NEITHER PICTURES NOR PROPOSITIONS:

THE INTENSIONALITY OF MENTAL IMAGERY

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We explore several implications of the claim that mental images are mental representations, i.e. that imaging creates an intensional context. The experiments show, first, that images are entirely unambiguous in what they represent, and, second, that how an image is understood places limitations on what the image is likely to call to mind. We argue that images have two different kinds of properties: some by virtue of being mental representations, and some by virtue of being a particular kind of representation, i.e. embodying meanings in a certain (quasi-perceptual) way. We discuss both the relationship between images and pictures, and between images and other forms of representation.

We begin with a simple claim: Mental images are conscious mental representations, and this has important consequences for how images function. In this paper, we spell out just part of what this innocent-sounding claim implies. While our primary agenda is to show that this view is correct, we also intend to show that this view is genuinely different from how others in the field conceive of images, and, most important, to show how much is at

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We wish to thank Ed Casey and Friderike Heuer for their comments. In addition, both this work and our thinking in general have been deeply influenced by Julian Hochberg and Irvin Rock, and we gratefully acknowledge that debt.

stake in the argument.

One way to think about mental images is to think of them as being just like pictures, so that imagery is in many ways just like perception. There is much to recommend this view, including both common sense introspection and the vast amount of data from imagery research. Those data, for example, indicate that how we inspect an image (how we scan across it, or how we zoom in to see detail) seems to match how we inspect pictures. Likewise, we seem to be influenced in comparable ways by imaged and actual stimuli. The imagery medium itself reveals many picture-like qualities: Images, like pictures, respect spatial relations in a certain way. Aspects that are salient in a picture are also prominent in an image, etc.

However, there is one regard in which images are not like pictures. A picture is a physical thing, with an existence independent of the perceiver. If we want to know what a picture represents, we must inspect it in order to form some interpretation. And that is the critical part: Pictures must somehow be interpreted. Among other consequences, this creates the possibility for misinterpretation, and, since many interpretations might be possible, a picture can be ambiguous, as for example the Necker cube is.

One might claim that all of this is true for images. On this conception, imagery begins with some raw material, an array of lines or points. To figure out what the image is an image of, we interpret it, through a process related to perceiving. Kosslyn (1980, 1983) offers one version of this view; similar arguments can be found in Finke (1980).

There is, however, an alternate account of how mental images are comprehended. (Cf. Casey, 1976; Chambers and Reisberg, 1985; Fodor, 1981; Kolers and Smythe, 1984. Reed, 1974, and Hinton, 1979, have also offered similar conceptions.) At the core of this argument is the claim that images, as mental representations, only exist through our understanding of them; hence the image and the understanding are inseparable. There is no free-standing icon in imagery in need of interpretation, and there is no interpretive process.

To put this differently, images are embodiments of thoughts. Consider for a moment what it means to have a thought, for example, a thought about tigers. It would be absurd to say, "Right now, I believe I'm thinking about tigers, but this belief might be false." It might be true that I do not know much about tigers, making the thought impoverished. It may turn out that some of the things I know about tigers are false, so that my thought will be counterfactual. Nonetheless, if I understand the thought as being about tigers, then it is about tigers, because it is only through my understanding of it that the thought has any definition at all. There is certainly no need to interpret the thought to learn what it is about; there is no way to be mistaken about what a thought refers to, and no possibility for ambiguity in what a thought is about.

Images are one of the forms thoughts can take. Thus, images are thoughts, or, in the customary terms, are mental representations. When an

image comes into being, it comes into being understood in a particular way, as an image of some particular thing. Just as with thoughts in any other form, there is no interpretive process needed to learn what the image depicts, and there is no way to be confused or mistaken about an image's contents.

Our research began with an examination of an assertion central to this view: the claim that images, like thoughts in general, cannot be ambiguous. To test this claim, however, we must deal with a complication: Whether or not one can reinterpret an image, one can certainly replace an image. Therefore, one could image the Necker cube (Figure 1), for example, by first imaging Cube A, then B, then A again, and so by a succession of replacements seem to be reinterpreting a single image. This possibility is easily removed: To replace an image, one needs to know with what to replace it. Thus the critical question is not simply whether one can reparse an image by imposing an already familiar scheme; the question instead is whether one can discover an unanticipated, uncued shape in an image.

