Mental Images in Human Cognition
Robert H. Logie and Michel Denis (eds.)

Chapter 21

Word meaning and the links between the verbal system and modalities of perception and imagery or In verbal memory the eyes see vividly, but ears only faintly hear, fingers barely feel and the nose doesn't know

Nick Ellis
University College of North Wales, Bangor, United Kingdom

INTRODUCTION

When people are asked to learn lists of words, the greater the imageability of a word, the more likely it is to be recalled. This is a robust effect in Free Recall (FR) experiments (Paivio, 1971). It is even more reliable in Paired-Associate Learning (PAL) (Paivio, 1971; Rubin, 1980). It has withstood many attempts to demonstrate that its association with recall is spuriously attributable to attributes such as meaningfulness (Paivio, Yuille & Smythe, 1966; Dukes & Bastian, 1966; Christian, Bickley, Tarka & Clayton, 1978; Rubin, 1983), concreteness (Christian et al., 1978), familiarity (Paivio, 1968; Frinke, 1968), or age-of-acquisition (Gilhooly & Gilhooly, 1979).

In Paivio's 'Dual Coding Theory' abstract words (of low imageability) have only verbal semantic representations in memory and only these representations and those for concepts associated in meaning are accessed following exposure to the word. In contrast, words with high imageability are represented not only in this semantic system but also in an imagery code, as "sensory images awakened" (James, 1890). "Concrete terms such as *house* readily evoke both images and words as associative (meaning) reactions, whereas abstract words such as *truth* more readily arouse only verbal associations. The meaning of the latter is primarily intraverbal." (Paivio, 1971, p. 85).

Thus images and verbal processes are alternative coding systems, or modes of symbolic representation, which are developmentally linked to experiences with concrete objects and events as well as with language.

In verbal learning tasks the stimuli must be represented in memory and associations forged with other items, these inter-item associations serving as retrieval cues making other items more accessible (Tulving & Pearlstone, 1966): "If S can discover or learn a simple rule or principle which characterizes the items on a list and which relates them to one another, then he uses that rule as a retrieval plan in reconstructing the items from memory, with a consequent improvement in his performance" (Bower et al., 1969, p. 340). The effects of imagery in such experiments may result from imageable words having richer representation as a result of their associations in the modalities of perception, and/or these imagery representations may allow greater associative linkages with other items, these facilitating retrieval.

Prior analyses of imagery have concentrated on the visual system and Paivio has proffered different explanations of visual imageability effects, at times emphasising the number of different codes (*coding redundancy*), at times the richness of representation in vision (*coding richness*) and at times the parallel nature of the visual system (*visual parallelism*). These options are not mutually exclusive, but it would be well to assess their separate effects by investigating the effects of different imagery systems. That such different modalities of imagery exist is demonstrated both by phenomenal reports and by clinical cases of loss: Betts (1909) showed that 95% of the college students that he studied could invoke mental images corresponding to visual, auditory, cutaneous, kinaesthetic, gustatory, olfactory, and organic sensory fields, and Rubens (1979) reviews evidence for the dissociation of visual, auditory and tactile agnosias. The visual system differs from the others both in terms of its massive parallelism and its richness of representation, and thus a word's imageability in these other modalities may not operate in verbal learning tasks in the same way as does its visual imageability.

In this paper we therefore derive word norms for imageability in visual, auditory, olfactory and touch modalities and investigate the effects of these separable factors in (i) incidental learning whilst the subjects were rating the words, (ii) intentional learning followed by either null, picture imagery, or sound imagery interference, (iii) PAL, and (iv) the Stroop effect. We then ask subjects to consider prototypically visual, auditory, smell and touch words for their meaningfulness and their attributes, and to imagine the referents in their 'home' sensory modality and report (i) the attributes that they perceive through this home sensory modality, (ii) all other percepts which are simultaneously available in that imagery episode, and (iii), as many items as possible that are perceptually similar to the referent in that modality. Their generated responses are then analysed for modality differences and for the degree to which the different modalities and aspects (similarity, contemporaneity, etc.) contribute to meaningfulness and memorability.

NORM DERIVATION

Five lists of words were prepared: words with high visual, auditory, olfactory, or tactile associated activity, along with a set of words with none of these associations.

