

**§I.C.5. Imaginary Sizes.**

In the last section our central concern was with experimental studies carried out by Stephen Kosslyn, and that will be the case here too. We are also again going to deal with work that attempts to experimentally demonstrate that mental images have a subjective internal structure which parallels the spatial structure of the perceived environment. Kosslyn has expressed this point by saying, with Shepard {1}, that images are "analogues" of percepts {2}. However, we are not concerned here with what we have found to be the somewhat artificial and methodologically suspect task of 'scanning' over images. In this case the experiments deal with what is surely the far more natural, or at least more commonplace, activity of examining images and picking out their various details. Actually, although this work postdates Kosslyn's original study of 'mental scanning', it is far more closely related to the chance observations which first inspired Kosslyn's interest in imagery - the fact that some of his subjects had tried to decide whether a flea could bite by imagining a flea and 'looking' for its teeth {3}. In that case the use of imagery misled the subjects, and we would probably find that most people would not use an image to answer that particular sort of question. However, there are similar sorts of question where the use of an image seems much more appropriate and likely. An informal example frequently used by Kosslyn when introducing his views on imagery is: "What

shape are a German Shepherd [Alsatian] dog's ears?" (4). It surely seems quite natural and sensible in this instance (and many more could easily be constructed) to form an image of the dog and 'look' at the ears. Anyway, although it has very similar implications for realism about imagery, the work to be described here has not suffered anything like the amount of methodological criticism (5) that has been endured by the work on 'scanning'. For instance, in his recent book *Pylyshyn* devotes almost fourteen pages largely to a criticism of image 'scanning', and only a comparable number of lines to the work now to be discussed (6). On the whole, the iconophobe is left with what will be the serious task of explaining these results, of accounting for them without postulating mental pictures. It is not so easy to explain them away, to dismiss them as experimental artifact.

Kosslyn was apparently inspired to do these experiments (7\*) by a possible analogy which occurred to him between mental imagery and the displays produced by computer graphics programs (8). This analogy, which he calls the cathode ray tube (CRT) metaphor, has continued to strongly influence his theorising (9). However, it is fortunately not necessary to take this analogy seriously in order to appreciate the rationale behind the experiments. A simple and uncontroversial analogy with visual perception is quite sufficient. Quite simply, Kosslyn took note of the fact that small things are harder to see than large ones. If something is visually small, either because it really is

small or it is a long way away, it is likely to take us longer to satisfy ourselves that we have seen it properly than when it looms large in our sight. Small things need to be peered at, or perhaps we will even feel the need to move physically closer to them. In any case, the process takes time. It occurred to Kosslyn that if imaging was like seeing (which is virtually true by definition) then similar considerations should apply. The details of small images, or particularly small details within images, should take longer to 'discern' than features which appear large. It might even be necessary to 'enlarge' or "zoom in on" the image, and this would surely take time. If this could be demonstrated to be true the spatial nature of imagery would be vindicated. Size, after all, is meaningless outside a spatial context. The main problem which Kosslyn faced as an experimenter was how to control the sizes of his subjects images.

Kosslyn's original solution to this problem was ingenious and striking. He chose twenty types of animal, ranging in size from a collie to a mouse, as "targets", and had his subjects imagine each of these animals standing next<sup>t<sub>o</sub></sup> a "context" animal, which was to be either an elephant or a fly {10}. An image had to be formed in which the two animals had to be simultaneously visible and at the same distance, standing up against a blank wall. The idea was that in any image containing an elephant the other, "target", animal would appear quite small. Conversely, in any image in which a fly could be clearly seen even a mouse

next to it would loom quite large. Kosslyn allowed his subjects 18 seconds to form each of their two-animal images, and they then heard the name of an animal "property" or part (e.g. beak, palm, legs). In half of the trials this property was one that belonged to the target animal in the image, and in the other half it was not. The subjects' task was to

look at their image of the second [i.e. target] animal (which was standing next to the first [i.e. elephant or fly]) and see if that property looked appropriate. That is, they were to place the property on the animal if it was not in evidence initially. As soon as the subject had determined whether the property was appropriate, he had to depress one of two buttons, one for each decision outcome (hand of response was counterbalanced over subjects). Subjects were urged to respond as quickly as possible, but to keep errors to a minimum.

