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11. I am grateful for the context provided by the Center for Advanced Study in the Behavioral Sciences, Stanford, and the financial support of the Spencer Foundation for the preparation of this review. I thank Kenji Hakuta, Muriel Bell, Salvador Luria, and Robert H. Bloom for reading and commenting on an early draft.

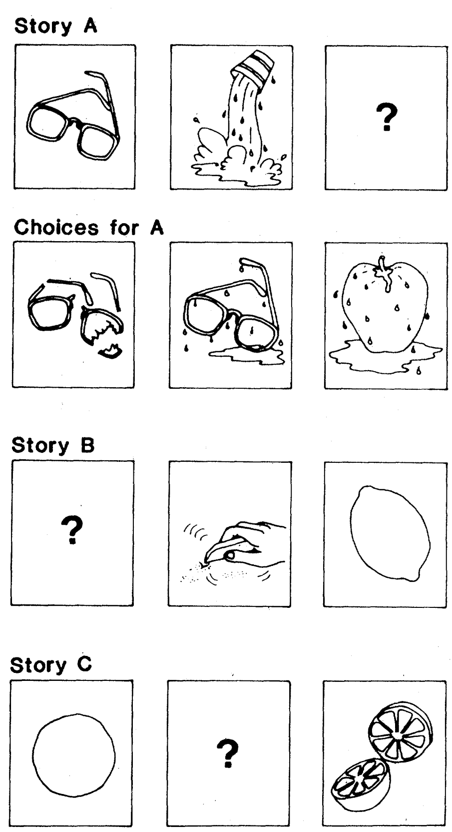
Understandings of Time

The Developmental Psychology of Time. WILLIAM J. FRIEDMAN, Ed. Academic Press, New York, 1982. xiv, 286 pp., illus. $29. Developmental Psychology Series.

Research on children's knowledge about time has a picturesque history. In 1928, Albert Einstein attended a lecture given by Jean Piaget. At the end of the lecture, Einstein posed a question: In what order do children acquire the concepts of time and speed? Almost 20 years later, Piaget published a two-volume, 500-page reply to Einstein's query. In essence, Piaget claimed that children acquire an understanding of time and speed at the same age, roughly 7 or 8 years, in technologically advanced societies. The two concepts were said to develop from a common ancestor, a rudimentary spatial concept in which both time and speed were equated with distance traveled.

The Developmental Psychology of Time, the first book published in English on this topic since Piaget's pioneering effort, reflects both the progress that has been made in the ensuing 35 years and the challenges that this progress has brought. When Piaget wrote his book, it was possible to view time as a single concept that had a single age of mastery. Piaget of course realized that the time concepts of 8-year-olds were not those of physicists. Nonetheless, he believed that the essential aspects of time, which for him were the combining of beginning and ending time to estimate duration and the relating of time to speed and distance, were mastered simultaneously. When children understood these notions, they fairly could be said to understand time.

Today, as the contributions in this book make eminently clear, the diversity of children's understandings is far more evident than the unities. As Friedman, the editor of the volume, states on the very first page, "It is not unusual in reading the older literature to come across developmental studies of 'the time concept.' The implied unity is appealing but illusory." Different aspects of time are understood at radically different ages, and there seems to be no principled way of deciding what constitutes true understanding. Fraisse reviews literature indicating that even infants possess some understanding of duration. If the feeding of 3-month-olds is delayed, they show unusually great agitation in the hour following the end of the usual interval. Two-month-olds respond to differences among musical sequences that vary only in the temporal spacing of notes. Harner notes that when 2-year-olds speak they distinguish between present and non-present and also between past and future. Bullock, Gelman, and Baillargeon describe how preschoolers segment time into episodes in making causal inferences. Stein and Glenn pursue a similar theme in discussing how elementary-school-age children comprehend stories. Three separate research efforts, one by Richards, one by Levin, and one by Wilkening, extend Piaget's initial efforts to study 4- to 11-year-olds' inferences of temporal duration. Friedman's own research extends the learning



Examples of test sequences used by Gelman *et al.* to test children's understanding of causal relations. The correct answer for story B is a lemon with a drawing on it; the correct answer for story C is a knife. [Reproduced in *The Developmental Psychology of Time* from R. Gelman, M. Bullock, and E. Meck, *Child Development* **51**, 691–699 (1980)]

of aspects of time into adolescence and adulthood, focusing on understanding of cultural conventions such as calendars, daylight savings time, and time zones.

The contents of this book illustrate both why conceptual development is so fascinating and why it is so difficult to explain. Consider the following set of findings described in the volume. Richards demonstrates that when 5-year-olds are presented two moving objects traveling in the same direction on parallel paths they often confuse temporal duration with spatial end points. That is, they consistently choose the object that stops farther down the path as the one that traveled the longer time, even when it did not. Such findings are enticing and not particularly disturbing. If other factors are equal, the object that stops farther down the path *will* have traveled for the longer time. However, Levin finds that when 5-year-olds are presented two lamps with bulbs of differing wattages, they usually choose the more intense bulb as having been on for the longer time, regardless of the actual durations. Here, there is no obvious reason why children should make the choice that they do, except perhaps for a general rule "More of any dimension implies greater duration." We cannot conclude from these findings that 5-year-olds have no understanding of duration. Levin reports that when 5-year-olds are asked about the relative duration of the naps of two sleeping dolls, they typically judge correctly. Taken together, these data and others cited by Richards and Levin suggest that 5-year-olds' judgments conform to the formula "If it is possible to judge on some dimension related to time but not identical to it, do so. Otherwise, if it is possible to judge on a dimension unrelated to time, do so. If your back is really to the wall, and there is no apparent other dimension on which to judge, then judge on the basis of time, as you were told to." Explaining why children would adopt such an approach is no easy task.