Five raters listed the nouns which represented the objects which most readily came to mind as receiving one modality of sensory analysis. From these initial lists four sets of 40 nouns were selected. An additional set of 40 more abstract words was compiled where each word referred to a concept which the subject used fairly frequently but where the object referent did not typically receive sensory analysis. The five sets were matched for word frequency The four sense modalities were, as far as possible, unassociated - each word predominating in one sensory modality only.

Sixteen volunteers rated the 200 words first for familiarity of conscious recognition of use of the concept, then the four modality ratings followed in a Latin square ordering. After rating them the subjects recalled as many of the words as possible.

The norms for these ratings on each of the five dimensions are available from the author, as are fuller descriptions of all subsequent methods and results. This corpus is used in subsequent experiments.

To assess the weight of the contribution of the different sensory modalities to traditional judgements of overall imagery value, the present ratings for vision, olfaction, audition, touch and familiarity along with word frequency were used as predictors of the Gilhooly & Logie (1980) and Paivio, Yuille & Madigan (1968) imagery and concreteness ratings in full multiple regressions. In this and subsequent regression analyses we report the standardised regression coefficient, ß, for the significant predictors from full multiple regressions where the full set of predictors was forced into the regression equation; ß thus reflects the *independent* contribution of each predictor, controlling for covariance with other effects. Vision was by far the greatest contributor to Imagery ratings ($ß=0.80$, $p<0.001$ and 0.98, $p<0.001$ respectively), along with a smaller, but significant, effect of olfaction ($ß=0.17$, $p=0.01$ for Gilhooly &

Logie). Audition was a significant predictor for the Gilhooly & Logie set (ß=0.28, $p<0.01$), but not for the Paivio, Yuille & Madigan overlap words. In neither case did touch show any significant predictive power. Overall these ratings explain most of the variability in imagery ratings (R^2s of 78% and 95%).

The ratings also explained much of the variance in concreteness (R^2s of 83% and 90%). The relative contributions of the different modalities were much the same as for imagery, except touch was a stronger predictor of concreteness.

There is, understandably, somewhat less explanation of Paivio, Yuille & Madigan meaningfulness (R^2=51%), and again there is a significant effect of the visual modality alone (ß=0.62, $p<0.001$) .

FREE RECALL - INCIDENTAL LEARNING

The rating exercise encouraged subjects to concentrate on associations in a particular perceptual domain, and it is likely that this emphasis at encoding would affect later recall.

Table 1. Full multiple regression solutions for prediction of word recall from incidental learning during ratings of word sensory-association.

Predictor Variables	Dependent variable: Recall from rating conditions (200 words)				
	Vision beta	Olfaction beta	Audition beta	Touch beta	Familiarity beta
Word associate					
Visual imagery	0.50**	0.32**	0.25**	0.09	0.13
Olfactory imagery	0.09	0.50**	-0.05	0.12	0.06
Auditory imagery	-0.01	-0.02	0.46**	-0.02	0.02
Touch imagery	-0.25**	-0.19*	-0.02	0.43**	0.05
Familiarity rating	-0.02	-0.14	0.01	-0.12	0.24**
T&L Frequency	0.26**	0.12	0.14	0.17*	0.03
R^2	0.24	0.32	0.30	0.23	0.14

*$p<0.05$ **$p<0.01$

The words recalled after incidental learning during each of the 5 different rating conditions were analysed using full multiple regressions to investigate the predictive power of each of visual, olfactory, auditory, tactile imagery, concept familiarity and frequency on recall. There was an effect of visual sensory-association on word recall from three of the rating conditions (visual, auditory and olfactory). Furthermore, as is shown in Table 1, there were modality of processing effects whereby the dimension being used by the subjects in the rating task determines that words high on that dimension were better recalled after the completion of the rating task.

When subjects are oriented towards modality-specific attributes of words, it is these attributes which determine later recall. At the time of recall it is associations within and seeded from this modality which cue retrieval for recall. However, it is not the case, except perhaps for visual imagery associations, that the word's attributes in all modalities are automatically accessed.

FREE RECALL - INTENTIONAL LEARNING

Do the strong effects of imagery on FR occur for perceptual modalities other than vision?

273 school children participated in one of the three conditions - control, picture or sound interference. They saw a 100 word subset of the corpus in a FR experiment. In the control condition the retention interval was unfilled; in the picture interference condition it was filled by the presentation of 15 pictures of famous scenes which were to be learnt and recalled; in the sound interference condition the subjects learnt and recalled 15 environmental sounds.