{11}.

Kosslyn's prediction was that it would take longer to 'see' whether a property was appropriate to an animal imagined next to an elephant (and therefore, initially at least, imagined small) than it would take to 'see' it when the animal was imagined next to a fly. This prediction was borne out: on average the task took 211 milliseconds longer when the "context animal" was the elephant. This seems to indicate that the general analogy between image and percept has not been misleading, and that relative size is an appropriate notion to apply to the features of mental images. It provides further grounds for thinking that images have spatial properties.

Kosslyn carried out a number of variations of this experiment to try to eliminate the possibility of

explanations of the effect as being other than a result of relative subjective sizes. First of all, to eliminate the (surely remote) possibility that the time difference arose from something specific to elephants and flies he had subjects imagine the target animal as standing next to either a huge, elephant sized fly, or next to a tiny, fly sized elephant (12). It seemed to take the subjects slightly longer to do things this way, but the effect of the size of the context animal still occurred: it took longer, by roughly the same amount as before, to 'see' features of an animal imagined next to a giant fly than when it was imagined next to a Lilliputian elephant.

A rather more serious possibility is that the effects might be the result of differences in image complexity rather than size. It is quite a plausible assumption there is a limit to the complexity, the amount of detail, which we can maintain in an image. An animal imagined large, as the elephant will be, is likely to display a good deal of detail, and may simply be taking up more processing capacity than one imagined small such as the fly. Thus when the elephant (or the giant fly) is in the picture there may not be enough capacity left to imagine the target animal in any detail. There will be no such problem, however, when the context is supplied by the fly (or the pigmy elephant). If these speculations are correct then the experimental results may be explicable without reference to 'spatial' properties such as subjective size.

However, if a way to independently vary the 'size' and the complexity of the context part of the image can be devised then effects of complexity and of subjective size can be empirically distinguished. This is not really possible when using animals, or, indeed, most other sorts of real object, for the context, because their complexity is, for present purposes, effectively infinite. Imagining such an object as larger would be equivalent to looking at it more closely, and would thus reveal more detail, so size and complexity would always remain confounded. Kosslyn thus dropped the use of animals as context and instead used simple geometric figures. The target animal was now to be imagined as next to a square divided into four equal square quadrants, or else as next to a square divided into sixteen smaller squares. Kosslyn treated the first of these as a "simple" context figure, and the second as a more complex one. These context figures were to be imagined in each case as "painted" on the wall behind the target animal. Of course, there is no natural size for such geometric figures, so relative sizes of context and target had to be manipulated more directly than before. Figure I.C.5\_1 shows the context figures used in this experiment (13), but each context figure is shown next to a larger or a smaller blank square to its right. Each pair of squares indicates the relative sizes at which the subjects were to imagine the context figure and the target animal, with the blank squares representing the required size of the latter. The subjects were shown diagrams of this sort before embarking

on the experiment proper, where they heard, before forming their images on each trial, whether the simple or the more complex figure should be used as context, whether this context figure should be imagined small or large, and the identity of the target animal to be imagined next to it. Otherwise the experiment was very similar to that using the elephant and fly; after the image was formed the time taken for the subjects to 'see' some feature of the target animal was measured. The results indicate that both the complexity of the context figure and the imagined relative sizes of the figures affected these times, but these effects are quite independent of one another. The effect of size thus seems to be vindicated. To further reassure himself on this point Kosslyn also carried out a variant of this experiment using digits "painted" on the wall next to each animal instead of the geometric figures (14). Two given digits were used as the "simple" context figure, and four digits made up the "complex" one. Again, independent effects of complexity and size were found. Finally Kosslyn attempted to manipulate the imagined size of the target animals "directly" without using a context figure in the image at all (15). For this he simply showed his subjects a sequence of four squares of different sizes - each, in fact, six times the area of the preceding one. The different sized squares were different colours, and during the experiment proper the subjects heard the name of the target animal and the colour of one of these squares. They were told to "construct an image of the animal at the size of the square indicated by the colour" (16) (with the largest square

indicating as large as possible an image of the whole animal). When these images were formed then the subjects had to verify the presence of some given feature of the animal by 'looking' at their image, as before. As expected, the response times for this task decreased fairly steadily with increasing imagined size of the target.

