

rather than the "viewer centred" (i.e. from a point of view) system which image representations would seem to call for {37*}. None of this is to say that there could not be a representational format capable of capturing the full richness of any image in some form of "structural description". What is being said is that, despite what one might think from some of the psychological polemic on the subject, no such remotely adequate format has yet been worked out. The relevance of AI research to psychology is widely taken to be that a working program provides an "existence proof" of the coherence and viability of some putative psychological mechanism {38}. We should not be misled into thinking that such "proofs" are available for descriptive theories of imagery of even the slightest generality.

SII.C.3. Can Descriptions Account for Imagery Effects?

The short answer to the question posed in our section title must be "yes". The long answer, however, will look rather different. By "image effects" I mean to refer to those effects which we discussed in chapter I.C, and which persuaded psychologists during the 1960s and 70s that imagery had to be taken seriously. These were principally: the mnemonic effects of imagery; 'selective interference' experiments; mental visuo-spatial manipulations such as rotation and scanning; and the effect of imagined size on

the finding of features. There can be no doubt that it is possible to devise mechanisms which will account for each of these effects in terms of computational processes performed on language-like, 'propositional' descriptions. The problem is that these mechanisms are nearly always both **post hoc** and **ad hoc**. If the mind is like a programmed computer operating on 'propositional' data then there seems to be no good reason why The Programmer should have set it up in such a way as to show these effects. It looks as though there should be far simpler and more efficient ways of getting the required jobs done. Certainly there is no reason to think that any of the effects would have been predicted on the basis of computational theories of the mind, whereas, as we have seen, they were predicted by theorists who took imagery to be a form of representation in its own right.

If the mind is a computer then clearly it is not always programmed so as to solve problems in the maximally efficient way. For example, even the smallest electronic computer can do arithmetic much more quickly and accurately than a human being. But if the constraint of computational efficiency is removed then any information processing task which a computer can be made to perform at all can be done in an effectively unlimited number of ways, and any sort of output pattern that people may produce can be matched. And it is not simply that response patterns can be matched by arbitrarily adding delay loops, random error generators or whatever to the program's output stages. A program can be

so written that at a certain high level of description its processes can match those of any model of psychological information processing which might be suggested (and which would actually get the job done {1*}). (The Kosslyn & Shwartz {2} imagery simulation is an excellent example of this.) This means that despite its many attractions, the theory that the mind works like a computer has virtually no predictive power; it cannot suggest what actual effects psychologists are likely to find experimentally because in principle a program could be written to simulate any possible effect. By contrast, theories which draw analogies between psychological processes and familiar structured media, such as between a mental image and a physical picture, often make strong and testable predictions {3}. To re-orientate an image which is like a picture, for example, it will have to be rotated all in one piece, and through all intermediate orientations. Shepard would surely never have conceived his experiments on mental rotation if this analogy had not been in his mind.

As we have seen, the first contemporary psychologist to have really pushed mental imagery hard was Paivio, and he did this largely on the basis of the powerful effects on verbal memory of both the image evoking power of words and of instructions to use mnemonic images. This led him directly to his 'Dual Coding' theory of memory structure {4}, where imagery and (natural) language are seen as providing two distinct systems of mental representation, working in parallel. Iconophobic rivals to

this sort of theory are generally known as 'common coding' theories because they postulate that all mental representations are expressed in a single, common format. In the period before Paivio wrote his **Imagery and Verbal Processes**, in 1971, this 'common code' was generally taken to be a person's natural language (English, French, Finnish, Chinese etc.). At around that time, however, such views were losing currency and the 'common code' was coming to be taken as something unconscious and innate, which underlies and controls such conscious phenomena as both imagery and inner and outer speech. This has the advantage of at least being able to accommodate the experience of imagery, although it would seem to reduce its functional status to that of a useless epiphenomenon. Its main advantage is that it fits with - indeed it seems to be demanded by - computational theories of the mind {5}.