The average number of words recalled was 25 in the control condition, 21 under picture interference, and 15 under sound interference. The interference treatments were thus decreasing overall recall.

Control Condition. The recall scores were entered into a full multiple regression with the 4 sensory modality ratings, familiarity, frequency and serial position (SP) (as a U shaped transform) as independent variables. The only significant predictors were SP ($\beta=0.53$, $p<0.001$) and visual imagery rating ($\beta=0.33$, $p<0.01$).

Picture Interference. The same multiple regression analyses were performed for the word recall data after picture interference. Although the significant effect of SP remained ($\beta=0.53$, $p<0.001$), visual imagery rating now failed to be a significant predictor ($\beta=0.13$, n.s.). None of the betas for the other imagery rating scales changed markedly in their magnitudes from the control condition. Thus the picture interference task specifically interfered with visual imagery processes.

Prior attempts to selectively interfere with the imageability effect in FR have been largely unsuccessful. Thus there was no differential effect of pursuit-rotor tracking on recall of concrete and abstract nouns whether the tracking was concurrent with learning (Baddeley, Grant, Wight & Thomson, 1974) or recall (Warren, 1977). We believe this occurs because, although these interference tasks are using that spatial modality and disrupting its active control processes, unlike the present picture interference task they do not interfere with (i) the relevant associative pathways within that modality, and/or (ii) the referential pathways between the visual representations and semantic associates, and this finding is more consistent with models where the effect of imagery in FR is due to mediation between items rather than 'raw perceptual traces'.

Sound Interference. Here the significant predictors of recall were SP ($ß=0.46$, $p<0.01$), familiarity ($ß=0.36$, $p<0.01$) and visual imagery rating ($ß=0.24$, $p<0.05$).

Recall of Words with Low Visual Imageability. The large contribution of visual imageability may be swamping the potential effects of these other dimensions. To investigate the effects of these other modalities for words which have a negligible visual imageability rating yet which are high on these other dimensions the item pool was restricted to words with low visual imagery ratings. The 41 items included most words from the auditory set (16), and all of the abstract words (20) yet there was still no effect of auditory imageability in FR. Furthermore, even when the visual imagery variance is severely restricted, it remains a significant predictor of FR in all three conditions (control $ß=0.34$, $p<0.05$; picture interference $ß=0.34$, $p<0.05$; sound interference $ß=0.53$, $p<0.001$). Thus the effects of visual imageability are pervasive and remain even when its variance is tightly constrained to low values.

The only imagery dimension which predicts FR is visual imagery. Neither olfaction, audition nor touch imagery seems to play any role. The incidental recall findings demonstrate that people can use modality specific imagery associations beside vision. In contrast the FR results show that under normal circumstances either they do not, or that those that automatically come to mind are somewhat impoverished and lacking in extent of interconnectivity compared to those within the visual system.

PAIRED ASSOCIATE LEARNING (PAL)

PAL depends on the subject finding and remembering some kind of relation between the two words and the most robust visual imagery effects are found in PAL. It is thus an ideal medium for investigation the mediational role of different modalities of imagery in verbal learning.

72 undergraduates saw 100 paired-associates. These were subdivided into 25 different categories where the stimulus word was from either the visual, olfactory, auditory, touch or abstract sets and these were crossed with response words from the same range of categories. There were thus 4 examples of each of the 25 categories (V-V, V-O, ..,O-V, O-O, ...A-A).

The paired-associate recall data were analysed using a full multiple regression with the set of independent variables being visual, olfactory, touch and auditory imagery and familiarity ratings for each of the pair, stimulus and response, and SP.

As in the FR experiments, the only significant predictors were visual imageability (stimulus $ß=0.35$, $p<0.05$, response $ß=0.40$, $p<0.01$) and SP - there was no effect of imageability in the other modalities.

