any* kangaroo. Instead, it means *There is some kangaroo that Ted didn't eat*.

- (16) Ted didn't eat **some** kangaroo.
'There is some kangaroo that Ted didn't eat.'

Positive polarity items (e.g., English *some*, Chinese *huozhe*, Japanese *ka*) are interpreted as having scope over negation just in case the positive polarity item and negation are in the same clause. However, if negation appears in a higher clause than the one containing the positive polarity item, then negation takes scope over the polarity item, as long as negation c-commands disjunction (and there are no intervening quantificational expressions). Example (17) illustrates this for English *some*.

- (17) You didn't convince me that Ted ate **some** kangaroo.
'You didn't convince me that Ted ate any kangaroo.'

If Chinese disjunction operator *huozhe* and the Japanese disjunction operator *ka* are positive polarity items, as Goro suggests, then Chinese and Japanese should be expected to adhere to de Morgan's laws in sentences in which negation appears in a higher clause than the clause that contains *huozhe* or *ka*, as we have seen.

8. Children's Interpretation of Disjunction

There are several studies showing that young children know that disjunctive words in human languages correspond to inclusive-*or*. We begin with disjunction in the scope of focus expressions. Recent experimental research has sought to determine whether or not children know the two meaning components of sentences with certain focus expressions. In a series of studies (see, e.g., Crain, Goro & Minai 2007), we investigated children's interpretation of *or/ka* to assess their knowledge of the semantics of *only/dake*. The research strategy was to investigate children's interpretation of disjunction *or/ka* in the presupposition of

sentences with the focus operator *only/dake* in one experiment, and in the assertion in a second experiment. One of the test sentences was (18).

- (18) a. Only Bunny Rabbit ate a carrot or a green pepper. *English*
 b. Usagichan-dake-ga ninjin ka pi'iman-wo taberu-yo. *Japanese*
rabbit-only-NOM carrot or green.pepper-ACC eat-DEC
 'Only Bunny Rabbit ate a carrot or a green pepper'

Presupposition: Bunny Rabbit ate a carrot or a green pepper.

Assertion: Everyone else (being contrasted with Bunny Rabbit) did not eat a carrot or a green pepper.

As indicated, the disjunction operators *or/ka* in (18) yield *disjunctive* truth conditions in the presupposition. Suppose, then, that children assign the adult interpretation to *or/ka* in the presupposition. If so, children should accept sentences (18) in the situation where Bunny Rabbit ate a carrot but not a green pepper. This was Experiment I.

In the assertion, *or/ka* licenses a conjunctive interpretation — everyone else did not eat a carrot and did not eat a green pepper. Consequently, if children assign the correct interpretation to *or/ka* in the assertion, they should reject (18) in the situation in which Cookie Monster ate a green pepper (while, again, Bunny Rabbit ate a carrot but not a green pepper). This is Experiment II.

To summarize, if children understand both the presupposition and the assertion of *Only Bunny Rabbit ate a carrot or a green pepper*, then they should accept it in Experiment I, but reject it in Experiment II.

The experiments in English and Japanese were identical in design, with only minimal changes in some of the toy props. The experiment adopted the Truth Value Judgment task, in the prediction mode (Chierchia *et al.* 2001, Crain & Thornton 1998). There were two experimenters. One of them acted out the stories using the toy props, and the other manipulated the puppet, Kermit the Frog. While the story was being acted out, the puppet watched along with the child subject. In each trial, the story was interrupted — after the introduction of the characters and a description of the situation — so that the puppet could make a prediction about what he thought would happen. Then, the story was resumed, and its final outcome provided the experimental context against which the subject evaluated the target sentence, which had been presented as the puppet's prediction. The puppet repeated his prediction at the end of each story, and then the child subject was asked whether the puppet's prediction had been right or wrong.

The main finding was that both English-speaking children and Japanese-speaking children consistently accepted the test sentences in Experiment I in both languages, and children consistently rejected the test sentences in Experiment II in both. The two groups of children showed no significantly different behavior in interpreting disjunction within sentences containing a focus operator, *only* versus *dake*. The high rejection rate in Experiment II shows that children assigned a conjunctive interpretation to disjunction in the assertion of sentences with the focus expression *only/dake*.

Another series of experimental studies investigated children's knowledge of the asymmetrical interpretation of disjunction in sentences with the universal quantifier. Several studies have investigated the truth conditions children associate with disjunction in the subject phrase and in the predicate phrase of the universal quantifier. For example, in studies (e.g., Boster & Crain 1993, Gualmini, Meroni & Crain 2003) using the Truth Value Judgment task, children were asked to evaluate sentences like (19) and (20), posed by a puppet, Kermit the Frog.

(19) Every woman bought eggs or bananas.

(20) Every woman who bought eggs or bananas got a basket.

In one condition, sentences like (19) were presented to children in a context in which some of the women bought eggs, but none of them bought bananas. The child subjects consistently accepted test sentences like (19) in this condition, showing that they assigned a 'disjunctive' interpretation to *or* in the subject phrase of the universal quantifier, *every*. In a second condition, children were presented with sentences like (20) in a context in which women who bought eggs received a basket, but not women who bought bananas. The child subjects consistently rejected the test sentences in this condition. This finding is evidence that children generated a conjunctive interpretation for disjunction in the subject phrase of *every*. This asymmetry in children's responses in the two conditions demonstrates their knowledge of the asymmetry in the two grammatical structures associated with the universal quantifier—the subject phrase and the predicate phrase. The findings represent a challenge to the experience-dependent approach to language acquisition. The challenge is posed by the asymmetry in the interpretation of the same disjunction *or*, in the subject phrase versus the predicate phrase of the universal quantifier, since the distinction is one of interpretation, not the distribution, of lexical items.

