

In: The Quarterly Journal
of Experimental
Psychology.
Section A.
Vol. 41A. No.2.,
417-20.

Longuet-Higgins, H.C. (1987). *Mental processes: Studies in cognitive science*. Cambridge, MA: The MIT Press. Pp. 424. ISBN 0-262-12119-0. £22.50.

This book is an intellectual feast that should nourish and inspire generations of cognitive scientists. Its main message is that the brain performs tasks of extraordinary intricacy and complexity, but computer simulations enable ideas about how they are done to be tested, and in this way encouraging progress has been made in understanding what is involved in some simple mental processes.

Christopher Longuet-Higgins was Plummer Professor of Theoretical Chemistry at Cambridge from 1954 to 1967, when he courageously abandoned his established career to join Richard Gregory and Donald Michie at Edinburgh in the United Kingdom's first Artificial Intelligence group. In 1974 the freedom conferred by a Royal Society Research Professorship enabled him to move to Stuart Sutherland's department at Sussex, where he has been since.

The book consists of 31 chapters, 11 of them joint works with various colleagues. All but one have been previously published, the earliest in 1962,

the most recent in 1985. They are connected by passages explaining the general nature of the problems being tackled in each of the five sections, which are headed "Generalities", "Music", "Language", "Vision", and "Memory". "Generalities" makes a good introduction, because these six chapters are delightfully easy to read, and they illuminate the choice of the path that was taken by a brilliant "hard" scientist when he approached the softest of the "soft" sciences. Among them is a two-page comment on the Lighthill report of 1971, which had been commissioned to assess the potentialities of artificial intelligence, and whose somewhat negative conclusions were at least partially responsible for Longuet-Higgins and Gregory leaving Edinburgh. In these two pages he takes up Lighthill's challenge about the scientific worth of artificial intelligence, saying that "... it sets new standards of precision and detail in the formulation of models of cognitive processes, these models being open to direct and immediate test". He then goes on to list succinctly the areas of knowledge that will be affected and to name them *cognitive science*. These chapters might be especially illuminating to those who have difficulty in absorbing the fact that computers *can* mimic mental processes, for there can be no doubt that Longuet-Higgins understands very well the logical relation between what does the mimicking and what is being mimicked; his explanations may show a path through the verbal tangles that seem to worry some philosophers so much.

The rest of the book makes greater demands upon the reader, though the style is lively and exceptionally lucid. Most of the chapters can either be read quickly to see where the argument is leading, or slowly and thoroughly to appreciate critically the large amount of detail. He manages to achieve high scholarly standards without being pedantic, giving generous credit to antecedent authors and proponents of his views, packing in a lot of detail, and refusing to make exaggerated claims. To show what ground he covers I shall give brief descriptions of each section.

The first and earliest-written section is on music and has one chapter co-authored with M. J. Steedman and another with C. S. Lee. It must have been Longuet-Higgins' curiosity about the mental understanding of music that lead him into psychology, for he is an accomplished pianist and conductor. The mental processes he is concerned with are those that underlie the musician's senses of tonality and time. He says "In writing down a piece of music which is played to him, he (the listener) is giving overt expression to his capacity for interpreting it as a conceptual structure similar to that which originated in the mind of the composer". A computer program that successfully transcribes music clearly mimics the listener's mental processes, and it is the devising of such programs that he recounts in this section. At first this may not seem a very deep problem, for does not a tape recorder do rather better than the listener's rehashed score? It is, of course, a more

accurate reproduction, but it does not contain the bar lines, key signatures, and accidentals that betray the composer's intended rhythms and modulations, and it is these that are interesting—and puzzling. The relationship between score and sound is not unlike that between a painting and the 3-D world, for in both there are constraints that are implied in the score or picture and have to be assumed to construct the scene or sound. Longuet-Higgins' achievement is to bring some of these to light; his three-dimensional construction for expressing tonal relations seems to me the most fundamental advance since Helmholtz in understanding the scientific basis of music.