How might visual imagery aid mediation in PAL? There are a number of possibilities: (i) The concreteness of the items might allow a greater number of meaningful associative linkages, the image of a complex object including its many parts and attributes and thus awakening semantic associations from all of these parts and those which are similar either in image or meaning *(CODING RICHNESS)*, (ii) Any two images can be juxtaposed in the same 'still life imaginal frame' perhaps interacting in some vivid way in an integrative scene, the stimulus and response being thus relationally associated by capitalising on the parallelism of vision *(VISUAL PARALLELISM)*, (iii) If the two images are linked in a unique context then the awakening of the stimulus image at recall will involve implicit retrieval of contextual information that will serve as a maximally functional retrieval cue for the response image (*cue specificity*, Watkins & Watkins, 1975). These options are by not mutually exclusive and there is evidence for a separate contribution from each. Thus Bower (1970) demonstrated better recall following PAL where the subjects imagined the two objects denoted by the words interacting in some vivid way in an integrative scene than when they were imagined non-interacting, far separated in the "left versus right sides of the imaginary visual field". Yet Winograd and Lynn (1979) later showed that when separation imagery is used but each image is made in a distinctive context (the first pair in an imagined movie theatre, the next in a soccer field, etc.) then performance improves to approximate to interactive imagery levels.

In PAL the major determinant of success is thus the degree to which the stimulus and response words are strongly yet uniquely associated. The studies of Bower (1970) and Winograd and Lynn (1979) which held item imageability constant yet demonstrated clear effects of strategies of interactive imagery identify a large amount of the effect of visual imagery in PAL to be dependent on the parallel nature of the visual imagery system where two representations can be integrated interactively. The null effects of imagery in the essentially non-parallel auditory, olfactory and touch modalities in our present PAL experiment support this interpretation. However, it is also the case that the effect of visual imagery on PAL continues to increase across its full range (as opposed to being a simple step function where the effect cuts in at some threshold level which would allow image construction, but thereafter holds level), and this is more consistent with the *coding richness* interpretations where the extra associations in a distributed memory system afforded by rich representation in the visual imaginal system allows stronger association between the S and R in PAL, and thus better recall.

The present results therefore demonstrate a unique contribution of visual imageability in PAL and lend support to both the *visual parallelism* and *coding richness* explanations of this effect.

STROOP EFFECTS

The 'Stroop effect' originally concerned the large disruption and delay in the naming of the ink colours of written words which are the names of different colours. However, the phenomenon has been shown to generalise to other words and the imagery value of a word is a strong determinant (Davelaar & Besner, 1988).

The Stroop effect demonstrates automatic access to, and spreading activation of, the associations of the stimulus word. Warren (1972) provides a clear demonstration of this. Subjects first repeated three instances of a category which were presented aurally (e.g. *robin, canary, sparrow*), and then named the colour of ink of another word (the Stroop component). The coloured word was either a word from the spoken list (e.g. *robin*), the category of the word in the spoken list (e.g. *bird*), or a semantically unrelated word (e.g. *pencil*). Category words and list members slowed the colour naming by about 100 milliseconds in comparison with unrelated words. Such results clearly demonstrate automatic semantic access, and it appears from Davelaar and Besner (1988) that imagery associations are also obligatorily activated, hence the imagery Stroop effect. This effect must be attributable to *coding richness* since each trial in traditional Stroop tasks is entirely independent of all others - unlike the above FR and PAL experiments there is no requirement for the subjects to relate any of the items together. Therefore any imagery Stroop effects cannot be explained in terms of *visual parallelism*. The Stroop effect thus allows us to investigate *coding richness* in the absence of any contribution from *parallelism*. Hence we here compare the different imagery modalities for their effects in a Stroop colour-naming task.

Twenty one volunteers named the ink colours in eight trials where the stimulus was stars in each of four colours and the 200 words from our norms.

A stepwise regression with median Stroop effect as the dependent variable and visual, olfactory, touch, auditory imagery, familiarity, word length and frequency as the predictors stopped after just one block when it had entered visual imagery as the only significant independent variable ($ß=0.16$, $p<0.05$).

As with FR, so with PAL and thus with Stroop, only visual imagery has any effect on performance. However, in the Stroop task, in contrast to the learning experiments, each word is independent and there is no premium in relating them across trials, *visual parallelism* explanations are irrelevant here, and the visual imagery Stroop effect must be attributable to the *richness* of representation afforded by vision, these associations being automatically accessed and thus slowing ink colour naming. That there are no such effects of either auditory, touch or smell representation again indicates that vision is special and primary in the representations and associations that it affords.