It is no accident, therefore, that the first serious attempt to account for the mnemonic effects of imagery within a common coding theory of memory comes in a book whose main aim is to describe a computer simulation of human verbal memory and to defend its psychological relevance. This work is Anderson & Bower's **Human Associative Memory** {6*}, which describes their simulation HAM. Since the imagery effects could, by this time, hardly be denied (Bower, indeed, had played a significant part in establishing them {7}) Anderson & Bower had to cast about for explanations of these effects which did not involve postulating separate representational formats for imagery

and other forms of information. They point out {8} that imagery mnemonics have generally been used when subjects are learning to associate noun pairs ('paired associate learning'), and that it is only really effective when they are told to imagine the two things named 'in interaction' {9}. Their suggestion is that instructions to form such an image will induce the subjects to produce an elaborated 'propositional' description of the scene (which presumably is experienced as an image) which will contain many propositions specifying relationships between the two. By contrast, rote repetition will only establish one relationship (mere conjunction), which is also the case for images of the objects in separate places (which Bower {10} had found to produce no better performance than rote repetition). If we can accept the basic identification of experienced images with propositional descriptions then this is perhaps a fairly plausible explanation of imagery mnemonics.

However, when we come to the effects of the image evoking power of a word (what is often called its "imagery value") on the learning of lists of single words, the effects are not so easily to be explained away. What 'common coding' theorists seem to need here is some 'linguistic' attribute or set of attributes of words which correlate highly with 'imagery value' and which can also provide a plausible explanation of the effect. Anderson & Bower {11} suggest two possible candidates. One of these is the number of different senses, or dictionary meanings,

which a word has. Anderson & Bower claim that words with many senses are learned more slowly than others, and that there is a positive correlation between the abstractness of a word and its number of dictionary entries. This, admittedly tentative, proposal seems rather at odds with the proposal that imagery mnemonics have their effects by setting up more propositional links than otherwise. A more promising candidate to replace 'imagery value' is perhaps "lexical complexity". Anderson & Bower point out that whereas concrete, highly imagable nouns are usually simple, uncompounded words (like "dog", "table", "sea", "flower"), abstract, 'low imagery' nouns are often compound words formed from verb or adjective stems (nouns like "explanation", "ability", "refusal"). Experiments by Kintsch {12} did seem to show that when imageability was held constant then 'lexically complex' words were less well remembered than 'simple' ones, but further experiments, particularly by Richardson, seem to have shown that this conclusion was mistaken, and that 'complexity' cannot account for the effects of 'imagery value' {13}.

Other attributes which might replace 'imagery value' have been suggested. One of the most promising was 'concreteness'. Paivio, Yuille & Madigan {14} had found that people's ratings of word 'concreteness' and of 'imagery value' were very highly correlated (+0.83). In fact, 'imagery value' and 'concreteness' have generally been taken to be much the same thing (even by Anderson & Bower {15}), but Richardson questioned this and attempted

to show that the mnemonic effects were really due to 'concreteness'. He has now concluded that this attempt was a failure. If 'imagery value' and 'concreteness' are distinguishable attributes it is the former which has the effect on memory {16}. Richardson {17} has metatheoretical reasons for preferring 'common coding' theory. However, reviewing the whole field of the effect of 'imagery value' on memory for words, he nevertheless concludes that all of the attempts, up to 1980, to explain the relevant mnemonic effects by attributes other than imageability have failed:

The available evidence suggests that stimulus imageability is an excellent predictor of memory performance. (...) In learning tasks, imageability is the effective attribute of the experimental material, rather than its concreteness or its lexical complexity. {18}.

This is not to say that attempts to find some other alternative attribute which will explain the effects have not continued. The most recent such effect known to me is that by Jones {19}, who suggests that "ease of predication" (i.e. how easy it is to think up many suitable predicates for the word) is the relevant factor. I do not know what the fate of this suggestion has been. However, the fate of other such attempts over the past 20 years or so does not augur well for it (note that Paivio had already eliminated **twenty** such alternative attributes to imageability before 1971 {20}). Surely if those involved did not have such strong theoretical misgivings about imagery then the effort to replace such an excellent predictor of memory performance would have been abandoned long ago. I have tried to argue {21}, however, that well motivated

misgivings about images as mental pictures need not lead us to deny either the existence or the functional importance of imagery.