The case for logical nativism is also supported by evidence that English-speaking children respect de Morgan's laws at an early age. If adults judge that negated disjunctions license conjunctive entailments, then children must acquire the capacity to make similar judgments as they grow into adulthood. But that leaves a lot of time for exposure to a lot of data. But if very young children demonstrate knowledge of the semantic principles that characterize adult linguistic competence, then that would compress the acquisition problem considerably. Of course, no-one can ever prove that 2-year-old children have not already utilized a vast range of data, but the case for logical nativism is strengthened if it can be demonstrated that 2-year-old children adhere to de Morgan's laws before they are *plausibly* exposed to the data needed by learning-theoretic accounts. We will discuss one candidate for a learning-theoretic account in the next section. First, we present further empirical evidence for logical nativism based on experimental studies of 2-year-old English-speaking children.

In an ongoing longitudinal study of four 2-year-olds, we have presented them with negated disjunctions, and have recorded their behavioral and verbal responses. On a typical trial in one condition, children are shown three dogs, a white one, a brown one and a black one. Kermit the Frog, who is manipulated by

the experimenter, indicates that he wants to play with a dog. The experimenter then holds up the three dogs. Then Kermit says: "I don't want to play with the white dog or the brown dog". If children adhere to de Morgan's laws, they are expected to give Kermit the black dog. In another condition, negated disjunctions are used in *wh*-questions, such as *Who doesn't have A or B?*. On a typical trial, an array of characters are introduced, some with yo-yo's, some with sponge balls, and some with strawberries. Then, the target question is posed to children: *Who doesn't have a yo-yo or a sponge ball?*. One of the youngest children consistently responded in conformity with the conjunctive entailment beginning on the very first trial, at age 2;3. Other children produced consistent adult-like responses later than this, but all four children consistently respond in ways that demonstrate knowledge that negated disjunction yield conjunctive entailments by age 2;10. The transcripts of parental input reveal that children experience little evidence that disjunction is inclusive-*or*. The vast majority of the input is consistent with exclusive-*or*, so this interpretation would be adopted by many children if it were a possible semantic option in human languages. The fact that all four of the 2-year-olds we have tested have reached the opposite conclusion, that disjunction is inclusive-*or*, supports our claim that inclusive-*or* emerges in children's grammars in the absence of decisive evidence from experience. Emergence in the absence of experience is one of the hallmarks of innateness.

In this section, we produced empirical grounds for believing the inclusive-*or* interpretation of disjunction is universal and innate. The evidence from young children regarding their understanding of negated disjunctions seems compelling. Once they understand the meaning of *or* and *ka* they assent to the conjunctive entailments supported by de Morgan's laws, even for statements that do not obey de Morgan's laws for adult speakers, as in Japanese. Obviously, children do not learn to obey de Morgan's laws by observing how adults interpret disjunction. We think the conclusion to draw is, therefore, that children do not learn the meaning of disjunction; they bring knowledge that the meaning of disjunction is inclusive-*or* to the task of language development.⁵

In the next section, we consider what it would actually take for children to *learn* the meaning of disjunction. We will consider how children might learn the meaning of logical connectives, including disjunction, by observing how people use these connectives in drawing inferences. Once it is laid out for examination, such a learning story seems to us to be highly implausible. Then we summon some *a priori* arguments against such learning accounts.

⁵ One common argument against the universality of *v*-disjunction is that there is at least one language, namely Latin, which has separate words for inclusive and exclusive disjunction, *vel* and *aut* respectively, so that there is no such thing as *the* meaning of OR in Latin — in this language OR has two meanings, depending on whether it is inclusive or exclusive disjunction one has in mind. But Jennings (2001) has convincingly refuted this "mythical supposition", as he calls it. For if *aut* really did mean \oplus , then negating a sentence such as *Timebat tribunos aut plebes* 'One feared the magistrates or the mob' ought to produce a sentence meaning that everyone either feared both or neither. But this is not what *Nemo timebat tribunos aut plebes* means at all — it means that no one feared either, precisely as the inclusive interpretation of *aut* predicts.

9. Learning by Inference Rules

Some claim that there is a straightforward solution to the language-learning problem for a finite logical vocabulary: learning the meanings of logical expressions is simply a matter of learning the inferential rules associated with these expressions. This is the claim of Conceptual Role Semantics (CRS).⁶ Advocates of CRS attempt to explain our knowledge of the meaning of logical expressions by exploiting the role these expressions play in inferences. Thus, we can imagine that children learn the rules of logic in the same way they learn the rules of chess or any other game: someone instructs them in the rules or, more likely, they observe the linguistic behaviour of others who know the rules. On this account, there are no alternative hypotheses involved, just like the kinds of meaning-stipulations that are required for learning “a knight can move two squares vertically and one horizontally or two horizontally and one vertically”.

Admittedly, there is an undeniable appeal to this type of account. And, the CRS account could plausibly explain how even young learners come to use AND, based on experience. The requisite experience consists of observing the patterns of inference that involve AND, namely its introduction rule (&I):

$$(21) \frac{A \quad B}{A \ \& \ B}$$

and its elimination rule (&E):

$$(22) \frac{A \ \& \ B}{A \quad B}$$

All the learner needs to learn the meaning of AND is to be shown these rules, (&I) and (&E). No testing of hypotheses is involved, according to CRS.