DISCUSSION

The null effects of imagery modalities other than vision in this wide range of tasks makes the *coding redundancy* hypothesis (more codes = more memorable) untenable: it is only representation in visual imagery which affords greater memorability and greater interference in Stroop tasks. What then is special about visual imagery that might underlie these effects? In PAL there is the relational association afforded by the *parallelism* of vision: Any two images can be juxtaposed in the same 'still life imaginal frame' perhaps interacting in some vivid way in an integrative scene. The null effects of imagery in the essentially non-parallel auditory, olfactory and touch modalities in our present PAL experiment support this interpretation. However, in the PAL experiments it was also the case that the higher the visual imagery (even above the threshold where image generation was possible), the greater the recall. Thus the richer the representation in vision, the greater the recall. This richness effect is also present in the FR and Stroop effects where parallel representations in the same 'still frame' are unlikely mediators. Thus we have the further range of *coding richness* explanations whereby the visual imageability of an item allows the possibility of a greater number of meaningful associative linkages, the image of a complex object including its many parts and attributes and thus awakening semantic associations from all of these parts and those which are similar either in image or meaning.

Samuel Taylor Coleridge (1891) introspected on some of these possibilities:

> "Contemporaneity then, being the common condition of all the laws of association, and a component element in all the materia subjecta, the parts of which are to be associated, must needs be co-present with all. ... But if we appeal to our own consciousness, we shall find that even time itself, as the cause of a particular act of association, is distinct from contemporaneity, as the condition of all association. Seeing a mackerel it may happen that I immediately think of gooseberries, I at the same time ate mackerel with gooseberries as the sauce. The first syllable of the latter word being that which had co-existed with the image of the bird so called, I may then think of a goose. In the next moment the image of a swan may arise before me, though I have never seen the two birds together. In the two former instances, I am conscious that their co-existence in time was the circumstance that enabled me to recollect them; and equally conscious am I, that the latter was recalled to me by the joint operation of likeness and contrast." (Coleridge, 1891, pp. 60-61).

Here the mackerel->gooseberries association rests upon the parallelism of vision, the contemporaneity of episodic imagery; the gooseberries->goose association starts with lexical/semantic associations and traverses referentially to the image of the bird; the goose->swan association is discussed in terms of likeness and contrast, such similarity potentially being both semantic and imaginal. Just as these different factors may serve in Coleridge's reminding so they may serve in learners' subjective organisation and relational mediation in memory

