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The Problem with Logic in the Logical Problem of Language Acquisition

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Abstract

This paper discusses the motivation behind the nativist position with respect to linguistic knowledge. In particular, the discussion focusses on the argument from the “poverty of the stimulus”, which is generally assumed to be the most important argument in favor of a nativist position. On the basis of current views on human reasoning and learning, we will argue that the logical (i.e., non-empirical) part of the poverty of the stimulus argument is invalid. This result substantially weakens the nativist position, although it does not imply that the assumption that there must exist a certain amount of innate domain-specific knowledge has to be abandoned altogether.

1. The Logical Problem of Language Acquisition

A fundamental assumption within modern generative syntax is the assumption that knowledge of language is for a considerable part innate. This innate knowledge takes the form of universal principles and parameters that underly all human languages (cf. Chomsky, 1986a; Chomsky, 1995). The most important argument in favor of the nativist position with respect to linguistic knowledge is the so-called poverty of the stimulus argument. The poverty of the stimulus argument yields, in Wexler’s (1991) terms, “Chomsky’s most unique argument” and “the most powerful theoretical tool that we have available to us” (see also Wexler, 1999).

This argument forms the basis of the logical problem of language acquisition, which is essentially an induction problem. A child only hears a finite number of sentences but has to generalize from this input to an infinite set of sentences that includes the input sample. This infinite set is the set of sentences generated by the language the child has to learn, which will be referred to here as the target language. What makes this induction task an extremely difficult one, however, is that an in principle infinite number of hypothetical languages is consistent with the finite input sample. The child has to single out the correct set corresponding to the target language and reject all other sets, which are incorrect hypotheses about the target language. Because every child eventually ends up speaking her mother tongue, children must be guided by constraints that allow them to reject the incorrect hypotheses. Just presenting the child with more sentences of the language she is learning (i.e., providing her with more positive evidence) does not reduce the set of hypothetical languages to the

correct one in all cases (cf. Gold, 1967). If the target language is a subset of the hypothetical language the child entertains, no amount of positive evidence will lead the child to conclude that the adopted hypothesis is incorrect. In this case, only negative evidence will suffice to reject the larger set in favor of the smaller set. However, negative evidence does not seem to occur very frequently in the language input of a child (Brown & Hanlon, 1970), and if it does occur, it usually is not very effective.

The conclusion must be that the language input of a child is insufficient (or, in other words, the “stimulus” is too “poor”) to be able to conclude to the target language. So how are children able to learn their mother tongue, if the information available to them is not sufficient to draw logically valid conclusions from it? Because this is a variant of the question Plato asked himself with respect to knowledge in general, the logical problem of language acquisition is also referred to as Plato’s problem (Chomsky, 1986b).

2. The Defective Nature of the Language Input

Another aspect that is sometimes mentioned in relation to the poverty of the stimulus argument is the qualitatively and quantitatively defective nature of the language input the child receives. That is, children frequently hear ungrammatical sentences from their parents and other people. Moreover, the utterances they encounter form only a small fragment of the language they are learning. These two characteristics of the language input have been argued to make language learning extremely difficult, if not impossible, without prior knowledge. The presence of many ungrammatical sentences in the language input is highly problematic because these ungrammatical sentences do not come labelled as ungrammatical. Since the set of utterances the child encounters is relatively small, relevant examples of certain grammatical constructions might not be encountered during the language-learning years. However, both the claim about the qualitatively defective nature of the language input and the claim about the quantitatively defective nature of the language input have been questioned (e.g., Pullum, 1996; Sampson, 1997).

According to Newport, Gleitman and Gleitman (1977), “the speech of mothers to children is unswervingly well formed. Only one utterance out of 1500 spoken to the children was a disfluency”. On the basis of this evidence, it

cannot be maintained that the language input to the child is qualitatively defective, or “degenerate”.

The claim about the quantitatively defective nature of the language input, that is, the non-occurrence of relevant grammatical constructions in the child’s input language, has been refuted by empirical evidence as well. The standard example Chomsky and many others use to illustrate the poverty of the stimulus argument is the formation of yes/no questions (e.g., Chomsky, 1980; Chomsky, 1988). The formation of yes/no questions is dependent on the abstract property of structure-dependency, in particular on distinguishing the main clause from embedded clauses. In order to form a correct yes/no question, the finite verb of the main clause has to be moved to the front of the sentence. To refute the simple but structure-independent and thus false hypothesis that it is the first verb in the sentence that must be moved, the child needs to encounter questions involving an embedded clause which precedes the main verb (for example, “will those who are coming raise their hands?”). Although it is claimed by Chomsky and others (without providing any empirical motivation for this claim) that these examples are very rare, Pullum (1996) found that about 12% of the yes/no questions in the corpus he searched were crucial examples which refuted the incorrect hypothesis. So, relevant sentences for the acquisition of the formation of yes/no questions are expected to occur in the input language of the child. Of course, Pullum did not show this for all other examples that have been used to illustrate the poverty of the stimulus argument, but there is no evidence that it will be different for other examples. Thus, the language input to the child seems to be neither “degenerate” nor “meager”. For this reason, I will focus on the unavailability of negative evidence as the crucial and most uncontroversial aspect of the poverty of the stimulus.

