

"The Adaptive Function of Imagery", whose proceedings were published in the following year (55). In that same year, Paivio published his major monograph on the rôles of imagery and of language in human memory (56). Paivio's book is massive, and remains a major landmark in the field. Segal's is very slender and now rarely cited. However, it remains interesting in that it draws together many of the major strands which we have identified in the imagery revival. Paivio contributes a chapter on the relationships between imagery, language and memory; Haber discusses the 'icon'; T.X. Barber discusses the imagery produced under the influence of hallucinogenic drugs and hypnotic suggestion; Bugelski provides a theoretical discussion which attempts to set imagery research, especially on memory, in its proper relation to the Behaviorist tradition; and Segal reviews her own (and Perky's) work on the 'Perky effect'. From now on, it was clear, the mental image could no longer be ignored.

SI.C.2. Dual Coding Theory.

Since the mid 1960s many psychologists have contributed to the study of the effects of imagery on verbal memory, and have thereby helped to put imagery firmly on the psychological agenda. Two names who were early in the field and perhaps deserve particular mention are Gordon Bower and B.R. Bugelski. However, there is no

disputing that the most significant and influential of these workers has been the Finnish Canadian Allan Paivio. Bower, Bugelski and others mainly studied deliberate mnemonic techniques such as the 'method of loci', the 'one is a bun' technique, or simply the technique of remembering arbitrary pairings of nouns ("paired associate learning" as the jargon goes), by forming images of the two named things in interaction. Bower {1} showed that this last method was highly effective when the two things were indeed imagined in interaction, but forming separated images of the two (e.g. as if seen out of two different windows of a room) was no more effective than simple rote repetition. Thus far traditional mnemonic lore is born out. Another traditional injunction, that the images formed will be better remembered the more bizarre they are, has not been well supported by experiment {2*}. Also of relevance are the findings by Shepard {3} that recognition memory {4*} for pictures is superior to that either for single words or for meaningful sentences, and by Bevan & Steger {5} that free recall memory for pictures is also better than that for the equivalent nouns (and actual objects are remembered better still).

Paivio's special empirical contribution, however, was to find a way of demonstrating the effects of imagery on memory which did not involve the leading of subjects by asking them to deliberately form images. He and his colleagues had many subjects give a numerical rating for the image evoking powers of various English nouns. Thus,

eventually, a list of 925 nouns, each with a certain rating of "imagery value" was produced {6}, and could then be used in future experiments. With a few exceptions these imagery values correlated highly with similarly produced ratings of "concreteness" {7*}. In subsequent experiments, in which instructions to use imagery were not given, Paivio found that words with a high "imagery value" were consistently better remembered than those of low "imagery value". Pictures were remembered better still. As Paivio sees it:

It can be concluded that there is a completely reliable orderly progression in free recall performance as a function of concreteness, with objects or pictures being easiest, concrete (high-imagery) words intermediate, and abstract (low-imagery) words most difficult to recall. The finding is consistent with the view that nonverbal imagery is of major importance even when recall must be verbally expressed. {8*}.

Despite his very extensive experimental work on imagery and memory, however, Paivio's main claim on our attention must be the theory which he put forward to explain the effects: the mnemonic effects of instructions to image, the high memorability of pictures, and the differential memorability of high and low "imagery value" words. Before Paivio's work the task for iconophiles had been to demonstrate the reality of imagery by showing that it has real and undeniable psychological effects, to show that memory could not be accounted for in entirely verbal terms {9}. After his work had been assimilated the emphasis shifted to the questions of just how imagery effects could be explained, and what imagery must be like to explain them. Paivio's proposal, which he calls "Dual Coding