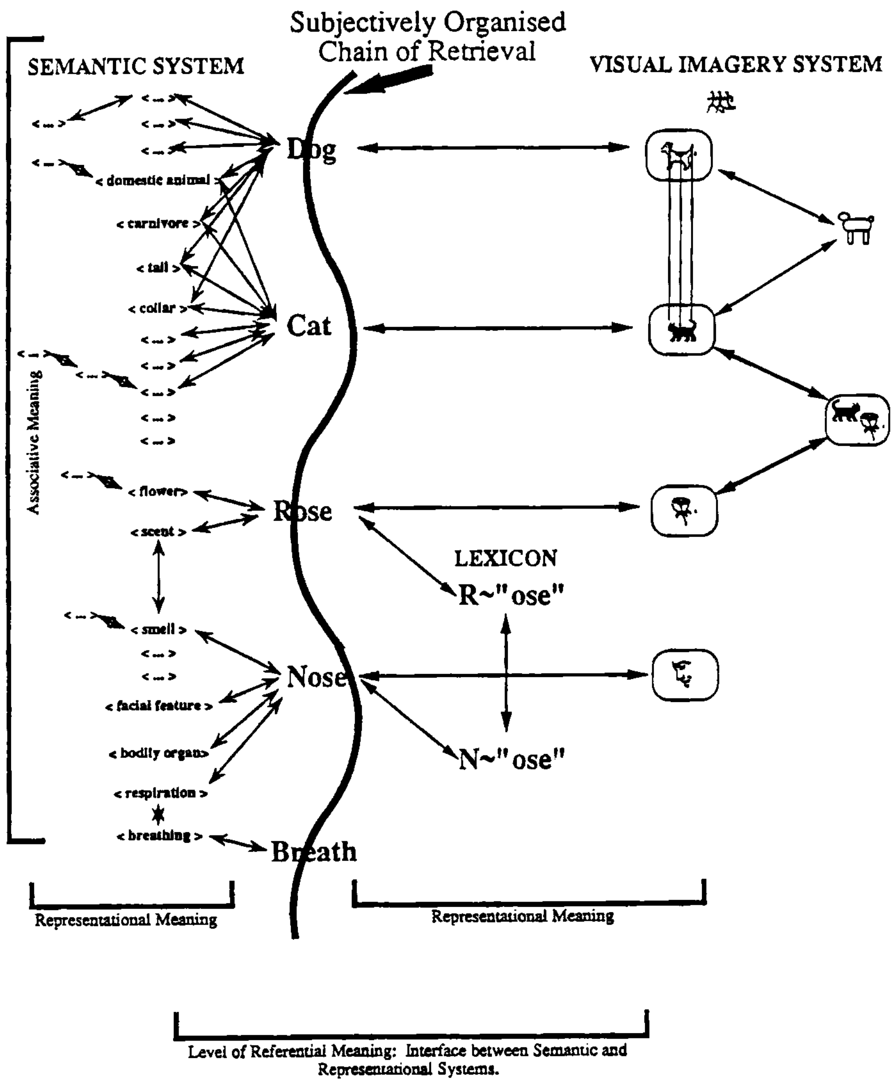

Figure 1. Tangled hierarchies of memory representations

experiments, using "any strategy they can devise to give meaning to an item or pair" (Baddeley, 1976, p.273). We summarise some of these potential associative paths in Figure 1. Imageable items, *dog, cat, rose, nose* are represented in both the semantic and visual systems whereas more abstract *breath* is not. The association between *breath* and *nose* is semantically mediated. *Nose* and *rose,* however, whilst sharing less meaning, may also be related by lexical similarities based on rhyme &/or orthography. *Rose* and *cat* may be linked by relational imagery mnemonics capitalising on the parallelism of vision, as indeed may any visually imageable words. The associations between *dog* and *cat* occur in both semantic and visual systems, in both of which they are exceptionally richly represented with many shared features. Thus at the semantic level they share the more formal connotations of, e.g. *carnivore* or *domestic,* at the visual level they share gross similarities like shape and size (there would be considerable overlap in their stored 3-D model descriptions [Marr, 1982]) as well as fine detail in many attributes down to the level of, e.g., their black noses and the way these shine with spittle, or their paws and the characteristic movements that these allow.

Just as the semantic associations spread and allow subjective organisation in memory so the visual associations prompt visually-based reminding, as Schank (1982, p.26) observes: "Sometimes one thing just looks like another. Since our minds organize perceptual cues and find items in memory based on such cues, it is hardly surprising that such reminding should occur.".

Similar factors operate in perception: just as there is semantic priming whereby recognising a word like *knife* is made faster and more accurate if one has just recognised a related word like *fork* or *spoon* (Meyer & Schvaneveldt, 1971), so the same holds for object recognition where a picture of a knife is recognised more quickly and accurately having just seen a picture of a fork or spoon (Guenther, Klatzky & Putnam, 1980). Importantly, semantic priming also occurs between words and objects: recognising the word *knife* is primed by preceding it with a picture of a fork, and vice versa (Guenther et al., 1980).

Notice that such spreading activation in perceptual priming is *not* tied to a particular interpretation of word meaning: e.g. Swinney (1979) demonstrates the faster visual lexical decision of both the 'insects' and 'microphones' connotations of 'bugs' when primed by the heard context 'Because he was afraid of electronic surveillance, the spy carefully searched the room for bugs'. Fodor (1983), in discussing the Swinney results, states: "associations are the means whereby stupid processing systems manage to behave as though they were smart ones. In particular, interlexical associations are the means whereby the language processor is enabled to act as though it knows that spies have to do with bugs (whereas, in fact, it knows no such thing). The idea is that, just as the [associationist] tradition supposed, terms for things frequently connected in experience become themselves connected in the lexicon. Such connection is not knowledge; it is not even judgement. It is simply the mechanism of the contextual adjustment of response thresholds." (Fodor, 1983, pp. 81-82). It is to be expected that this same unresolved spread of associations that is found in these perception experiments would also occur in the present Stroop experiment, since the same input modules are involved. However, we must show caution in extrapolating to the memory experiments. There are indeed many contrary demonstrations (e.g. encoding specificity, Tulving & Thomson, 1983) that it is the *particular* interpretation of a stimulus which determines its encoding and recall (e.g. the situation where recall is better than recognition - having learned the associated pair *air-port* the subject may fail to recognise *port*, yet will successfully give it as the appropriate PA response to the stimulus *air-*). In these situations where there is context, as is universally the case in the real world, the spread of activation is seriously confined to one particular resolution of meaning. However, all of the memory experiments reported in this paper stem from the unnatural world of the verbal learning tradition where individual words are presented out of context and the subject can choose which of many possible meanings makes for good organisation - the potential spread of activation is unconfined, and remembering, like perceiving, comes from a 'conspiracy of individual memory traces' (McClelland & Rumelhart, 1986) in "tangled hierarchies" of representations in memory (Anderson, 1983). Such experiments, like Coleridge's free associations and Shereshevskii's synaesthesia (Luria, 1968), tell us much about the connotations of words, but potentially less about knowledge.