However, an account of meaning via exposure to inference rules does not generalize to other logical constants. Consider how children would learn the meaning of OR. Earlier we argued that human languages validate the introduction rule for OR, Weakening (\vee I) — see (1)–(2). However, English-speaking adults find direct statements of Weakening unacceptable, so they are not likely to use Weakening in the simple form. Although adults assent to the validity of Weakening if this rule is validated for them via a step involving Existential Generalization, it is highly implausible that children learn that disjunction is inclusive-*or* by observing adults using this complex form of inference. Even if adults were to use disjunction in this way, this kind of input is just too exotic to be available in sufficient quantities to ensure that all children learning English, or any other language, reach the conclusion that the meaning of disjunction is inclusive-*or*. Therefore, this inference rule is not a likely source of evidence for children that the meaning of disjunction is inclusive-*or*. Yet, as we have seen,

⁶ The view originated with Wittgenstein’s (1953) thesis that meaning is use and was developed further by Sellars (1969). Proponents of CRS today include Block (1986, 1987), Brandom (2000), Field (1977, 2001), Harman (1987), Horwich (1998), Miller & Johnson-Laird (1976).

even 2-year-old English-speaking children seem to have reached just this conclusion.

This brings us to the elimination rule for disjunction, (\vee E):

$$(23) \quad \begin{array}{c} [A] \quad [B] \\ \cdot \quad \cdot \\ \cdot \quad \cdot \\ \cdot \quad \cdot \\ \hline A \vee B \quad C \quad C \\ \hline C \end{array}$$

Disjunction Elimination (\vee E) works in the following way: To prove that some conclusion C follows from a disjunction $A \vee B$, we need to establish that C follows from each of the disjuncts A , B in turn. If so, then C must follow from the disjunction $A \vee B$ since it has been shown that, irrespective of which specific disjunct holds, C follows. The disjuncts are bracketed to indicate that we are not committed to them by the end of our demonstration — they are ‘discharged’, i.e. removed from the list of assumptions to which we are committed.

Here is a simple illustration. Suppose we wish to show *Alice did not hear the telephone* can be derived from the disjunctive claim *Alice was out of the house or Alice was fast asleep*. We proceed by first assuming the left hand disjunct (LH), *Alice was out*, showing that if she was out, then she would not have heard the telephone in the house ring. We then assume the right hand disjunct (RH) *Alice was fast asleep*. Knowing how soundly Alice sleeps, we are able to derive the conclusion that she would not have heard the phone from the assumption that she was fast asleep. We don’t know whether she was out at that time or fast asleep, but let’s suppose since on either alternative she would not have heard the telephone ring, we have established that C *Alice did not hear the telephone* follows from *Alice was either out of the house or fast asleep*. Clearly, we are not committed to believing categorically that she was out nor are we categorically committed to believing she was fast asleep. We’re committed only to believing that one or the other alternative held, i.e. we’re committed to believing the disjunction *Either Alice was out of the house or fast asleep*. So we discharge both disjuncts *Alice was out*, and *Alice was asleep*.

We can formally vindicate the requisite conjunctive entailment of $\neg A \ \& \ \neg B$ by $\neg(A \vee B)$ as follows:

1.	$\neg(A \vee B)$	<i>Assumption</i>	6.	B	<i>Hypothesis</i>
2.	A	<i>Hypothesis</i>	7.	$A \vee B$	6 $\vee I$
3.	$A \vee B$	2 $\vee I$	8.	\perp	1, 7 $\&I$
4.	\perp	1, 3 $\&I$	9.	$\neg B$	6, 8 <i>RAA</i>
5.	$\neg A$	2, 4 <i>RAA</i>	10.	$\neg A \ \& \ \neg B$	5, 9 $\&I$

The child whose knowledge of the meaning of OR consisted in knowledge of the inference rules of *or*-introduction and *or*-elimination would know that the meaning of the English word *or* is inclusive-*or*. Yet even if these particular

inference rules for *or* are constitutive of the meaning of OR, it is quite another matter to conclude that these inference rules are available in the primary linguistic data (PLD) to which children are exposed. Disjunction Elimination, ($\vee E$), in particular is a highly sophisticated rule that young adults typically struggle with in the logic classes. Why would young adults struggle if, as children, they tacitly grasped this inference rule when they first learned the meaning of OR? It is even less plausible to suppose that young children should have any idea of the discharge of assumptions or sub-derivations. But such knowledge is a prerequisite to understanding the bare notion of disjunction using Disjunction Elimination.

A simpler Elimination Rule for disjunction, Disjunctive Syllogism, presents itself as a far more plausible candidate for something a child might learn that could serve to fix the meaning of OR:

$$(24) \frac{A \vee B \quad \neg A}{B}$$

Disjunctive Syllogism, unlike Disjunction Elimination, seems highly learnable. The 'elimination of alternatives' would seem to be a fairly primitive conceptual resource. It has been suggested that it is available even to creatures far simpler than humans. It is reasonable to suppose that a pattern of inference that plausibly predates the advent of language would be made explicit in the logic of human languages, and recognized as sound by young language-learners. If this were indeed so then there would no longer be any need for the child to acquire the concept of disjunction by learning the meaning of OR since s/he would already possess the concept in using elimination of alternatives. Even if this speculation were to prove wrong, however, Disjunctive Syllogism could not *by itself* fix the meaning of OR since it holds for *both* inclusive and exclusive disjunction and thus fails to distinguish between them.