Subjects in our first experiment were shown pictures of several ambiguous figures, to make certain they understood figural reversal. Subjects were next shown the test stimulus (the duck/rabbit, Figure 2A) and were asked to form a "mental picture" of this figure, so that they would be able to draw it later on. We took a variety of steps to ensure that subjects were unfamiliar with this figure, among them excluding psychology students from the experiment.

The test stimulus was shown only for five seconds. Pilot data indicated this was sufficient for encoding the figure, but not enough time for naive subjects to find both construals. This is critical, given our concern about excluding image replacement. Hence we want to ensure that the first reversal does not happen while viewing the picture, so that any reversals from the image (if they occur) will reflect bonafide discoveries.

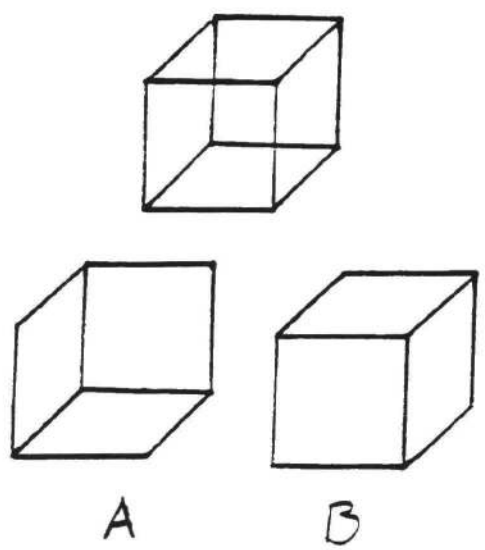


FIGURE 1: THE TWO ALTERNATE VIEWS OF THE NECKER CUBE.

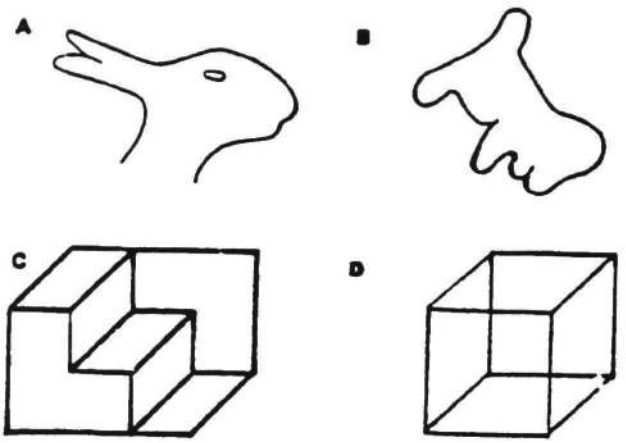


FIGURE 2: THE AMBIGUOUS FORMS USED IN THE STUDIES (SEE TEXT FOR DETAILS).

Next, subjects were shown the chef/dog (Figure 2B). We hoped this would make it totally clear to subjects what their task was. Like the duck/rabbit, this form is a simple line drawing; both figures reverse in a similar fashion. Subjects were told that shifting their gaze from the lower left corner of the chef/dog to the lower right might help in finding the alternate construal.

Subjects were then asked to recall their image of the duck/rabbit. All had either seen the duck or the rabbit initially; they were now asked to identify the alternate view. We gave the subjects a standardized series of prompts and hints, asking if they had a "clear mental picture" and whether they could find an alternative "in the same way that (they) did for the chef/dog." Subjects were urged to look at the "east corner" of the imaged figure, then the "west," and so forth. (These cues are effective in eliciting reinterpretations if there is an actual stimulus available, rather than an image.)

Finally, subjects were given a piece of paper and asked to draw a picture of the imaged stimulus, then to inspect their own drawing until they found the alternate construal. If needed, subjects were given the same cues that had been used with the image.

Exactly 100% of the subjects failed in the imagery task. That is, subjects never discovered the duck in a rabbit image or the rabbit in a duck image. In complete contrast, 100% of the subjects succeeded, a moment later, in reinterpreting their own drawing. Thus, the subjects did have an adequate memory of the figure, and did understand our task.