Theory", is, in outline, simply that the human mind contains two functionally separate (though interconnected) memory systems, one specializing in mental images and the other in verbal information. Pictures will leave a strong trace in the imagery system, but, as subjects are likely to spontaneously name or describe the contents of the pictures to themselves, a relevant trace will probably be formed in the verbal system as well. All words will, of course, leave traces in the verbal memory system, but mental images are likely to be spontaneously produced in response to words of high "imagery value", so these will leave a trace in the image memory as well. Thus pictures and highly imagable words will be stored twice over, as it were, in both the imagery and the verbal memories, whereas "abstract" words will be stored only once, in the verbal system. It is easy to see that items leaving two memory traces are likely to be more readily recalled than items leaving only one. When people are instructed to form mental images relating to the verbal material which they are given (or when of their own accord they deliberately use imagery mnemonics) the effort will be made to provide clear images appropriate to even the more abstract words, and no doubt images deliberately produced even for the "high-imagery" words will normally be stronger and more attended to than when they arise more or less inadvertently. Of course, none of this will prevent the verbal information being stored as such also. With the storage of both a well defined, well attended image and the relevant words (as opposed to the words plus, just perhaps, a vague, fleeting and ill attended image) it should be no

surprise that image mnemonics are effective {10*}.

It may be thought that Paivio has made an unfortunate choice in using the expression "Dual Coding" to describe his theory. If he has successfully thrown off our culture's widely deplored over-rationalistic stress on verbal, sequential, 'logical' thinking {11*}, perhaps he has nevertheless been seduced by a similarly unfortunate stress on vision to the exclusion of the other sense modes {12}. Thus, for example, Flanagan takes it that the choice faced by cognitive theorists is between a parsimonious single code theory or a "six-code" (one for each traditional sense plus one for language) theory of mental representation {13*}. A very similar idea has been, more approvingly, floated by Kintsch {14*}. Such suggestions, I believe, misconstrue the nature of Paivio's views. Although it is true that he, like almost everyone else, concentrates primarily (though not exclusively) on the visual aspect of imagery, a careful reading of his work makes it clear that he actually intends his imagery system to encompass all modes (and there are really more than five) of perceptual memory and quasi-perceptual experience. In this, of course, his treatment is conformable with Aristotle's conception of imagination as being a function not of the several individual material senses, but of the "common sense" which integrated their deliverances and rendered them coherent to reason {15}. Paivio is not individuating his representational systems in terms of peripheral anatomical structures (the five types of sense organ plus the vocal

apparatus, making six). This is shown by the fact that he actually takes his verbal representations to be embodied in imagery; verbal representations are presumed to be auditory-motor images of words (16). What really differentiates the two representational systems is not any difference in their anatomical embodiment, but the quite different ways in which they are supposed to be representational. Paivio seems to hold the the very venerable and widespread notion (it too can be traced to Aristotle (17)) that imagery represents things directly, whereas words represent in a secondary way, through being associated with the relevant imagery (18).

For a number of reasons - principally arguments descending from Berkeley (19*), and Wittgenstein (20) - nearly all contemporary philosophers emphatically reject the notion that imagery can represent directly and in its own right (21*). After we have discussed theories of the nature of imagery (in Part II) these arguments may no longer seem so compelling (I believe they are all premised on some form of 'pictorial' theory of imagery). However, even if the arguments are valid, a rationale for Dual Coding can still be maintained simply by reversing the direction of representational dependency, by making the representational power of images derivative from that of some sort of linguistic representation. This is not a view which I would care to defend myself, but it is not without its supporters. Kaufmann (22) seems to take the view that image representations are parasitic upon the repres-

entational power of our natural language (English, Norwegian or whatever) {23*}. Others such as Simon {24}, Baylor {25} and Fodor {26} seem to take the representational power of both imagery and natural language to be derivative from that of some unconscious, quasi-linguistic neural 'code', a so called "propositional" or "sentential" representation {27*}. Such views are not, of course, quite the same as Paivio's vision of Dual Coding, but they are attempting to account for much of the same range of data in quite a similar way, and Baylor at least acknowledges a specific debt to Paivio. Another important figure who postulates a form of dual coding, with acknowledgement to Paivio, in which an image representational system is set against a "propositional" quasi-linguistic system, rather than against natural language, is Stephen Kosslyn {28}, of whom we will be hearing much more later on. Kosslyn has been cautious in taking a view on the direction of representational dependence {29}, an issue which does not much affect his own research programme, although more recently he has given hints of sympathy with Paivio's position on the matter {30}.