The next section, with chapters co-authored with S. D. Isard, A. C. Davey, and R. J. D. Power, is on language, and his approach is rather similar. He takes an apparently simple linguistic task, such as learning the relationship between the verbal form of numerals and the numbers they represent, or choosing the right tense to describe the arrivals and departures of people attending a party, or giving an account of a game of noughts and crosses. He then devises computer programs that embody how he thinks the required words and sentences are produced; then, as he puts it, he holds a conversation with his theory, to discover its accomplishments and deficiencies. The numerous modifications and embellishments that are invariably required bring to light the complexity of the processes involved in deciding such questions as: When are succeeding members of a numeral multiplied and when are they added (for instance in "five hundred and three")? How are tenses chosen in a sentence like "Harold had left at the time Edward said he would arrive"? How are the conditionals used in a sentence such as "I would have blocked you by moving into the corner square if you had taken the centre of that edge"? Longuet-Higgins' thoroughness and the amount of detail are well illustrated in the chapter on counting, for his programs can handle the relationship between numerals and numbers not only in English, French, and German, but also in Japanese, Mixtec, Suppire, and Biblical Welsh! The main message is again the extraordinary complexity that is involved in these rather straightforward tasks that every linguistically competent human performs instantly and easily, but another important point also emerges: the appropriate grammatically correct sentences can only be produced if the program keeps accurate track of the state of knowledge of its partner in the discourse. Perhaps this is obvious, but I don't recall being taught it from the grammar books at school, and the requirement for knowledge of another's state of mind is altogether more complex and interesting than simple rule-following.

The section on vision has chapters co-authored with K. Prazdny and J. E. W. Mayhew. It is the most mathematical and perhaps less accessible to many potential readers than the others. It deals with the geometrical problem of combining two different views of a scene to construct a three-dimensional

model of it. His "eight-point algorithm" is much quoted in the literature on motion parallax, and his suggestion that vertical disparities are utilized has had almost as great an impact in the field of stereopsis. This section is different from those on music and language in that it does not try to mimic a simple and direct subjective experience by reproducing the implied performance on a computer. To me it has the flavour of a dry geometrical exercise, and I cannot help thinking that the brain of a fly, weighing less than a milligram, knows a thing or two about motion analysis that Longuet-Higgins' brain, weighing more than a million times as much, still has to learn. But it says a lot for the tone and temperament of the whole of this book that the author would probably take up this point with enthusiasm and come up with suggestions on the insect's expertise.

The final section describes the innovative concepts about storage in associative nets that he (together with O. P. Buneman and D. J. Willshaw) introduced to the subject between 1968 and 1970. One can cavil at Longuet-Higgins' somewhat uncritical acceptance of the arguments for holographic storage of information in the brain, but the later papers move away from this towards the direct storage of coincidences in associative nets. The final review chapter is masterly and relates Longuet-Higgins' and his colleagues own ideas to previous suggestions by Minsky and Pappert, Roy, Brindley, Marr, and others. Again one might quarrel with his conclusion that it is "entirely satisfactory" to store correlations indiscriminately in a large number of binary stores representing the coincident firing of input and output lines in an associative net, but it is typical that it is he himself who has given the best argument against it: two pages later he discusses the signal-to-noise ratio for recall from such a device, and it is far from obvious that such mechanisms could function with the reliability that the brain habitually achieves. But these are pioneering concepts, and his papers are not marred by the evangelical, crusading overtones of the later generation of connectionists. He seeks out the antecedent work, he carries the analysis a big step forward, and he does not conceal the failures and shortcomings of the ideas he is advancing.

Taken as a whole, the book has an enormous impact, perhaps comparable with a classic such as Mach's *Analysis of sensation*. In actual achievement, I think it goes further than any other work in Artificial Intelligence to justify his own claim that computer modelling of cognitive processes "sets new standards of precision and detail". But I would regard its strongest point to be the provision of starting points for further work; every chapter contains seeds for ideas that might, with ingenuity, be developed and experimentally tested.