We have reproduced this result several times, with minor procedural changes. We have tried changing the instructions, emphasizing to subjects that they should encode a literal, unbiased copy of the figure. (To this

end, we give subjects a brief lesson about distortion effects in memory, and urge them not to fall prey to these.) We have also tried giving more initial practice with figural reversal, and we have examined test figures other than the duck/rabbit (i.e. the Schroder staircase and the Necker cube, Figures 2C and 2D). The results are unchanged by any of these (Table 1).

These are obviously strong results, and warrant caution in their interpretation. In an early report of these data (Chambers and Reisberg, 1985), we consider many of the ways one might try to explain away these findings, and the results survive all of the attacks. One of those considerations, however, is worth a brief mention. Subjects' success in reinterpreting their own drawings provides an important support for our claims, indicating that subjects did encode an accurate copy of the stimulus. To ask whether these drawings really were ambiguous, we showed the drawings to a new group of subjects, subjects who had never seen the original figure. In a procedure similar to that already described, these new subjects were able to discover both interpretations of the drawings, strengthening the claim that the earlier subjects were in fact creating an ambiguous drawing from an unambiguous image.

We have also obtained parallel results with auditory imagery (Reisberg, Smith and Sonenshine, 1986). As our ambiguous stimulus, we employ rapid repetitions of the word "stress." When these repetitions are aloud, the resulting soundstream is ambiguous about the locations of the word boundaries, creating a stimulus which could be stress, dress, rest or tress. Our procedure with this stimulus is modeled after the one already described: we acquaint subjects with ambiguous auditory stimuli (using repetitions of life, with the soundstream ambiguous between life and fly). We then ask subjects to imagine the repetitions of stress, and ask them to find more than one interpretation of it, just as they did with life. In analyzing these results, we need to take steps to rule out both guessing strategies and subvocalization, but once this is done, the results echo those we have been discussing: Just as with visual imagery, subjects reliably fail to reinterpret the auditory image.

TABLE 1: SUMMARY OF RESULTS WITH VISUAL AMBIGUOUS FIGURES

Experiment and test stimulus	N	Number of reversals: From image	Number of reversals: From own drawing
1 Duck/rabbit	15	0	15
2 Duck/rabbit	10	0	10
4 Duck/rabbit	10	0	10
Necker cube	10	0	10
Schroder staircase	10	0	6

(After Chambers and Reisberg, 1985)

Unfortunately, though, there are many observations which do not seem to fit with this conception of imagery. In many mental rotation studies, for example, subjects must decide if a stimulus is a letter or a mirror-reversal of one. The data strongly indicate that, in making this decision, subjects first rotate the image; only then can they decide what the image depicts. Thus the understanding of this image seems to be arriving rather late: Until the rotation is complete, the subject does not know what the image is an image of, in seeming contradiction to our view.

Our account of this (and related cases) appeals to a notion already mentioned, namely, image replacement. It is clear that images can serve as memory cues, evoking other images or other thoughts. In the mental rotation case, one first has in mind an image of a particular form. That image may or may not evoke the thought of some letter. If it does, one replaces the shape image with a letter image, with the replacement, as it turns out, isomorphic with its predecessor.

While images can call forward other ideas in this way, it is critical to keep in mind that this evokation begins with an unambiguous representation. The image is understood in a certain way, and this gives the image a specific phenomenal appearance. It is this phenomenal appearance which governs what the image resembles, and, finally, it is the resemblance pattern which guides what an image will call to mind. We stress that this cascade of implications begins with how the image is understood, and so, in this way, the understanding places limits on what the image will evoke, and on what we can learn from or about the image. To put all this differently, the notion of image replacement seems initially troublesome for our view, since it appears to render the view immune to falsification. As we will see, though, this notion is not at all a source of trouble; far from it, image replacement provides a means of showing the importance of how an image is understood.

What exactly does it mean to understand an image in a certain way? This is in several regards an empirical issue; our experiments explore the obvious suggestion that the understanding which characterizes <u>imagery</u> is the same as that which characterizes <u>perception</u>; the results clearly favor this view.