3. The Nativist Solution

The solution that most generative syntacticians have adopted for the logical problem of language acquisition is to assume that the core of the grammar is already present in the child before language learning starts off. This assumption has changed the agenda of research on language learning completely. Language learning is no longer viewed as the acquisition of knowledge on the basis of information present in the input data. Rather, children are born with a “language instinct” (Pinker, 1994). Under this nativist view, language learning merely is a matter of setting the parameter values of an innate universal grammar (UG) on the basis of specific triggering experience. A nativist position is also taken in the recently developed linguistic framework of Optimality Theory (Prince & Smolensky, 1993; Prince & Smolensky, 1997), although their solution to the logical problem of language acquisition differs from the generative solution (see Tesar & Smolensky, 1998).

Although it is seldomly recognized, the logical problem of language acquisition is not an unavoidable and theory-independent problem. Even if one agrees on the mentalist claim that the human brain contains a symbolical

representation of a mental grammar (an assumption which is refuted by radical connectionists) and that this mental grammar is at least as complex as a context-free grammar, the logical problem of language acquisition only arises as a result of two additional assumptions that are generally adopted within generative syntax.

The first assumption is the assumption that syntax forms an autonomous module of language. This assumption is fundamental to generative syntax. Hence, generative syntacticians like Lightfoot (1982) and Cook and Newson (1996) illustrate the logical problem of language acquisition by putting it on a par with trying to learn chess or snooker by watching people play the game. Crucial here is the fact that chess and snooker are systems of purely formal rules that do not refer to anything outside the system. The nature of the input and output of the process of learning has implications for the type of information available to the learner. As Grimshaw (1981) puts it: because of the autonomy of syntax, “UG does not permit deduction of a syntactic analysis from an analysis of the semantics of a phrase”. In other words, because syntax is autonomous, the formal properties of the grammar must be learnt from the formal properties of the input and cannot be inferred from its meaning.

The second assumption that is crucial to the view that there exists a logical problem of language acquisition is the identification of learning a language with finding the correct hypothesis through a process of hypothesis formulation and refutation (cf. Pinker, 1989; Wexler & Culicover, 1980). Note that this view of language acquisition as hypothesis testing is not present anymore in current nativist theories of language acquisition. I will return to this point in section 5. In the next section, I will demonstrate the dependence of the logical problem of language acquisition on the assumption that language acquisition is a process of hypothesis testing and logical deduction.

4. Language Acquisition as Logical Deduction

As was noted in the previous section, an assumption underlying the logical problem of language acquisition is the assumption that the child learns her mother tongue through hypothesis formulation and refutation. Now if syntax is assumed to be autonomous, this process of hypothesis testing must be a process of logical reasoning. In particular, the process of hypothesis testing must involve logical deduction. Deductive reasoning involves deriving a conclusion from given information by using a set of formal (i.e., based on the form of the input) mental operations, without adding new information. This contrasts with inductive reasoning, which involves extrapolating a rule based on limited information. If it is not assumed that children employ deductive reasoning in hypothesis testing, there would be no logical problem of language acquisition at all, since nothing prevents children from concluding to the target language in the absence of negative evidence, except for the rules of logical deduction. Of course, it then remains to be explained how children arrive at exactly the same

grammar, but note that it is an empirical issue whether children indeed do.

Very few linguists actually discuss the mechanism that is supposed to lead children to conclude to the target language in the situation sketched by the logical problem of language acquisition. Linguists who use the poverty of the stimulus argument to support their theoretical point of view but do not discuss the learning mechanism involved, sometimes have been criticized for neglecting to take into account this mechanism. A common reaction to this criticism is that the actual mechanism does not really matter because Gold's (1967) proof, that positive evidence is not sufficient to learn a context-free language, is a formal proof. Such a formal proof is argued to be independent of the learning mechanism involved. However, implicit in Gold's proof is the assumption that learning a language can be identified with logically deducing the correct hypothesis on the basis of relevant evidence. Although it has been noted that there are some problems with Gold's model of language acquisition (Elman et al., 1996; Quartz & Sejnowski, 1997), this particular aspect of Gold's model has not been mentioned before as yielding a problem.