Dual Coding Theory is not only of relevance to memory experiments. It is generally, and I think quite reasonably, assumed amongst cognitive psychologists that the forms of mental representation stored in memory will, in general, be just the same as those which are manipulated during active thinking. A further plausible assumption is that when two tasks involving similar forms of

representation are done simultaneously then they are likely to interfere with one another; more mistakes will be made and performance of each task will be slower than when only one of them is being done. Conversely, if two simultaneous tasks are done within quite different representational systems then such interference effects should be much less pronounced. Experiments along these lines, "selective interference" experiments as they are called, were carried out during the late 1960s by another psychologist working in Canada, Lee Brooks. His results contributed significantly to the formation of Dual Coding Theory. Visualization and actual vision, Brooks reasoned, must surely involve similar forms of representation, and should thus show interference. In one set of experiments {31} he gave his subjects the visualization task of forming a mental image of a grid of numbers from a verbal description (such as "In the starting square put a 1. In the next square to the right put a 2. In the next square up put a 3...." etc.). The subjects' subsequent recall of the grid turned out to be better when they had merely heard the description than when they not only heard it but also read a typewritten version of it at the same time. The visual activity of reading, it seemed, interfered with the visualization in a way in which the mere hearing and understanding of verbal material did not. There was no such interference effect from reading when visualization was not called for, when the material to be remembered was not a visualizable description but could only be remembered in a purely verbal form {32*}. It is as if there are two

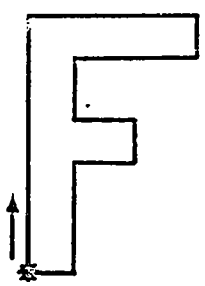
independent 'channels', one for verbal and one for visuo-spatial information. As well as interference during the 'input stage' Brooks was able to show interference occurring during the 'output stage' within the same experimental set-up. The subjects were better able to say what the relations between the letters in the grid were than they were able to complete a written multiple choice test about the same information {33}.

In a second set of experiments, Brooks was able not only to show interference between visual and visual image tasks but also between two verbally based tasks {34*}. These experiments played on the effect of 'output stage' interference by using the required form of response as the interfering task. The verbal task was to categorize words of an aurally presented sentence as either nouns or non-nouns. This task proved relatively difficult when the subjects had to respond by merely saying "yes" or "no"; the response was quicker and more accurate when they had instead to point to a succession of written "YES"s and "NO"s scattered across a chart (see figure I.B.6_1). If the latter response condition is taken to be primarily a visuo-spatial task, and the former, calling for the actual formation and pronunciation of words, is taken as essentially verbal, then the results would seem to indicate selective interference in the verbal 'channel'. The converse effect was found when using the same two response methods with an imagery task. This consisted of being shown and subsequently visualizing a 'block letter' such as the F

Y N
 Y N
 Y N
 Y N
 Y N
 Y N
 Y N
 Y N
 Y N
 Y N
 Y N
 Y N

A sample output sheet for the pointing condition of Experiment I. The underlined letters are those which would be pointed to in categorizing the sentence "a bird in the hand is not in the bush." The letters are staggered to force close visual monitoring of pointing.

Figure I.C.2_1
 (Reproduced from Brooks [1968].)



A sample of the simple block diagrams used. The asterisk and arrow showed the subject the starting point and direction for both reproduction and categorization.

Figure I.C.2_2
 (Reproduced from Brooks [1968].)

of figure I.B.6_2. The subjects then had to go round their image of the letter, starting at the point indicated by the star and in the direction indicated by the arrow, and respond "yes" or "no" at each corner according to whether it was an extreme top or bottom corner or in between (in the example of figure I.B.6_2 correct response would be "yes, yes, yes, no, no, no, no, no, no, yes"). In this case the opposite results were obtained to those found for the verbal task. Responding by speech was relatively easy whereas responding by pointing at the chart was significantly slower and more error prone. This, like the earlier set of experiments with the imagined number grid, seems to indicate selective interference between a visual task and an imagery task. However, Brooks also did a version of this experiment where the pointing response was not monitored by looking at a chart but by feel. The subjects made their positive or negative responses by writing a tick or a cross in positions indicated by a column of holes cut in a cardboard sheet which was laid over their paper. The experiment was done with the eyes closed, so that the next hole had to be located by touch. Although this difficult response task did interfere somewhat with the verbal task, interference with the block letter visualization task was considerably greater {35}. Brooks thus concluded that it was not so much visual as spatial perception, through whatever mode, which interfered with imagery {36}. This conclusion may be puzzling to those who, in the tradition of Empiricism, regard imagery as being the reproduction of sensation, and thus associate