In unpacking this argument, it may be simplest to begin with the data. We tell subjects in the next experiment that we are studying memory for abstract forms. Subjects are shown a succession of shapes, each for 5 seconds. After the shape is removed, subjects are asked to form an image of it, and then to rotate the image by a certain amount, sometimes 90 degrees and sometimes 180 degrees, and so on. Finally, subjects draw a picture of the form in its rotated position.

This sequence is designed to set the subject for seeing abstract, unidentifiable forms, so that we can now smuggle in our test figure: The tenth shape in the series, presented with no special notice, was an outline drawing of Texas, rotated so that its eastern edge was at the top of the picture (Figure 3). Subjects encoded this shape, then imaged it, and finally rotated the image 90 degrees, so that they were now contemplating

FIGURE 3: TEST STIMULUS FOR THE ORIENTATION STUDIES.

an image of a correctly righted map of the Lone Star State. Then, instead of asking the subject to draw a picture, as they had been doing, we tell them that this shape "resembles a familiar geographic form," and we ask them to identify that form.

This experiment rests on two premises, both extrapolations from the data of perception. First, phenomenal shape depends heavily on an assignment of orientation. That is why, for example, diamonds look differently from squares, as can be demonstrated in a variety of ways. (These include resemblance patterns, subjects' ability to judge whether the figure's corners are right angles, with much less sensitivity to this in diamonds, and so on.) Second, once the perceptual system has assigned an orientation, there seems to be resistance to changing this assignment. As Mach noted many years ago, if one rotates a square, it does not become a diamond; it becomes a tilted square. (This presumably plays a role in how we recognize objects despite changes in retinal orientation.)

Subjects will presumably understand our test stimulus as being oriented such that the perceived top is the side topmost in the drawing. This specification about how the form is to be understood will be part of the image, and will influence the subjective appearance of the image. Rotating the image will not change this specification, if imagery is like perception in this regard. Given all this, we claim that, by virtue of having an orientation different from that of Texas, the image is a different shape. Geometrically, the image and Texas are isomorphic, but, psychologically, they represent different forms. Hence, the image does not resemble Texas, and will not call Texas to mind.

The data are quite clear-cut. Of the 15 subjects, 100% failed to identify Texas in the image, even though the image has been rotated into, so to speak, the Texas position, and despite the cue that the image resembles a geographic form. We know in addition that the subjects did adequately

encode the shape: After the subjects had tried unsuccessfully for 60 seconds to identify the shape, we asked them to draw a picture of their image. Eight of the 15 subjects identified Texas in their drawings.

Is orientation really critical in the failure to recognize Texas? If so, we should be able to change the outcome of this procedure if we change how subjects understand the image's orientation. We know from many perceptual studies that rotation by itself does not change how a form is understood; we relied on this in the study just described. But we also know that deliberate intention can step in and take over in reassigning orientation, e.g. if subjects are told directly to think about a form as having a different top (cf. Rock and Leaman, 1963; Attneave and Reid, 1968). Our next study exploits this fact, using the same procedure as the previous study, but with a slight change in instructions: Instead of asking subjects to rotate the image of each figure, we simply told them to think about each as having a new top, making the left side the figure's top, or the right side, and so on.

As before, subjects were shown a series of shapes, each for 5 seconds. Subjects imaged each, then were asked to reassign the form's top. Sometimes we told them to think of the left edge as the top, sometimes the right, all matched to the previous experiment. Subjects then drew each form, with its new top at the top of the drawing. For the test figure, again Texas, subjects were asked to reassign the left side as the top, setting the map upright. Once again, we told them that the shape resembled a familiar geographic form, and asked them what the form was.

In sharp contrast to the first study, 7 of the 15 subjects, almost half, identified Texas in their image (see Table 2). Thus, orientation does seem to be the key. If we change how the subject understands the image's orientation, we change the results.