To motivate the claim that a process of hypothesis testing forms the basis of the logical problem of language acquisition, here are a number of quotations from the literature. According to Pinker (1989), for example, "[e]xplaining successful learning basically consists of showing that the learner can entertain and stick with a correct hypothesis and can falsify any incorrect ones" (p. 6). Chomsky (1988) likens the problem of language acquisition to the endeavour of a Martian scientist trying to understand Spanish, "pursuing the methods of the sciences, the methods of rational inquiry [...] His problem is to construct a hypothesis as to what the rule is and to test it by looking at more complex examples" (pp. 41-42). Perhaps children proceed exactly as this Martian scientist did in his inquiry, Chomsky continues. But this cannot be correct, since no negative evidence is available to children. Therefore, Chomsky concludes that innate principles must guide language acquisition. The motivation for assuming that certain properties of human language must be innately determined is explained by Crain (1991) as follows: "every child comes to know facts about language for which there is no decisive evidence from the environment. In some cases, there appears to be no evidence at all; in others the evidence is compatible with a number of alternative hypotheses (including false ones)" (p. 598). Jackendoff (1994) suggests that the unconscious task of a language-learning child can be compared with the conscious task of a linguist trying to discover the basic principles of human language: "they [i.e., children] must (unconsciously) discover for themselves the patterns that permit them both to understand these sentences and to construct new sentences for other people to respond to. Whether this process of discovery goes on unconsciously in the child or consciously in the linguist, the very same problems have to be solved" (p. 27). About the only way it can be explained that children are able to learn their

language is to assume that "children have a head start on linguists: children's unconscious strategies for language learning include some substantial hints about how a mental grammar ought to be constructed".

Summarizing, the basic idea of these authors is that a strategy of hypothesis testing is not sufficient for learning a natural language in the absence of negative evidence. This rejected strategy of hypothesis testing assumes children to behave like scientists and gather evidence in order to falsify incorrect hypotheses and employ hypothetico-deductive reasoning to draw the correct conclusions. However, the strategy of hypothesis testing by hypothetico-deductive reasoning seems to be based on implausible assumptions about human reasoning, as will be argued in section 6.

5. Language Acquisition as Parameter Setting

Many generative syntacticians will respond to the conclusion of the previous section by claiming that this is not a correct characterization of the current view on learning within the field of language acquisition. Rather, they will argue, language acquisition is currently viewed as a (blind) process of changing parameter values on the basis of specific triggering experience (cf. Gibson & Wexler, 1994). This is indeed true for the nativist framework of Principles and Parameters Theory and the Minimalist Program. However, the notion of parameter setting was introduced (along with the concept of an innate universal grammar) as a solution to the logical problem of language acquisition. Thus, first there was the logical problem of language acquisition, which made implicit use of the assumption that children employ logical deduction. This problem was subsequently solved by assuming an innate UG, which is accompanied by its own learning mechanism: parameter setting on the basis of triggering. Parameter setting therefore is the result of an argumentation that started out with the assumption that children employ logical deduction. If it would not have been assumed that children employ logical deduction, there would be no logical problem of language acquisition to be solved, and hence there would be no motivation for innate principles and for parameters that have to be set.

Discussions about learning mechanisms should be careful to distinguish between learning mechanisms assumed prior to the acceptance of the logical problem of language acquisition, and learning mechanisms assumed as a solution to this problem. This is not a trivial warning. When Lightfoot (1998) criticizes Elman et al. (1996) for their seeming lack of interest in the linguistic motivation for the innateness claim, in particular the poverty of the stimulus argument, and contrasts this with linguists, who seem to be interested in learning issues, Lightfoot is in fact already one step too far: "[I]inguists are actively interested in questions about learning algorithms. For example, an interesting debate is emerging about a trading relation between properties of UG and learning algorithms". Since the linguists Lightfoot refers to proceed from the conclusions drawn from the poverty of the stimulus argument, their

work does not bear on the innateness debate tackled in Elman et al. Rather, these linguists have already taken sides in the innateness debate, which makes it impossible to apply their results to the same debate again.

6. Do People Reason Logically?

One of the central themes within cognitive science is the question pertaining to the mechanisms underlying human reasoning. To investigate the role of logic and formal rules in the process of human reasoning, Wason (1966) and Griggs and Cox (1982), among others, carried out a series of well-known selection task experiments.

In Wason's experiment (Wason, 1966; Wason, 1968; Johnson-Laird & Wason, 1977), subjects were presented with an array of cards and told that every card had a letter on one side and a number on the other side. In addition, the following rule was given: "If a card has a vowel on one side, then it has an even number on the other side". Subjects were asked to select those cards that definitely have to be turned over to find out whether or not they violate the rule. Note that this rule has the form of a logical implication: *if p then q*. In propositional logic, such a rule is false if *p* is true and at the same time *q* is false. If the subjects in Wason's experiment would reason according to the rules of deductive logic, they would choose the cards with a vowel and the cards with an odd number. All other cards are irrelevant from a logical perspective. Indeed, most subjects chose the card with the vowel. On top of that, many subjects (46%) also chose the card with the even number, although it does not matter for the validity of the rule whether the other side of this card carries a vowel or a consonant. On the other hand, a card that was overlooked by almost all subjects was the card with the odd number. If there is a vowel on the other side of this card, the rule is violated. The correct answer, namely the card with the vowel and the card with the odd number, was given by only 4% of the subjects.