Richardson, however, does not quite fit this pattern. He seems to have not the least inclination to deny the reality of the experience of imagery (22), and he also seems, after careful consideration of the experimental evidence (23), to accept that mental images really are involved in mental manipulations such as rotation and scanning, and in the 'mental comparison' and perhaps also the 'selective interference' experiments, both of which we discussed in §I.C.2 as supporting evidence for Dual Coding theory. Likewise, he concludes that Dual Coding theory provides the best explanation for the results found in experiments on memory for pictures, which he also considers at some length (24). However, when he comes to consider memory for verbal material (25), although in each case he builds up a strong case for the positive effects of imagery, either in the form of imagery mnemonic instructions or as the 'imagery value' of individual words or narrative, he concludes in each case that a 'common coding' theory is to be preferred here. The reason for this seemingly perverse conclusion appears to lie in his conception of the nature of imagery. Unlike many psychologists Richardson takes philosophers' worries about imagery seriously. In particular he is concerned about the intentionality, the meaningfulness, of images, about how an image comes to be an image of a particular thing or type of

thing {26}. His answer to this is the same as Fodor's (which he quotes {27}): images gain their intentionality through being associated with linguistic, or rather 'propositional', descriptions. My image of a tiger, no matter how much or little it looks like a tiger, is an image of a tiger because I tell myself (in "mentalese") that it is {28}. This does not seem to me to be a very helpful move, for it merely transforms the mystery of the intentionality of imagery into the mystery of the intentionality of the inner language (a problem for which Fodor admits he has no inkling of a solution {29*}). But Fodor makes this move because he uncritically takes it that images must be quasi-pictorial {30*}, and, sensibly enough, he aligns himself with all of those who, from Berkeley {31*} to Wittgenstein {32} and Goodman {33} have provided persuasive arguments that pictorial images are not suitable for specifying meanings. Since, in verbal learning, if it is not the mere sound of a word we remember {34*} it is something about its meaning, Richardson takes it that when imagery seems to be involved in verbal memory it must be the associated description which is doing the real work {35}. If Richardson were to abandon pictorial theories of imagery and embrace a theory in which, as Aristotle {36*} and Albertus Magnus {37} held, images carry their intentions within themselves, he would not get himself into the peculiar position of affirming Dual Coding for some forms of memory whilst denying it for others even where imagery variables seem to be a potent factor in performance.

It must be conceded, however, that even if Dual Coding theory is entirely accepted a descriptive theory of imagery can still be maintained. All that is required is the positing of two 'propositional' memory systems, one specialized for perceptual information, and the other for everything else. Recalling and recombining memories from the former system would be the basis for imagery experiences, and if this is considered as the 'imagery' system all the standard moves of Dual Coding theory can still be made. A theory like this has actually been advocated by Kieras (38) and, indeed, Baylor's pioneering computational model of imagery has, so far as it goes, this form (39). Models like Anderson's "tri-code" theory, which seems to regard both imagery and inner speech as alternative forms of 'higher level' representation built upon a 'propositional' base (40), also have a good deal in common with such a view. Of course, there is no possible justification for taking this sort of line unless one feels that *sui generis* image representations are conceptually quite unacceptable whereas 'propositional' representations are thoroughly solid. We should note that Paivio firmly rejects this sort of theory (41), not so much on experimental grounds (there could hardly be any) but because he feels, as I do, that the whole notion of 'propositional' or 'quasi-linguistic' representation is far more suspect than that of imagery. I shall be tackling this question later on, but for now let us be content with noting the *ad hoc* nature of the move which Kieras makes.