"visualization" very closely with vision. However, if we take our concept of the imagination as a direct descendant of the Aristotelian *phantasia*/'common sense', the faculty which derives spatio-temporal information from the deliverances of the material senses {37}, this conclusion should come as no surprise at all. If we think of images in this way, as spatio-temporal representations, Brooks' work seems to provide strong support for the idea of there being separate representational systems for imagery and for verbal information.

The essentially spatial character of the imagery system derives further support from experiments conducted by Baddeley, Grant, Wright & Thompson {38}. They repeated both of Brooks' imagery experiments (i.e. both the number grid and the block letter tasks), but instead of looking for interference between the mental task and the response mode (spoken responses were used throughout) they looked for interference between the imagery tasks and the simultaneous tracking of a "pursuit rotor". This is a device in which spot of light is made to move around a circular track, and the subject has to follow this light with a stylus. A photocell in the tip of the stylus allows precise measurement of just how accurately the subject is managing to track the light. This is quite a demanding spatio-temporal task. As we might expect, Baddeley and his colleagues found that both the number grid and the block letter tasks seriously impaired their subjects ability to keep track of the light spot. Likewise, the verbal tasks

from Brooks' experiments did not seriously impair the tracking.

However, Baddeley's group also did a third experiment whose results are rather less welcome to the supporter of Dual Coding Theory (39). This time the imagery task was the kind of verbal memory experiment with which Paivio has been mostly concerned. The subjects had to learn and then recall word pairs, whilst tracking the rotor. The materials used were either pairs of abstract words, the learning of which, on Paivio's view, should not normally involve imagery, or pairs of concrete words: the type which Paivio would expect to spontaneously leave a trace in the imagery as well as in the verbal memory system. No specific instructions to use imagery were given, but, as in Paivio's own work, the concrete word pairs were remembered much better than the abstract pairs. Unfortunately, however, neither the learning of concrete nor of abstract pairs seemed to significantly interfere with tracking the pursuit rotor, and although tracking the rotor did seem to result in the words being rather less well learned than otherwise this effect was just as strong for the abstract as for the concrete words. The corroboration of Dual Coding Theory from 'selective interference' experiments seems to have broken down precisely on Paivio's home ground of verbal learning.

Interference effects between a visual task and a verbal memory task involving imagery had previously been

found, however, by George Atwood (40*). Atwood's subjects had to learn either pairs of concrete or of abstract words embedded in short phrases such as "nudist devouring a bird" (concrete) or "the intellect of Einstein was a miracle" (abstract). Unlike Baddeley and his group, Atwood explicitly instructed his subjects to form an image, in the case of the concrete phrases, and to "contemplate the meaning" of the abstract ones (41). Atwood's interfering tasks were very simple: after hearing each phrase (each subject had to memorize 35 phrases) the subjects were presented either visually or auditorily with either the number 1 or 2, to which they had to respond by saying the other number (i.e. saying "two" or "one" respectively). Atwood found that, for the concrete, imaged pairs, visual presentation of the number interfered with the memory performance much more than did auditory presentation. This pattern was reversed for the abstract, "contemplated" phrases. This is a similar pattern of selective interference to that seen in the experiments of Brooks, and Atwood's own interpretation of his results is, essentially, a version of Dual Coding Theory (42).

Unfortunately, there are some rather serious methodological flaws in Atwood's work (43) which leave his results open to alternative explanations, and for some time quite a number of psychologists seem to have failed to reproduce similar results within a more rigorous experimental design (the Baddeley group's experiment just described is one such 'failure' (44*)). However, Janssen,