Griggs and Cox (1982) presented subjects with a task that was identical in form to Wason's task, but in which the abstract problem and the abstract rule had been replaced by a concrete problem and a concrete rule: "if a person is drinking beer, then he or she must be over 19 years of age". One side of the card had information about a person's age (16 or 19 years old) and the other side had information about what this person was drinking (a beer or a coke). If human reasoning takes place purely on the basis of the form of a problem, the results of the two experiments should have been identical. However, they were not. Like in Wason's experiment, all subjects turned over the card that affirmed the antecedent of the conditional clause (i.e., the card with "drinking a beer"). In contrast with Wason's experiment, however, many subjects (74%) also turned the card with "16 years of age", whereas almost none of Wason's subjects turned the card with the odd number. So, in Griggs and Cox's experiment most subjects gave the correct answer, namely the cards with "drinking a beer" and "16 years of age".

Apparently, then, the subjects in the second experiment used semantic information to solve the problem. In the first experiment, in which only information about the form of the problem was available, only few of the subjects managed to solve the problem. This suggests that human reasoning does not rely on a kind of mental logic. Logical rules are formal rules, which only take into account the form of the basic elements, not their meanings. If only information about the form of a problem is available, as in Wason's experiment, people make mistakes. Whenever they can, they use information about the meaning of the problem and about its context. In fact, people not only make mistakes in conditional reasoning tasks like the ones discussed above, they also make mistakes in other reasoning tasks requiring logical reasoning, for example in syllogisms. Conclusions that are consistent with beliefs or desires are more likely to be accepted as valid than conclusions that are not (e.g., Janis & Frick, 1943; Mayer, 1983). In general, people are not particularly good at solving problems correctly when the problems are presented to them in an abstract form. Concrete problems are solved by using all the knowledge that is available and might bear on the problem.

7. What Does Reasoning Tell Us about Language Learning?

The main conclusion that can be drawn from the reasoning experiments discussed in the previous section is that adults apparently are not naturally logical reasoners. But if adults do not reason according to some kind of mental logic, and if children do not differ from adults in this respect, then one of the two assumptions underlying the logical problem of language acquisition is not valid. As was argued in section 3 and 4, the logical problem of language acquisition only exists if it is assumed that syntax is autonomous and children reason logically. If one of these assumptions does not hold, then there is no logical problem of language acquisition. This does not imply that there is no empirical problem of language acquisition, though. But it implies that it is not *in principle* impossible that children learn their mother tongue from the language input they receive. Note that we cannot conclude from this that children definitely do not possess innate knowledge of language of some kind. But since the argument based on the logical problem of language acquisition appears to be invalid, the evidence for an innate UG is substantially weakened.

One could object that there is a difference between learning and reasoning and, therefore, that it is questionable whether results from the cognitive domain of reasoning apply to the domain of learning. However, human learning often involves deductive reasoning, in which one is able to discover or generate new knowledge based on beliefs one already holds. In addition, the logical problem of language acquisition is stated in such a way that it assumes children to reason about the hypotheses that are compatible with a given set of data and draw conclusions on the basis of the sentences they encounter. As an illustration, recall from section 4 Chomsky's comparison of a child learning her

language with a Martian scientist trying to understand Spanish. So, irrespective of whether learning and reasoning must be distinguished in practice, since learning involves reasoning in the logical problem of language acquisition, the results from the selection task experiments discussed in the previous section bear on the validity of the logical problem of language acquisition.

8. Conclusions

The logical problem of language acquisition is taken to be one of the strongest arguments in favor of the nativist view on language, since its validity is independent of specific empirical evidence. The basic idea behind this argument is that it is impossible in principle to acquire a language solely on the basis of the language input, irrespective of the presentation of the input data and the amount of positive feedback the child gets. In this paper, it was argued that there is no logical problem of language acquisition, since the combination of assumptions on which the formulation of the problem rests cannot be maintained in the light of current views on human reasoning and learning. In particular, people do not reason logically, which was the main assumption behind the logical problem of language acquisition. This does not imply that every aspect of language must be learnt from the input and that no innate linguistic knowledge or innate linguistic mechanisms can exist. But the evidence in favor of an innate UG must be based solely on empirical observations, now that the argument based on the logical problem of language acquisition has been shown to be invalid.

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