In this unnatural world of possible meanings rather than those constrained by context, we find these possibilities engendered by semantic associations, experiential contemporaneity, the parts or attributes of the word referent, and its similarity to other concepts. This interpretation of imagery effects in terms of inter-item relational processing rather than the retention of images in some modality-specific form accords both with recent theoretical developments by Marschark and Surian (1989) and with Ryle's (1949) analysis of imagery where he dismisses the existence of mental pictures: "Roughly, imaging occurs, but images are not seen. ... a person picturing his nursery ... is not being a spectator of a resemblance of his nursery, but he is resembling a spectator of his nursery." (Ryle, 1978, p.234).

But we must also ask how much each perceptual modality affords on each of these dimensions of semantic association, experiential contemporaneity, and information regarding the parts or attributes of the word referent, and its similarity to other concepts. The above experiments suggest that Vision affords much more than the other senses with respect experiential contemporaneity and gives more information concerning the parts and attributes of a concept. We next validated these conclusions by studying responses in perhaps the only other situation where individual words are unbounded by context - the free association task. These experiments (details available from the author) involved subjects imagining word referents in particular sense modalities and using the image to generate its attributes, to describe perceptually similar concepts, and to describe other concepts that are contemporaneous in the same imagery episode.

These association generation exercises demonstrated that visually imageable words are more meaningful (in the sense of prompting more free associates), this confirming the oft reported correlation between imageability and meaning, but qualifying it with respect to modality, i.e. it is visual (rather than auditory, smell or touch) imageability that is making the contribution. Quantitative and qualitative analyses demonstrated that vision also predominates in the number of attributes of a word referent that are invoked through its being imaged, and also in the number of associated concepts that are contemporaneously imaged, thus confirming the *richness of representation* and *visual parallelism* explanations of the advantage of visual imagery in memory and Stroop experiments: the connotations of a word, which contribute to both its memorability and its meaningfulness as presently measured, in part result from (i) the parts of its referent and their interrelations, and, (ii) contemporaneous associates in time and space. Vision, in comparison with the other senses, affords much information about the former and more opportunity to perceive the latter.

REFERENCES

Anderson, J.R. (1983) *The Architecture of Cognition.* Cambridge, Massachusetts: Harvard University Press.

Baddeley, A.D. (1976) *The Psychology of Memory.* New York: Harper and Row.

Baddeley, A.D., Grant, S., Wight, E. & Thomson, N. (1974) Imagery and visual working memory. pp. 205-217 in P.M. Rabbitt & S. Dornic

(Eds.) *Attention and Performance* (Volume 5). New York: Academic Press.

Betts, G.H. (1909) *The Distribution and Functions of Mental Imagery.* New York: Teachers College.

Bower, G.H. (1970) Imagery as a relational organizer in associative learning. *Journal of Verbal Learning and Verbal Behaviour* **9**, 529-533.

Bower, G.H., Clark, M.C., Lesgold, A.M. & Winzenz, D. (1969) Hierarchical retrieval schemes in recall of categorised word lists. *Journal of Verbal Learning and Verbal Behaviour* **8**, 481-493.

Christian, J., Bickley, W., Tarka, M. & Clayton, K. (1978) Measures of free recall of 900 English nouns: Correlations with imagery, concreteness, meaningfulness, and frequency. *Memory and Cognition* **6** (4), 379-390.

Coleridge, S.T. (1891) *Biographia Literaria; or, Biographical Sketches of My Literary Life and Opinions; and Two Lay Sermons.* London: George Bell and Sons.

Davelaar, E. & Besner, D. (1988) Word identification: imageability, semantics, and the content-functor distinction. *Quarterly Journal of Experimental Psychology* **40A** (4), 789-799.

Dukes, W.F. & Bastian, J. (1966) Recall of abstract and concrete words equated for meaningfulness. *Journal of Verbal Learning and Verbal Behaviour* **5**, 455-458.

