THE EMERGENCE OF MEANING

Over the past forty years, scientists have developed models of human reasoning based on the principle that human languages and classical logic involve fundamentally different concepts and different methods of interpretation. In *The Emergence of Meaning* Stephen Crain challenges this view, arguing that a common logical nativism underpins human language and logical reasoning. The approach which Crain takes is twofold. First, he uncovers the underlying meanings of logical expressions and logical principles that appear in typologically different languages – English and Mandarin Chinese – and he demonstrates that these meanings and principles directly correspond to the expressions and structures of classical logic. Second, he reports the findings of new experimental studies which investigate how children acquire the logical concepts of these languages. A step-by-step introduction to logic and a comprehensive review of the literature on child language acquisition make this work accessible to those unfamiliar with either field.

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Preface

This book is an introduction to logic and language. It reports the findings of experimental investigations of how logical expressions are acquired by English-speaking children and by Mandarin-speaking children. By comparing different languages, and by examining how logical expressions enter children's language, we hope to shed some light on one of the key questions in linguistics, philosophy, and in cognitive science: are human languages logical?

For at least forty years, it has been widely accepted that human beings are not logical, and that the culprit is the languages we speak. Researchers in the psychology of reasoning have concluded that the meanings of logical expressions in human languages are not the same as the meanings of the corresponding expressions in classical logic. Evidence cited in support of this conclusion includes assessments of people's understanding of basic logical concepts, such as the expressions in human languages which correspond to *disjunction* in classical logic. In English the word for disjunction is *or*. In one series of experiments, English speakers were asked to respond to instructions such as *Give me the red balloon or the blue balloon*. In responding, subjects never gave the experimenter both the red balloon and the blue one. From a logical point of view, it would have been correct for the English-speaking subjects to have given the experimenter both balloons. Because in classical logic, a formula with disjunction, *A or B*, is true if both A and B are true, as well as in circumstances in which A alone, or B alone, is true. Based on the responses by subjects, reasoning experts inferred that the meaning of *or* in English is exclusive disjunction: *A or B, but not both*, rather than inclusive disjunction, *A or B, and possibly both,* as in classical logic. Of course this is just one finding, among many, that has led to the view that human languages and classical logic have little in common.

I was not convinced. For one thing, the experiments that evoked the exclusive meaning of disjunction probably encouraged this interpretation, and discouraged the subjects from giving both the red and the blue balloon to the experimenter. After all, if the experimenter had wanted both balloons, he

would have said so. But more importantly, even if the subjects responded in a way that was consistent with an exclusive interpretation of disjunction this does not justify the conclusion that they *lacked* the inclusive-*or* meaning of disjunction. In classical logic, disjunctive statements such as *A or B* are true in three circumstances – when just A is true, or just B, or when both A and B are true. The finding that people judge sentences of the form *A or B* to be true if just A or just B is true does not entail that they would not *also* have judged *A or B* to be true in circumstances where both A and B were. No one seemed to have conducted an experiment in which the statement *A or B* was presented in a situation in which both A and B are true. Worse still, no one had tested people's understanding of negative statements like *Max doesn't have a red balloon or a blue balloon*. We have seen that, if English *or* is exclusive disjunction, then statements of the form *A or B* are *false* if both A and B are true. It follows that negative statements, *Not A or B*, should be *true* if both A and B are true. So, if English *or* is exclusive-*or*, then English speakers should accept *Max doesn't have a red balloon or a blue balloon* in circumstances where Max has both a red balloon and a blue balloon. It seemed highly unlikely that human languages could be as illogical as this.

About ten years ago, I was playing in the front yard with my (then) 4-year-old daughter Aurora. I tested her understanding of *or* by asking her whether or not the sentence *Max has a red balloon or a blue balloon* was a correct description of a situation in which a character named Max had both a red and a blue balloon. To cut a long story short, she said that my statement was correct. Before long, colleagues and I were testing English-speaking children's interpretation of negative statements like *Max doesn't have a red balloon or a blue balloon,* to further confirm that English *or* has the same meaning as the expression for disjunction in classical logic. Not long after that we were investigating children's interpretation of disjunction in Mandarin Chinese, a language that is typologically distinct from English. This book reports the findings of much of that research also.

As noted earlier, lots of other evidence has been offered in support of the conclusion that humans are not logical. Both children and adults have been found to make incorrect logical inferences in many reasoning tasks. But when the experimental subjects are informed about the mistakes they have made, they often readily understand the nature of their incorrect inferences, and how they should have responded. The fact that people recognize the correct patterns of inference when these are pointed out to them suggests that they are cognizant of the underlying logical principles, despite having failed to access these principles during the experiment.

Further evidence that humans are not logical has been derived from the observation that both children and adults struggle, and often fail to correctly judge whether or not one sentence logically entails another. But the errors that arise in this kind of situation, too, could be the consequence of the computational demands of the task, rather than a lack of knowledge. Moreover, people succeed far more often than they fail in making valid logical inferences, both in experimental settings and in ordinary life.

In addition, certain observations about human languages invite the conclusion that human languages equip their speakers to make valid logical inferences. For example, regardless of the language children acquire, children from different linguistic communities grow up to be scientists. It is hard to see how this could be possible unless human languages somehow contain the essential ingredients for logical reasoning.

Finally, reasoning tasks are not the only means at our disposal for assessing whether or not humans are logical. Another way to assess whether human languages are logical is to investigate these languages directly. We can assess the relationship between logic and language by seeing the extent to which the truth conditions children and adults assign to sentences with logical words are consistent with the truth conditions that are assigned to the logical formulas that correspond to these sentences. Of course this presupposes that we can translate sentences from human languages into logical formulas. Assuming this can be done, and if the truth conditions assigned to these sentences are the same as those assigned to the corresponding formulas, then this invites the conclusion that human languages are logical after all.

As an undergraduate, I took classes in logic at UCLA. One of these classes was taught by Richard Montague, who showed us how English sentences could be recast using the symbolic expressions of logic. The present book adopts a similar approach, especially in Chapters 1 and 3. The remaining chapters are concerned with adjudicating between two different approaches to language acquisition. In broadest strokes, the alternative approaches can be characterized as the 'nature' approach and the 'nurture' approach. As will become clear, my own thinking about the nature versus nurture debate, and hence this book, have been strongly influenced by Noam Chomsky. At the same time I was taking classes from Montague and others at UCLA, I was reading Chomsky, whose proposals about a Universal Grammar have resonated with me ever since. Early in my career, I designed experiments with young children to evaluate the syntactic principles of Chomsky's theory of Universal Grammar. More recently, I have turned my attention back to logic. With several colleagues, I have been investigating the possibility that the basic concepts of logic are

innately embedded in the minds of children, and awakened by experience as children acquire human languages. So one way of looking at this book is as an attempt to build a bridge that spans a linguistic enterprise established by the work of Noam Chomsky – exploring the emergence of innate linguistic knowledge in children – and the analysis of human languages using the tools of logic, an enterprise established by Richard Montague.

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