We have some other data which corroborate the Texas results: We show subjects the shape in Figure 4, with the same kind of cover story, so that they encode it as merely an abstract form. If we tell them to rotate the image, they never discover anything. If we tell them to think of the bottom edge as being the top, they discover the old man, but not the map of the U.S. If we instead tell them to think of the left edge as being the top,

TABLE 2: SUMMARY OF RESULTS FOR THE ORIENTATION STUDIES

Instruction	N	Number of subjects who recognize Texas	
		From image	From own drawing
"Rotate"	15	0	8
"Reassign top"	15	7	11

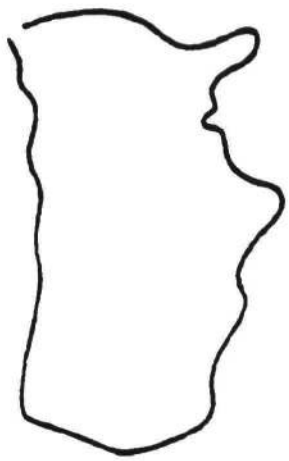


FIGURE 4: THE "OLD MAN / UNITED STATES" FIGURE

they discover the U.S., but not the old man. All of this obviously mimics the Texas results already described.

What is going on in these data? We have already mentioned the core of the argument: Whether an image will be recognized as familiar, or what the image will evoke from memory, depends on how the image is understood. If the form is isomorphic with some previously viewed shape, but understood differently, then it will fail to remind the subject of the previously viewed shape. But we need to connect this to our earlier comments about mental representation, and we also need to clarify what it means to understand a form in a particular way. Let us return to the example we used earlier: Imagine thinking about a tiger. We argued before that this necessarily means that you know that you are thinking about a tiger. But this does not mean merely that you are associating the label "tiger" with your thought. Instead, by knowing that your thought is a tiger thought, you know that this is a real beast, that "tiger" is the name others call it, that this is a concept with which you are familiar, about which you have further knowledge, etc., etc. In short, you are attaching meaning to the notion, tiger.

For contrast, we could find someone who has never heard of tigers, and we could tell that person: Imagine a fictional beast with a cat-like shape, stripes, etc. Then we could tell this person to call this beast "tiger," a label which, for this person, is a made-up word. Would that person have a "thought without meaning," without knowing what a tiger is? Clearly not. That person would know that a tiger was a fictional beast, created by the imagination with these instructions, and that would be the meaning of tiger for this person. Moreover, this person would be having a different thought than you or I do, when we think about tigers.

It is this background of associations and knowledge which is involved in saying that mental representations are meaningful, that they are trans-

parent to the understanding. We can describe this as a phenomenologist might: Thoughts are embedded in a context of understanding, against, so to speak, a particular mental landscape, what Husserl called a set of horizons, or with what William James called a particular "fringe of consciousness," defining that consciousness. Or we can describe this by noting that mental representations are referentially opaque. Hence we cannot describe the representation merely by pointing to the thing in the world which is represented; we instead need to ask how the represented thing is thought about, what the representer knows about it. To take the tiger example, the person thinking about the fictional tiger, on the one side, and you or I, on the other side, are representing what turns out to be the same beast; nonetheless, we understand it in different ways, and we are having different thoughts.

How to apply this to images? When one thinks about a form, one thinks about it in ways that differentiate that form from other forms. As in the tiger case, this does not amount merely to placing a label on the form; instead, the form is embedded in a context of understanding that defines what the thing being represented is. If the form is thought about in a new way, then it is a new form. As a minimal implication, a form understood differently should look different, should have a different phenomenal shape. Look again at the Texas figure, shown in Figure 5. The left shape does, for most viewers, look like a different form from the right one, just as a diamond looks different from a square. To be sure, one can force oneself to think about the right shape as being sideways -- i.e. impose a different understanding. In this case, one sees immediately that the shapes are isomorphic. But if one does not resist the orientation given in the figure, the two outlines look like two different shapes. We do not need to rely, though, on phenomenal impressions, since these changes in perceived form can have strong impact on similarity relations. Figure 6, borrowing a demonstration from Goldmeier, makes the point clearly.