All of this complexity involves one age group's knowledge of a single aspect of a single concept. The general issues that the book raises about conceptual development are even tougher and at least as interesting. Consider just two of these. First, how can we draw useful conceptual boundaries? Would we be best off thinking about understanding of time as a single entity, as an extremely large number of particular understandings, or as a limited set of domains in which temporal understandings are expressed? At present, researchers have little basis for assuming that different aspects of understanding of time are more closely related than, say, understanding of how to infer temporal duration and how to do arithmetic problems. Second, and related, at what level can we most profitably model conceptual understanding? The chapters in this volume include a few promising leads in this direction. For example, Bullock, Gelman, and Baillargeon divide children's knowledge into the principles that define understanding, the stimulus relations such as contiguity that suggest likely connections, and the knowledge about objects and events that inform us as to the plausibility of possible causal connections. Presumably each type of understanding would need to be included in a comprehensive model of conceptual knowledge. At present, however, these promising leads remain just that. None of the contributions in the book provide detailed models that integrate different aspects of understanding of time. Few authors even present detailed models of understanding of individual aspects of time. *The Developmental Psychology of Time* documents the progress that has been made in describing children's conceptual understanding since Piaget's initial efforts. It also documents the tasks that still remain.

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Life in the Universe

Extraterrestrials: Where Are They? Papers from a symposium, College Park, Md., Nov. 1979. MICHAEL H. HART and BEN ZUCKERMAN, Eds. Pergamon, New York, 1982. x, 182 pp., illus. Cloth, $22.50; paper, $9.50.

The pendulum of opinion on the probability of extraterrestrial life has swung several times. Classical civilization was willing to populate the moon and other heavenly bodies. But medieval views of the earth as the only material object in the universe rendered the question rather moot. The Copernican revolution led to acceptance of the reality of other planets, also to very widespread belief in life on them—for some early astronomers, even on the sun. This wave crested with Percival Lowell's claims around 1900 to have found evidence of intelligent life on Mars. Furthermore, in the 19th century Laplace's nebular hypothesis of solar system formation led to the supposition that other stars probably had planetary systems and hence could be havens for life.

The first major counterattack came around the turn of the century. The nebular hypothesis in its primitive form could not adequately explain the degree of angular momentum in the planets, so T. C. Chamberlin and F. R. Moulton proposed that the solar system formed through a close encounter of two stars, tearing out mutual tidal filaments that condensed to form the planets. Stars are so awesomely far apart in relation to their sizes that such a near miss should practically never have occurred in the history of the galaxy. Our solar system would thus be essentially unique. Widespread acceptance of this cosmogony gave an entire generation, up to the 1940's, little reason to think very seriously about life elsewhere in the galaxy. Anti-extraterrestrialists took solid comfort from the U.S. space probes in the 1960's and '70's, which scotched the idea that there were canals on Mars and showed that life on Mars, if present at all, must be very well concealed, for example in moist subsurface regions. Nor have probes to the other objects in the solar system given much encouragement to the search for life.

On the other hand, over the last 30 or 40 years the nebular hypothesis has not only revived but has been shown by several lines of evidence to be essentially correct. Planetary systems are thus presumably quite commonly associated with other stars, although to be sure no case has yet been unambiguously detected. Further evidence includes the generally uniform chemical compositions throughout space, the vast spans of time available, and the overwhelming numbers of stars, and hence of potential solar systems, in our galaxy alone. This evidence led, after the Second World War, to an almost euphoric acceptance by most astronomers that life could well be a ubiquitous phenomenon in the universe. This belief has been encouraged by the explosive progress in biochemistry, probing toward mechanisms of origin of life, and in paleontology, showing that life apparently appeared on earth rather soon after it became physically possible. It is difficult to imagine life without evolution and natural to suppose that senses of growing power, the organization of such senses into brains, and the ultimate development of intelligence leading to science and technology would also occur widely throughout the universe. The highly publicized project Ozma and a number of other searches for radio transmissions from such hypothetical civilizations were accordingly undertaken.

Some skeptics of course always remained. Michael Hart was the first to crystallize a number of the counterarguments in an important 1975 paper. He and several like-minded colleagues organized a conference in 1979 to explore these ideas more fully. Publication of the proceedings is belated but welcome. The title of the book stems from Fermi's famous question: "Where are they?" The argument, as fleshed out by Hart in the opening paper, is simple and somewhat spine-tingling. After only one or two centuries of what might truly be called science, the human race has already learned how to travel through the solar system. Another century or two should see our descendants forging out to the nearby stars. Colonies planted around these stars would be expected soon to expand further in a wave that should result in descendants from this planet spreading through the entire galaxy in less than a hundred million years. But our galaxy is more than a hundred times older than that. If other intelligent civilizations are so ubiquitous, surely some, if not even a vast number, must have gotten a head start on us and should long since have filled the galaxy. Yet to quote from Ben Zuckerman's splendid preface: "To astronomers who work with giant optical and radio telescopes the Universe appears to be a gigantic wilderness area untouched by the hand of intelligence (with the possible exception of God's)."

Where are they, indeed? A series of fascinating papers explores various facets of the question. Hart begins by throwing down the challenge: We observe no extraterrestrial intelligence because there *are* no other advanced civilizations in our galaxy. Zuckerman briefly reviews the half-dozen sensitive searches so far made by radio techniques. Robert Sheaffer examines claims that extraterrestrial visitors are being observed, giving good evidence for rejecting any such claim as a viable scientific hypothesis. Michael Papagiannis points out reasons why the asteroid belt should be examined carefully for evidence of any tampering by extraterrestrials. Se-