So far, we have concluded that the child's PLD is unlikely to contain instances of those inference rules, such as Weakening and Disjunction Elimination, that could serve as the basis for learning the meaning of OR. We established earlier that language-users are committed to Weakening as a sound form of inference governing their understanding of OR *even if they do not in general recognize this fact*. But in light of this latter point, Weakening is highly unlikely to appear in the primary (or other) linguistic data available to the child, so it cannot serve to fix the meaning of OR. Of the two Elimination Rules canvassed for OR, Disjunction Elimination and Disjunctive Syllogism, the former is wildly implausible as a possible route for a child to acquire the meaning of OR, because of its sheer conceptual complexity. Disjunctive Syllogism failed for exactly the opposite reason: given the pre-linguistic child's reasoning proclivities, its conceptual simplicity suggests it might already be available to the child prior to any acquisition of the meaning of OR. Yet, regardless, it is too weak by itself to fix the meaning of OR since it does not distinguish the exclusive reading of disjunction from the inclusive one.

In sum, the account of learning offered by CRS seems implausible, with the possible exception of the acquisition of the meaning of conjunction. Such worries

pale into insignificance, however, when compared to Prior's (1978) famous problem for CRS accounts of the logical constants. Prior invented a logical constant 'TONK' with the following introduction and elimination rules:

$$(25) \quad \text{(TONK I)} \quad \frac{A}{A \text{ TONK } B} \quad \frac{B}{A \text{ TONK } B}$$

$$(26) \quad \text{(TONK E)} \quad \frac{A \text{ TONK } B}{A} \quad \frac{A \text{ TONK } B}{B}$$

Prior then used these inference rules to prove that any two arbitrary sentences were identical:

$$(27) \quad \text{(TONK I)} \quad \frac{[A]^1}{A \text{ TONK } B} \quad \frac{[B]^2}{A \text{ TONK } B}$$

$$\text{(TONK E)} \quad \frac{B \quad A}{A \leftrightarrow B} \quad \text{(1, 2 } \leftrightarrow \text{ I)}$$

Of course, TONK is an incoherent rule. It grafts the introduction rule for OR onto the elimination rule for 'and'. Prior's point was that a purely inferentialist account of the meaning of the logical constants, such as CRS, doesn't have the resources to say what is wrong with the acquisition of the meaning of TONK. We think what has gone wrong with CRS is that nature hasn't designed us to be CRS machines. Instead, it has engineered us through evolution to be creatures with rich conceptual resources to check the reliability of our mental representations. The upshot is that CRS does not, in principle, provide an adequate model of how language-learners acquire the meanings of logical constants such as OR. Of course, we think the meanings are not learned at all, but are innately specified. We now proceed to offer two *a priori* arguments for logical nativism, one based on Quine's (1979) critique of logical positivism, and one based on Fodor's (1980) argument for the innateness of primitive lexical concepts.

10. Quine's Critique of Truth by Convention

Like the rest of his logical positivist peers, Carnap (1937) sought to account for the necessity of logical and mathematical truths. Carnap offered a linguistic account of necessity: The necessary truths of a given language L are simply those generated by linguistic stipulations that determine L, stipulations that are purely conventional. Moreover, it is because necessary truths are really disguised linguistic stipulations that they can be known *a priori* to be true. For the logical positivists, necessary truths are true irrespective of how the world happens to be since they are *true in virtue of meaning*.

Take the logical truth known as the *Law of Non-Contradiction* (LNC): 'It is not the case that p and not p are both true'. According to Carnap, once we know what the logical operators NOT and AND mean, we have *a priori* knowledge of the

truth of the LNC: It simply *follows from* the meanings of NOT and AND.

Quine's objection was simplicity itself. The conventionalist account just rehearsed makes essential use of the notion of 'follows from', i.e. of *logical consequence*. So, according to the Carnapian account of logical necessity, our *a priori* knowledge of logical truths does not simply arise from our knowledge of the conventional linguistic meanings we have adopted to define the logical terms NOT and AND. To get from these linguistic conventions to the truth of LNC we must appeal to an already understood notion of logical consequence. Now either this nascent understanding of logical consequence is *a priori* or it is not.

- (I) If it is *a priori*, then some *a priori* knowledge cannot be explained conventionally.
- (II) If it is *not a priori* then our knowledge of at least some necessary truths cannot be explained by means of linguistic conventions.

Either way, the conventionalist account of logical truth breaks down. Meaning-stipulations (conventions) by themselves thus fail to secure *any* truths, even language-relative ones such as the logical truths were held to be. Quine admitted that so-called logical truths, such as LNC, had a different status from ordinary truths that are learned from experience. But, Quine had an alternative account of the special status of truths such as LNC. To characterize the contrast, Carnap endorsed (28), Quine argued for (29).

- (28) The reason we know that LNC holds, and holds of necessity, is that $A \ \& \ \neg A$ is a contradiction, and thus cannot possibly be true.
- (29) The reason we know that LNC holds, and holds with such tenacity, is that it is a strongly held belief that experience would never force us to conclude that $A \ \& \ \neg A$ holds true.

So there are two possible explanations about the epistemic status of LNC. Carnap's explanation is that, having learned the conventional meanings ' \neg ' and ' $\&$ ', we know *a priori* that the LNC is true without investigating what the world is like. By contrast, Quine's explanation is that the LNC, along with other fundamental logical and mathematical truths, occupies a privileged position in our web of belief purely because that web is so structured that the logico-mathematical truths lie at its core, well-insulated from the impact of experience. Another way to frame the contrast in epistemic status is to consider it from the vantage point of the learner. Assuming that the learner comes to know somehow that $\neg [A \ \& \ \neg A]$, two possibilities arise for the learner:

- (i) Is $\neg (A \ \& \ \neg A)$ true because it could *never be correct* to assert $A \ \& \ \neg A$?
- (ii) Is $\neg (A \ \& \ \neg A)$ true simply because I *never hear* $A \ \& \ \neg A$ asserted?