While we have focused here on the specification of orientation, the data of perception indicate that other aspects also contribute to the perception of form. And it is indeed the data of perception which are relevant, as a quick example will illustrate: One might expect that symmetry will be an important property of percepts, immediately noticed, playing a key role in resemblance and so on. But, as Figure 7 shows, symmetry in general does not have these

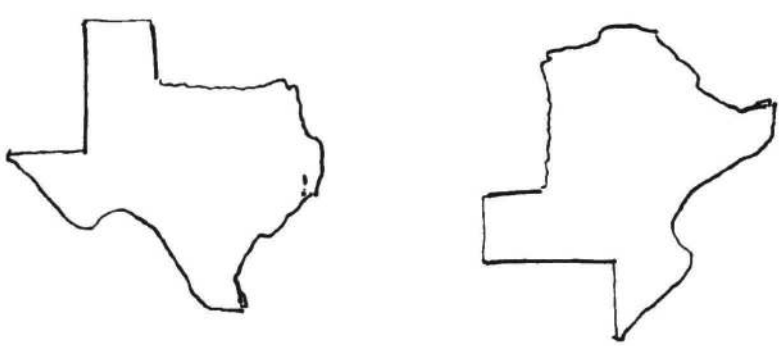


FIGURE 5: A CHANGE IN ORIENTATION ALSO CHANGES PHENOMENAL SHAPE.

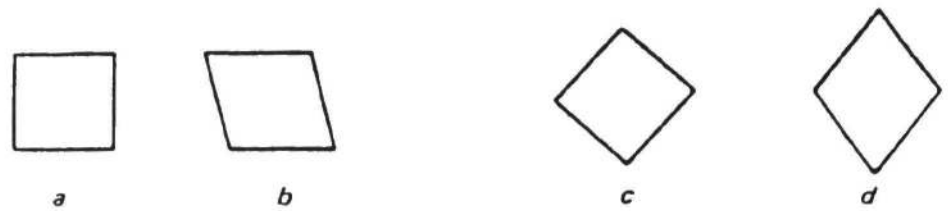


FIGURE 6: A AND C ARE IDENTICAL EXCEPT FOR ORIENTATION; LIKEWISE FOR B AND D. THE CHANGE IN ORIENTATION CAUSES A CHANGE IN PHENOMENAL SHAPE, AND A CONCOMITANT CHANGE IN SIMILARITY PATTERNS.

properties; it is only symmetry about the vertical axis which seems to characterize a form. Symmetry around other axes is considerably more difficult to detect, and does not seem to influence resemblance patterns.

Happily, we do not need to go out and collect the relevant data, since much of it is already available, thanks largely to Gestalt psychology and its descendants. The full set of appearance specifications (and we count a half-dozen or so) includes unit formation, figure/ground assignment, orientation, assignment of relative depth, and so on. In all these ways, perception goes beyond the information given, imposing meaning on a form. These specifications literally shape how the form looks, and changing these will change appearance. This in turn will change resemblance patterns, and so will change what a form is likely to call to mind.

Just as the specifications shape percepts, they also shape images. Hence changing how an image is understood will create a new phenomenal form. As Casey (1976) puts it, "to imagine something differently is to imagine something different." As a consequence, while the present experiments exploit orientation, similar imagery demonstrations should be possible with other specifications. One of our current studies is exploring this point, but there are

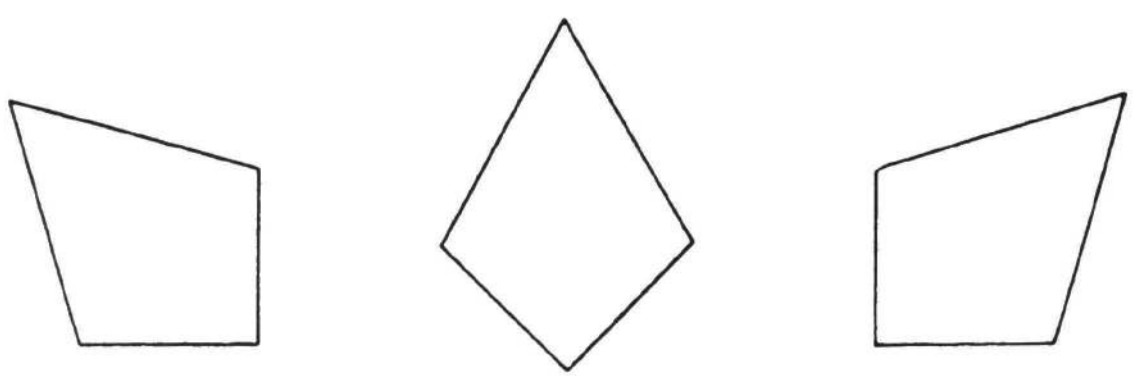


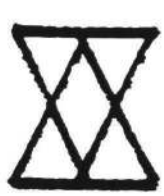
FIGURE 7: IT IS SYMMETRY AROUND THE VERTICAL AXIS WHICH INFLUENCES FORM.