Nothing in the nature of 'propositional' representation, as it is conceived, seems to call for the division of memory into two semi-independent systems. There is no motivation for the move save to accommodate what would otherwise seem to be disconfirming experimental results {42*}. I would not, of course, claim that it is never proper to save a theory by *ad hoc* alterations, but we are dealing here with a theory whose appeal has more to do with the romance of the attempt to create intelligent machines than with any very great empirical success or conceptual self-evidence.

Now the sort of move made by Kieras can in principle be applied to all forms of imagery effect. That is to say that, in principle, arbitrary constraints can be placed on the way that a 'proposition' manipulating system (or part of it) works, so as to mimic the behaviour of any non-computational system one may care to devise {43}. But these constraints can seldom be made to seem as if they flow naturally out of the basic theory. Rather they appear as inelegant *ad hoc* accommodations to inconvenient data; data, moreover, which were positively predicted by the rival theory. In a well known paper, Kosslyn & Pomerantz {44} take us through possible 'propositional' and 'image' accounts of many of the well known image effects, such as mental rotation, image size effects and mental scanning. In each of these cases they find that the 'propositional' account, though quite possible {45*}, is awkward and looks decidedly *ad hoc* {46*}. The flavour of this discussion can only really be captured by direct quotation:

Mental rotation:

A propositional account. An image of an object may be represented in terms of a network of propositions that describes how lines and arcs are interrelated. A letter "A," for example, might be described as two lines meeting at the top to form a vertex and bridged about halfway down by a short horizontal line. Rotation would proceed by replacing all relations with new ones, systematically altered in regard to spatial reference. When rotating 45° clockwise, for example "top" might be replaced by "northeastern orientation," and "right" by "southeastern orientation."

Critical comparison. The imagery account seems somewhat plausible and relatively straightforward. The propositional account seems less satisfactory: Aside from the problem of not knowing how to represent the letters in the first place, it is not clear why rotation is gradual in such a system. It should be especially easy to rotate an image 180° because all the relations could simply be reversed (e.g., right becomes left). To rotate an image 45° should be more difficult, because more complex substitutions must be implemented. Nevertheless, subjects take longer to rotate an imaged object 180° than 45°. It appears that people do not (or cannot) skip from one orientation of an image directly to another, but must proceed gradually. Such a prediction does not follow from the basic concepts of propositional representation (...). {47};

Image size effects:

A propositional account. (...) Kosslyn's initial results for image size can be understood if an image of an animal corresponds to the activation of a list structure. This structure contains propositions representing characteristics of the animal and how they are related together. It could be assumed that the larger the size of an image, the more such representations are activated. As more representations are activated, the probability increases that a queried property's representation will be available. If so, a subject discovers it at once when probed; if not, he must consume time in activating it.

The results on the size of the

probed part would be explained if it were assumed that larger properties are located higher (i.e., nearer the point of list entry) than smaller properties in the list describing an animal. Thus, subjects would discover larger properties more quickly because these properties are more likely to be activated and available at the time of the query. When images are not used, other lists - ordered in terms of association strength - are accessed in the manner described above.

Critical comparison. (...) The propositional account of Kosslyn's results (...) seems less satisfactory than the image account: Why should people access less information about an object when asked to "image it small"? This seems ad hoc; a propositional model would not lead one to expect such effects. The requirement that people represent an object's properties in two differently ordered lists - one to be used in response to imagery instructions and one for use on other occasions - also seems strained. {48};

Image scanning:

A propositional account. Measures of distance between pairs of locations may be explicitly listed in memory. Time to respond is regulated by values associated with each entry, longer distances causing a longer lag in the output system prior to executing a response.

Critical comparison. The imagery account seems somewhat plausible, while the propositional account seems entirely ad hoc. A propositional framework based on discrete units and links is inherently ill-suited for representation of metric, analog information. {49}.

Palmer {50} has complained that these discussions reflect a "simplistic notion of how the alternative [i.e. 'propositional'] type of theory might operate", but this is really to miss the point. The more simple the 'propositional' explanations can be made the less awkward they should look. What is needed to make a 'propositional' account look good is some sense that it is well motivated by basic theoretical principles, and not merely an ad hoc