Fodor, J.A. (1983) *The Modularity of Mind.* Cambridge, Mass.: MIT Press.

Frinke, G. (1968) Word characteristics, associative-relatedness and the free-recall of nouns. *Journal of Verbal Learning and Verbal Behaviour* **7**, 366-372.

Gilhooly, K.J. & Gilhooly, M.L. (1979) Age-of-acquisition effects in lexical and episodic memory tasks. *Memory and Cognition* **7** (3), 214-223.

Gilhooly, K. & Logie, R. (1980) Age of Acquisition, Imagery, Concreteness, Familiarity and Ambiguity Measures for 1944 words. *Behaviour Research Methods and Instrumentation* **12** (4), 395-427.

Guenther, R.K., Klatzky, R.L. & Putnam, W. (1980) Commonalities and differences in semantic decisions about pictures and words. *Journal of Verbal Learning and Verbal Behaviour* **19**, 54-74.

James, W. (1890) *The Principles of Psychology.* New York: Holt.

Luria, A.R. (1968) *The Mind of a Mnemonist.* New York: Basic Books.

Marr, D. (1982) *Vision.* San Francisco: W.H. Freeman & Co.

Marschark, M. & Surian, L. (1989) Why does imagery improve memory? *European Journal of Cognitive Psychology* **1**, 251-263.

McClelland, J.L. & Rumelhart, D.E. (1986) A distributed model of human learning and memory. In J. L. McClelland, D.E. Rumelhart and the

PDP Research Group, *Parallel Distributed Processing: Explorations in the Microstructure of Cognition. Volume 2: Psychological and Biological Models.* Cambridge, Mass.: MIT Press.

Meyer, D.E. & Schvaneveldt, R.W. (1971) Facilitation in recognising pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology* **90**, 227-234.

Paivio, A. (1968) A factor-analytic study of word attributes and verbal learning. *Journal of Verbal Learning and Verbal Behaviour* **7**, 41-49.

Paivio, A. (1971) *Imagery and Verbal Processes.* New York: Holt, Rinehart and Winston.

Paivio, A., Yuille, J.C. & Madigan, S.A. (1968) Concreteness, Imagery and Meaningfulness values for 925 nouns. *Journal of Experimental Psychology Monograph Supplement* **76** (1,2), 1-25.

Paivio, A., Yuille, J.C. & Smythe, P. (1966) Stimulus and response abstractness, imagery and meaningfulness, and reported mediators in paired-associate learning. *Canadian Journal of Psychology* **20**, 362-367.

Rubens, A.B. (1979) Agnosia. In K. M. Heilman & E. Valenstein (Eds.) *Clinical Neuropsychology.* New York: Oxford University Press.

Rubin, D.C. (1980) 51 properties of 125 words: a unit analysis of verbal behaviour. *Journal of Verbal Learning and Verbal Behaviour* **19**, 736-755.

Rubin, D.C. (1983) Associative asymmetry, availability and retrieval. *Memory and Cognition* **11** (1), 83-92.

Ryle, G. (1978) *The Concept of Mind.* Harmondsworth: Penguin. First published by Hutchinson, 1949.

Schank, R.C. (1982) *Dynamic Memory: A Theory of Reminding and Learning in Computers and People.* Cambridge: Cambridge University Press.

Swinney, D. (1979) Lexical access during sentence comprehension (Re)consideration of context effects. *Journal of Verbal Behaviour and Verbal Behaviour* **18**, 645-660.

Tulving, E. & Pearlstone, Z. (1966) Availability versus accessibility of information in memory for words. *Journal of Verbal Learning and Verbal Behaviour* **5**, 381-391.

Tulving, E. & Thomson, D.M. (1973) Encoding specificity and retrieval processes in episodic memory. *Psychological Review* **82**, 261-275.

Warren, M.W. (1977) The effects of concurrent visual-motor distraction on picture and word recall. *Memory and Cognition* **5**, 362-370.

Warren, R.E. (1972) Stimulus encoding and memory. *Journal of Experimental Psychology* **94**, 90-100.

Watkins, O.C. & Watkins, M.J. (1975) Buildup of proactive inhibition as a cue-overload effect. *Journal of Experimental Psychology: Human Learning and Memory* **104**, 442-452.

Winograd, E. & Lynn, D.S. (1979) Role of contextual imagery in free recall. *Memory and Cognition* **7** (1), 29-34.