The problem with (ii) is that it invites the learner to infer that p is untrue on the grounds of a (persistent) absence of evidence for p. That is a risky inference, to say the least. So the learner should guess that (i) is likely to be right — he never

hears $A \ \& \ \neg A$ because there is something amiss with its assertion: It would never be correct to assert it. But the question is why, and Carnap and Quine return opposite answers, (28) and (29). Quine cannot endorse (i). According to Quine, knowing that you could not as a matter of principle ever hear $A \ \& \ \neg A$ asserted sneaks in a notion of knowing that certain statements are semantically illicit — that is, it sneaks in an implicit notion of *logical incoherence* in the form of a *contradiction*. So, Quine could endorse (ii) which claims that, as a matter of fact, we never hear anyone saying $A \ \& \ \neg A$. Despite their differences, both Carnap and Quine agreed on one thing — that the meanings of logical expressions such as NOT and AND are learned. For Quine, these were learned through observation of the assent and dissent dispositions of speakers. For Carnap these were learned through understanding the implicit conventions (stipulations) governing the meanings of these terms.

In a further critique of Carnap, Putnam (1975) added another argument, similar in spirit to the argument by Quine, but more relevant for our purposes, because Putnam's argument challenges the common assumption of both Quine and Carnap — that knowledge of logical truths can be learned. According to Putnam, Carnap's account of logical truth in terms of meaning-stipulations or conventions cannot be correct for the simple reason that the entire set of meaning-stipulations M could only be finite (or else recursive), whereas the entire set of logical truths T is infinite. So the question arises as to how T is to be generated from M. The only way this could be done is by deriving the elements of T from the elements of M — that is, by making use of the notion of logical consequence. Since it was precisely the notion of logical consequence that was supposed to be explicated by the meaning-convention approach, that approach is viciously circular.

Putnam is obviously correct in pointing out that the learner can only ever receive finitely many 'instructions' (either as to the meaning-stipulations or as to the assent-dissent dispositions of adults with respect to logical expressions). But the critical observation is that the learner somehow develops an unbounded competence in logic, on the basis of fragmentary experience. In the present article we have demonstrated that this human logical competence is both universal and emerges very early in children. These arguments, of course, are nothing other than an instance of Chomsky's familiar poverty of the stimulus argument for the language faculty (see, e.g., Crain & Pietroski 2002, Crain, Gualmini & Pietroski 2005, and Pietroski & Crain, in press). The difference is that it is applied to logic competence, rather than linguistic competence.

As counter-point to Putnam, Noam Chomsky and his followers ask how learners acquire knowledge that an unbounded number of strings are associated with certain meanings, and could never be associated with other meanings. Take a familiar example. In the string *He danced while Max ate pizza*, the pronoun *he* cannot refer to Max; it must refer to some unmentioned male individual. Where does the knowledge come from about what such sentence cannot mean? Again, there are two possibilities for the learner:

- (iii) Is $\neg (he = Max)$ true because it could *never be correct* that $(he = Max)$?
- (iv) Is $\neg (he = Max)$ true simply because I *never hear* strings where $(he = Max)$?

The critical point is that children know an unbounded number of such linguistic facts, such as the disjoint reference facts about pronouns and referential noun phrases. And children acquire knowledge of such facts despite having only fragmentary and often misleading evidence, as we have seen in the case of OR. In the case of pronouns and names, misleading data are abundant, consisting of examples which are similar in meaning, but in which the name precedes the pronoun (*Max danced while he ate pizza*), and where the pronoun precedes the name, but appears in a subordinate clause (e.g., *While he danced Max ate pizza*). Of course, this is just one example. For others, see Thornton (1990), Crain & Pietroski (2001), and Thornton (2007).

It is remarkable, then, to find that young children implicitly conclude that certain sentence meanings are ‘necessarily’ correct, permitting children to make judgments about entailments, contradictions, paraphrase, and ambiguity. Augmented by evidence that such linguistic phenomena are universal, and mastered by very young children, it has been argued that there is an innate Language Faculty (for a recent statement, see Pietroski & Crain, in press). We have presented a similar set of arguments for an innate Logic Faculty, based on the universality and early emergence of knowledge that disjunction is inclusive–or in human languages.

11. Mad Dog Logical Nativism

Fodor (1980) produced a notorious argument that is purported to prove every primitive lexical concept is innate. This is often referred to as Mad Dog Nativism. Whilst Mad Dog Nativism may be mistaken for lexical concepts, there is something right about the form of Fodor’s original argument in favour of it: properly construed, the argument provides a good reason for believing, not that *all primitive lexical* concepts like TURNIP and CARBURETOR are innate, but that primitive *logical* lexical concepts like DISJUNCTION and NEGATION are innate. Fodor’s argument proceeded as follows:

1. *All concepts are either learned or innate.*
2. *If learned, a concept must be acquired through hypothesis-testing.*
3. *Any concept acquired via hypothesis-testing is a logically structured concept.*
4. *Primitive Lexical concepts are not logically structured.*
5. *So, Primitive Lexical concepts are not acquired via hypothesis-testing.*
6. *Hence, Primitive Lexical concepts are not learned.*
7. *Thus, Primitive Lexical concepts are innate.*

It is unclear from Fodor’s presentation whether he thinks that primitive lexical concepts are unlearnable due to their primitive status, or due to their acquisition through hypothesis-testing. We think the status of lexical concepts as primitive (or derived) is a red herring when it comes to issues of learnability. What matters for learnability is not whether the learning net catches the little fish of primitive or unstructured concepts, what matters is the composition of the net.