These results seem fairly convincing to me. Kosslyn took his usual precaution of asking his subjects whether they had guessed the purpose of the experiment, and the data from two was actually discarded because they did claim to have guessed the purpose whilst participating in the last described experiment, where the image sizes were manipulated "directly" (17\*). However, an interpretation in terms of 'experimental demand' still seems fairly possible here. Subjective image sizes are, after all, fairly obviously being manipulated in all the experiments, and the idea that details should be more difficult to discern on a small image (or a distant object) seems commonplace enough. Perhaps it is sufficiently commonplace for the factoring of the consequences of such a notion into one's responses to occur more or less automatically, being understood as an index of correct performance of the requested task.

However, Kosslyn has done another experiment which addresses the same issues but in which it must surely be far less obvious that relative size is the key independent variable. In this case the size of the imagined "target" object (in fact animals were again used) was not

manipulated at all, either "directly" or indirectly via a "context" object. It will be recalled that Kosslyn's interest in imagery was sparked off when he discovered that a few subjects were spontaneously using imagery to find the answers to certain questions. He saw that the response speeds of subjects who did not use imagery was correlated with the verbal association strength of the question elements, but for those who did use imagery this correlation disappeared (18). In collaboration with Keith Nelson he repeated the relevant experiment, but with some subjects specifically asked to use imagery. Again it was found that only the response speeds of the subjects who did not use imagery were correlated with the relevant association strengths (19\*). It seems that at the time Kosslyn could discern no pattern to the results from the imagers. However, as he later became convinced of the importance of size in imagery, he realized that response speeds of imagers in tasks like this might vary with the size of the relevant part of the animal relative to the whole. For example, whatever size the image of a whole cat might seem to be, it is likely to be easier (and so quicker) to 'see' the cat's head rather than its claws. On the other hand, the verbal association between "cat" and "claws" is much greater than that between "cat" and "head". Thus one would expect that someone using a verbal strategy would be able to confirm the truth of "A cat has claws" faster than "A cat has a head", whilst for those using an image strategy this order would be reversed.

Kosslyn was thus able to devise an experiment which would show an objectively measurable difference between the use of imagery and of other cognitive strategies (20). In each experimental trial the subjects heard the name of an animal and the name of a feature. Their task was to say whether or not the feature was appropriate to that animal. Half of the animal/feature pairs were 'inappropriate' distractors (i.e. the animal does not have that feature), but the instances where the features were appropriate are more significant. These 'true' features were carefully selected to be either highly associated with the animal but of small relative size (e.g. rabbit - nose) or else of large size but less associated (e.g. rabbit - back) (21\*). Half of the experimental subjects were told to do the task by forming an image of the animal and 'looking' for the feature on it. The other half were not instructed to use imagery (although they were not instructed explicitly not to use it).

There are two significant aspects to the results of this experiment. First of all, the subjects not instructed to use imagery generally responded a good deal more quickly than did those who were instructed to use it. Employing imagery thus seems to be rather a poor strategy in tasks of this kind. However, the large difference in response times between the two groups does seem to bear out the view that imagery is a distinct cognitive process which we can use or not at will. The fact that the faster group were those who had not been given any particular instructions about

imagery at all also lends support to Kosslyn's implicit assumption that, in this sort of task, adults will generally not spontaneously use imagery.

The second aspect of the results was, however, even more revealing. Quite apart from the large overall difference in speed we find we find a quite different pattern for the imagers and the non-imagers. As predicted, the imagery group was relatively quick at confirming the large (but poorly associated) features, and took longer for the small (but highly associated) ones. By contrast, the non-imagery group were faster to confirm highly associated (though small) features than they were for the poorly associated (but large) ones. It seems hard to deny in the face of this that imagery and non-imagery cognitive strategies {22\*} are quite different, or that imagery processes resemble those of perception, at least inasmuch as large things are more noticeable than small ones.