In our view, however, Fodor’s argument raises a genuinely significant issue

concerning hypothesis-testing and its relation to learning. First, an obvious point needs to be borne in mind in any discussion of concept acquisition. Without having acquired the concept, say FROG, a learner, say Ollie, can think no thoughts with froggy content. That is, Ollie cannot think thoughts like *frogs are slimier than mice* or *I'd much rather play with a frog than with a rat!* No frog concept, no frog thoughts. Without having acquired the concept FROG, Ollie also cannot frame a frog hypothesis like *I get it! Claude is talking about frogs when he says 'grenouille'!* Nor can he use any special tacit knowledge about frogs in testing various hypotheses about the meaning of the French word *grenouille* or the English word *frog*.

The reason we refrain from endorsing Fodor's argument in its full generality can be illustrated by the frog-case. Ollie can acquire the concept of FROG by linking the word *frog* to other non-FROG concepts he has which he can use to identify frogs — for example, *those funny pop-eyed green hopping things*, or even *those things* (Ollie is pointing at some frogs). Fodor himself allows that Ollie will have mastered the concept FROG if his mental tokens of the word *frog* are causally linked in the right way to frogs. So, at least when the primitive lexical concepts pick out recurrent features of the language-learner's environment, there seems to be no special reason why our language-learner has to deploy the concept itself in hypotheses designed to settle the meaning of the lexical expression denoting that concept. Perhaps for Ollie to acquire the concept of FROG it will suffice if he has *some* innate primitive concepts, colour concepts, natural kinds, motion verbs, and so forth. Based on such innate primitive concepts, we see no reason, in principle, to suppose that other concepts, like frog, turnip and carburetor, cannot be acquired rather than being innate.

So Fodor's premise (3) does not seem *generally* correct. Nonetheless, there may be specific cases for which it does hold, and we claim that logic is precisely one such case. So we need to recast Fodor's argument, applying it specifically to *primitive* logical concepts rather than primitive lexical concepts. The argument for Mad Dog Logical Nativism proceeds as follows:

- 1'. *All logical concepts are either learned or innate.*
- 2'. *If learned, a logical concept is acquired through hypothesis-testing.*
- 3'. *If a logical concept is acquired through hypothesis-testing, neither the formulation of the hypothesis nor the methods used to test it can invoke the concept.*
- 4'. *In determining the meaning of a term denoting a primitive logical concept, learners make use of the concept to be acquired, if not in framing the hypothesis then in testing it.*
- 5'. *So, primitive logical concepts cannot be acquired through hypothesis-testing.*
- 6'. *Therefore, primitive logical concepts are not learned.*
- 7'. *And, therefore, primitive logical concepts are innate.*

To many ears, perhaps even to most, the conclusion 7' may sound incredible. If it is wrong, though, there must be something amiss in the argument. The suspicious premises seem to be 2', 3', or 4'. Indeed, 2' looks a tad suspicious —

two-year-olds are not scientists; so whatever goes on inside their heads when they learn the meanings of words, it is not by theory construction. While 2' stands in need of defense, it is not overturned by such simple considerations: Two-year-old theory construction could be worlds away in conceptual sophistication from theory construction by scientists, yet it could still be, for all that, genuine theory construction. For example, if Ollie initially thinks *or* means the same as *and* and later corrects this, he has surely revised his conjecture about the meaning of *or*.

As for 3', if Ollie has not yet acquired the concept OR, he cannot frame a hypothesis that is an OR-thought (a disjunctive thought). He cannot think *I get it! Claude is talking about alternatives when he says 'ou'!* Neither can he use any special tacit knowledge about alternatives in testing various hypotheses about the meaning of the French word *ou* or the English *or*. Indeed, he cannot even recognize alternative hypotheses as alternatives.

What about 4'? Does the formulation of a hypothesis about the meaning of French *ou* or English *or* require the use of the concept of disjunction? It is not at all obvious that it does. Suppose Ollie hears *A or B* a lot, in circumstances in which only *A* is true, or only *B* is true. After a while, he could use indirect negative evidence (e.g., that he hasn't heard *A or B* used when both *A* and *B* are true, or when both are false) to infer that these circumstances make such sentences false. Then, Ollie will have learned that disjunction has the truth conditions associated with exclusive-*or*.

However, one persistent criticism of truth-conditional semantics has been that the truth-conditions of logically complex sentences are only intelligible to someone who already possesses the relevant logical concepts.⁷ Thus the truth-conditions for OR statements that Ollie learns can be summarized as: "*A or B* is true if and only if either *A* is true or *B* is true". According to this view, these truth-conditions are not intelligible to Ollie unless he already possesses the concept of disjunction, which was precisely what he was supposed to have acquired through learning the meaning of the word *or*.

Let's consider the method Ollie used to acquire the meaning of OR. When Ollie worked out that *or* meant exclusive-*or*, we must suppose that he learned what *or* means without engaging an innate concept of disjunction. It follows that no consideration of alternative hypotheses could have played any role in his hypothesis-testing.

That is, he could not have recognized H₁: "*A or B* means at least one of *A* or *B* is true", as against H₂: "*A or B* means exactly one of *A* or *B* is true" as alternatives, weighed up evidence *pro-and-con* for each, etc. But then, if he did not do any of *that*, how was his acquisition of the concept of disjunction (or the meaning of OR) a case of hypothesis-testing? So, if learning really *is* hypothesis-testing, as is widely assumed, how did Ollie learn that *or* meant exclusive-*or*? The critical point is that, quite generally, it seems that rich logical resources must be ascribed to the linguistic novice for him to learn anything, meanings or concepts

⁷ Cf. Dummett's (1977: 114) complaint that a 'modest' theory of meaning containing clauses such as the above for disjunction "merely exhibits what it is to arrive at an interpretation of one language via an understanding of another, which is just what a translation manual does, it does not explain what it is to have mastery of a language".

included.