To further confirm these results, Kosslyn returned to the data from the unpublished study which he had done with Nelson some years before, and analysed these afresh both in terms of association strength (as had been done originally) and in terms of feature size (which had not been done before) {23}. Essentially the same pattern of results was again found {24\*}. It is also worth pointing out that in this case there is no possibility of the result having been influenced by the experimenter's expectations. When these results were collected it had not occurred to

Kosslyn that subjective size might affect image inspection times, and, indeed, his ideas about imagery had hardly begun to crystallize at all.

I find these results even more persuasive than those where overall image size was manipulated by "context" animals and the like. It seems highly unlikely that the subjects here would realize that the relative sizes of the animal's features were being manipulated at all. Kosslyn himself did not realize it when collecting the earlier set of data with Nelson! Nevertheless, the work still suffers from the fact that imagery use is not the most efficient nor the normally chosen way to do these tasks. As with 'mental scanning' the suspicion may arise that the imagery instructions lead to an 'unnatural' type of performance which does not truly reflect normal cognitive functioning. What is needed, again, is some sort of demonstration of these effects which does not involve telling subjects to use imagery.

This time Kosslyn himself found a way in which this could be done. It is widely believed by developmental psychologists {25\*}, and probably by laymen too, that children, not yet fully competent with language, employ imagery much more in their thinking than do adults. Presumably, as linguistic competence develops efficient verbal strategies increasingly take over the functions performed by less efficient imaginal ones. If this is right, Kosslyn realized, then it should be possible to

reproduce the different effects of feature size and feature association on response times without instructing anyone to use imagery. Sufficiently young children could be expected to use the imagery strategy as spontaneously as most adults use the verbal one. Such an experiment would have the additional virtue of testing the view that young children do think largely in images, a belief which heretofore depended more on guesswork and *a priori* reasoning than on evidence. Kosslyn thus administered the task used in the experiment described above (i.e. confirming the presence on animals of features of different sizes and degrees of associative connection) to groups of children of different ages. This time he gave no instructions regarding the use of imagery (or any other particular cognitive strategy) to any of the children involved. The results produced by 10 year olds proved to be very similar to those produced by adults under the same conditions. The faster, verbal strategy, which is affected by association strength but not by size, was generally spontaneously preferred. However, the pattern for 6 year olds was quite different. Although they had not been instructed to use imagery they spontaneously showed a response pattern like that of adults instructed to use imagery. That is to say, the relative size of the probe feature was the main determinant of response time. This seems to me to be one of the clearest evidences we yet have that imagery is a distinct and highly significant type of cognitive function. Also, we now have some hard evidence that imagery is developmentally prior to linguistic forms of mental representation. This also provides a hefty hint,

though admittedly not a proof, that, as Paivio {26} holds, imagery is logically prior to language as well.

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We have not had the space here to consider all of the areas of psychological research which have contributed to the upsurge of interest in imagery over the past 25 years or so. We might briefly note that: imagery has been put forward by some as playing an important rôle in informal logical inference and other forms of problem solving thinking {27\*}; imagery has been widely taken to be of great relevance to psychotherapy, both in the professional {28} and the 'self-help' {29} contexts; and the use of imagery in 'mental practice' has, perhaps surprisingly {30}, been found to significantly improve physical and sporting skills {31}. Despite all this, and other, activity, I think that few would deny that it is the work of (or inspired by) Paivio, Shepard and Kosslyn which has done most to put imagery firmly back in its place as a central concern of experimental psychology. This does not mean, however, that the iconophobes have been routed. Still less does it mean that 'Aristotle's problem' has been solved, or even seriously tackled. In fact, as Ned Block has pointed out {32}, the claims made for imagery may ultimately be incompatible with the basic assumptions of mainstream contemporary cognitive theory. The nascent hybrid discipline of 'Cognitive Science', although by no means univocal, seems to be largely built round the assumption that all mental representation is somehow quasi-linguistic {33\*}. The implication must be that if