The challenge to opponents of logical nativism is how to accommodate the learning-as-hypothesis-testing problem without supposing innateness. We have already seen that the most obvious alternative to learning-as-hypothesis-testing doesn't fly. This was the case of learning the logical operators using the primitive inference rules that govern their introduction and elimination. This approach was appealing, since the logical vocabulary amounts to little more than five or six essential words *not, and, or, if, all, some*, and the primitive inference rules only add up to about double that number. But, we have seen that this alternative account of learning is fraught with empirical and conceptual problems.

At present, we see no plausible alternative to logical nativism. Empirical evidence from child language (including 2-year-old children) and cross-linguistic research (from typologically different languages) supports logical nativism, and several a priori arguments provide additional grounding. *A priori* arguments that logic must be innate are even stronger than scientific 'abductive' inferences from the empirical evidence gathered in investigations of child language, and cross-linguistic research. If any such argument is sound, logical nativism would remain true even if language-learners were given unlimited time and input in which to acquire logical concepts and inference rules: logic would be transcendently unlearnable, not just contingently so. Whether a Logic Faculty is intrinsically tied to a Language Faculty remains an open question for future research.

References

- Barrett, Robert B. & Alfred J. Stenner. 1971. The myth of the exclusive 'or'. *Mind* 80, 116-121.
- Block, Ned. 1986. Advertisement for a semantics for Psychology. *Midwest Studies in Philosophy* 10, 615-678.
- Block, Ned. 1987. Functional role and truth conditions. *Proceedings of the Aristotelian Society* 61, 157-181.
- Boster, Carole T. & Stephen Crain. 1993. On children's understanding of *every* and *or*. Paper presented at the symposium *Early Cognition and the Transition to Language*, Austin. [University of Texas at Austin, 23-25 April 1993.]
- Braine, Martin D.S. & Barbara Romain. 1983. Logical reasoning. In Paul Mussen, John Flavell & Ellen Markman (eds.), *Handbook of Child Psychology*, vol 3: *Cognitive Development*, 261-340. New York: Academic Press.
- Brandom, Robert B. 2000. *Articulating Reasons*. Cambridge, MA: Harvard University Press.
- Carnap, Rudolf. 1937. *The Logical Syntax of Language*. New York: Harcourt, Brace.
- Chierchia, Gennaro. 2004. Scalar implicatures, polarity phenomena, and the syntax/pragmatics interface. In Adriana Belletti (ed.), *The Cartography of Syntactic Structures*, vol. 3: *Structures and Beyond* (Oxford Studies in Comparative Syntax), 39-103. New York: Oxford University Press.
- Chierchia, Gennaro, Stephen Crain, Maria Teresa Guasti, Andrea Gualmini &

- Luisa Meroni. 2001. The acquisition of disjunction: Evidence for a grammatical view of scalar implicatures. In *Boston University Conference on Child Language Development (BUCLD) 25*, 157-168.
- Crain, Stephen, Takuya Goro & Rosalind Thornton. 2006. Language acquisition is language change. *Journal of Psycholinguistic Research* 35, 31-49.
- Crain, Stephen, Takuya Goro & Utako Minai. 2007. Hidden units in child language. In Andrea Schalley & Drew Khlentzos (eds.), *Mental States*, vol. 1: *Evolution, Function, Nature* (Studies in Language Companion Series 92), 275-294. Amsterdam: John Benjamins.
- Crain, Stephen, Andrea Gualmini & Paul Pietroski. 2005. Brass tacks in linguistic theory: Innate grammatical principles. In Peter Carruthers, Stephen Laurence & Stephen Stich (eds.), *The Innate Mind*, vol. 1: *Structure and Contents*, 175-197. New York: Oxford University Press.
- Crain, Stephen, Weija Ni & Laura Conway. 1994. Learning, parsing, and modularity. In Charles Clifton, Lyn Frazier & Keith Rayner (eds.), *Perspectives on Sentence Processing*, 443-467. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Crain, Stephen & Paul Pietroski. 2001. Nature, nurture and Universal Grammar. *Linguistics & Philosophy* 24, 139-185.
- Crain, Stephen & Paul Pietroski. 2002. Why language acquisition is a snap. *The Linguistic Review* 19, 163-183.
- Crain, Stephen & Rosalind Thornton. 1998. *Investigations in Universal Grammar: A Guide to Experiments in the Acquisition of Syntax and Semantics*. Cambridge, MA: MIT Press.
- Dummett, Michael. 1977. What is a theory of meaning? In Samuel Guttenplan (ed.), *Mind and Language*, 67-137. Oxford: Oxford University Press.
- Field, Hartry. 1977. Logic, meaning and conceptual role. *Journal of Philosophy* 69, 379-408.
- Field, Hartry. 2001. Attributions of meaning and content. In Hartry Field, *Truth and Absence of Fact*, 157-175. Oxford: Clarendon Press.
- Fodor, Jerry. 1980. On the impossibility of acquiring 'more powerful' structures. In Massimo Piattelli-Palmarini (ed.), *Language and Learning: The Debate between Jean Piaget and Noam Chomsky*, 142-162. London: Routledge & Kegan Paul.
- Gadzar, Gerald. 1979. Logical functors. In Gerald Gazdar, *Pragmatics: Implicature, Presupposition and Logical Form*, chap. 4. New York: Academic Press.
- Goro, Takuya. 2004. The emergence of Universal Grammar in the emergence of language: The acquisition of Japanese logical connectives and positive polarity. Ms., University of Maryland, College Park.
- Goro, Takuya & Sachie Akiba. 2004. The acquisition of disjunction and positive polarity in Japanese. *West Coast Conference on Formal Linguistics (WCCFL) 23*, 251-264.
- Goro, Takuya, Utako Minai & Stephen Crain. 2005. Two disjunctions for the price of only one. In *Boston University Child Language Development (BUCLD) 29*, 228-239.
- Grice, H. Paul. 1975. Logic and conversation. In Peter Cole and James Morgan (eds.), *Syntax and Semantics*, vol. 3: *Speech Acts*, 41-58. London: Academic

- Press.
- Gualmini, Andrea, Luisa Meroni & Stephen Crain. 2003. An asymmetric universal in child language. *Proceedings of Sinn und Bedeutung VII – Arbeitspapiere des Fachbereichs Sprachwissenschaft “Konstanz Linguistics Working Papers”* 114, 136-148.
- Harman, Gilbert. 1987. (Non-solipsistic) conceptual role semantics. In Ernie Lepore (ed.), *New Directions in Semantics*, 55-81. London: Academic Press.
- Horn, Laurence R. 1969. A presuppositional approach to *only* and *even*. *Chicago Linguistic Society (CLS)* 5, 98-107.
- Horn, Laurence R. 1996. Presupposition and implicature. In Shalom Lappin (ed.), *Handbook of Contemporary Semantic Theory* (Blackwell Handbooks in Linguistics), 299-319. Oxford: Blackwell.
- Hurford, James R. 1974. Exclusive or inclusive disjunction. *Foundations of Language* 11, 409-411.
- Jennings, Ray. 2001. Disjunction. *Stanford Encyclopedia of Philosophy*. [<http://plato.stanford.edu/entries/disjunction>]
- Johnson-Laird, Philip N. & Ruth M. Byrne. 1991. *Deduction*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Kegley, Charles W. & Jacquelyn Ann Kegley. 1978. *Introduction to Logic*. Columbus, OH: Charles E. Merrill Company.
- Lakoff, Robyn. 1971. If's and's and but's about conjunction. In Charles Fillmore & D. Terence Langendoen (eds.), *Studies in Linguistic Semantics*, 114-149. New York: Holt, Rinehart & Winston.
- MacWhinney, Brian. 2000. *The CHILDES Project: Tools for Analyzing Talk* (3rd edn.). Mahwah, NJ: Lawrence Erlbaum.
- McCawley, James D. 1981. *Everything that Linguists Have Always Wanted to Know about Logic, but Were Afraid to Ask*. Chicago: University of Chicago Press.
- Miller, George & Philip Johnson-Laird. 1976. *Language and Perception* (Belknap). Cambridge, MA: Harvard University Press.
- Minai, Utako, Takuya Goro & Stephen Crain. 2006. Covert downward entailment in child English and Japanese. *The Proceedings of the Inaugural Conference on Generative Approaches to Language Acquisition–North America (GALANA) – University of Connecticut Occasional Papers in Linguistics* 4, 217-228.
- Pietroski, Paul & Stephen Crain. 2005. Innate ideas. In James McGilvray (ed.), *The Cambridge Companion to Chomsky*, 164-180. Cambridge: Cambridge University Press.
- Pietroski, Paul & Stephen Crain. In press. The language faculty. In Eric Margolis, Richard Samuels & Stephen Stich (eds.), *The Oxford Handbook of Philosophy and Cognitive Science*. Oxford: Oxford University Press.
- Prior, Arthur. 1978. The runabout inference ticket. In Irving Copi & James Gould (eds.), *Contemporary Philosophical Logic*, 44-48. New York: St. Martin's Press.
- Putnam, Hilary. 1975. The refutation of conventionalism. In *Mind, Language and Reality*, vol. 2: *Philosophical Papers*, 153-191. Cambridge: Cambridge University Press.
- Quine, Willard Van Orman. 1979. *The Ways of Paradox and Other Essays* (3rd edn.). Cambridge, MA: Harvard University Press.
- Reichenbach, Hans. 1947. *Elements of Symbolic Logic*. New York: Macmillan.

- Richards, Thomas J. 1978. *The Language of Reason*. Rushcutters Bay: Pergamon Press.
- Sellars, Wilfrid. 1969. Language as thought and as communication. *Philosophy and Phenomenological Research* 29, 506-527.
- Szabolcsi, Anna. 2002. Hungarian disjunctions and positive polarity. In István Kenesei & Péter Siptár (eds.), *Approaches to Hungarian 8*, 217-241. Budapest: Akadémiai Kiado.
- Thornton, Rosalind. 1990. Adventures in long-distance moving: The acquisition of complex *wh*-questions. Storrs, CT: University of Connecticut dissertation.
- Thornton, Rosalind. In press. *Why* continuity. *Natural Language & Linguistic Theory* 26.
- Wittgenstein, Ludwig. 1953. *Philosophical Investigations*. London: Macmillan.

Stephen Crain
Macquarie University
Macquarie Centre for Cognitive Science
Sydney, NSW 2109
Australia
scrain@maccs.mq.edu.au

Drew Khlentzos
University of New England
Language and Cognition Research Centre
Armidale, NSW 2351
Australia
dkhlentz@une.edu.au