already some relevant data in the literature (e.g. Hinton, 1979; Reed, 1974; Slee, 1980). In Slee's task, for example, subjects are first shown a series of shapes, including a Roman numeral twenty (Figure 8). Later, subjects are shown probe figures (such as the parallelogram) and asked whether these were contained in any of the earlier forms. Subjects are explicitly urged to imagine various constructions around the probe shapes, in order to discover if they can "build" their way back to any of the shapes in the memory set.

When the probes and memory figures differ in their organization, this task is very difficult, and failure rates are high. This obviously parallels our own findings: By virtue of the different organization, the probe does not resemble the memory figure, and so will not call it to mind. (Interestingly, the Reed and Slee data differ from ours in one respect: Our data yield 0% success rates; they report occasional successes. Neither Reed nor Slee, however, have any check in their procedures on how subjects initially encoded the figure. It seems entirely possible that the successes come from subjects who encoded the form in a manner consistent with the probe.)

In these various ways, then, mental images behave as mental representations must behave, with their function bounded by their particular meaning. In fact, by being a property of mental representations in general, rather than just of images, we should be able to find parallel demonstrations in other domains. We have been discussing the parallels between imagery and perception, but we can also find comparable effects in more distant regions. For example, consider Tulving's encoding specificity demonstrations. In these studies, subjects are led to understand a verbal stimulus one way during the learning process and a different way during the test. Because of this, subjects fail to recognize a word seen just minutes before, just as our subjects failed to recognize the familiar shape of Texas. And this parallel should exist, inasmuch as certain properties are entailed by being a mental representation, whether the representation is an image or in some other form, whether the thing represented is a shape or a word.

Subjects are shown a series of figures, including this "Roman-numeral 20".



Subjects are later asked, "Was this part of one of the previous figures?"

FIGURE 8: SUMMARY OF SLEE PROCEDURE.

We do not, however, wish to suggest that these various forms of mental representation are interchangable. Images, as one mode of representation, are a particular means of representing, of embodying an idea, and they employ a particular medium. The nature of imagery demands that some aspects of the idea be spelled out, while other aspects can be omitted. For example, to abuse the tiger example one last time, if one thinks about the tiger without imagery, one may or may not include in the thought whether the tiger is standing or sitting, whether it is facing to the left or to the right, and so on. If, however, one images a tiger, one must commit oneself on these aspects, but give no thought to whether the tiger is hungry, for example.

In other words, there are properties that images must have because they are mental representations -- they cannot be ambiguous, they cannot be indeterminate in certain regards. At the same time, there are properties that images have because they are images -- they must spell out position in a way that other representations may not, they spell out a viewing perspective, etc. It is this second set of properties, the ones that make images images, which is tapped by current imagery paradigms. And these are important properties: Since the image represents the tiger in a certain shape, one might be reminded of things sharing that shape. Since the image might leave out the fact that tigers are predators, one might not be reminded of other predators, and so on. Thus, if the same idea were embodied in a different representational guise, one is likely to fill in a somewhat different set of aspects, creating a different pattern of resemblances, and so a different pattern of evokations.

This obviously invites a flood of questions: What are these modes of representing? How many of them are there? How are they different or how are they alike? You will recognize these as just the issues at stake in the Kosslyn / Pylyshyn exchanges, and we believe they are precisely the right issues to be pursuing. Our view of imagery draws elements from both of the participants in these exchanges: With Pylyshyn, we are arguing that images are not only cognitively penetrable, they are cognitively penetrated. With Kosslyn, we are arguing that there are special properties which identify imagery. More, we share Kosslyn's view that the representational medium underlieing imagery is also the medium underlieing perception. That obviously fits both with our data and the many commonalities between images and percepts.

We have been focusing on the parallels between images and percepts with regard to resemblance and evokation, so it is worth circling back to the earlier discussion of ambiguity. We argued at length that images are totally unambiguous; we want to stress that the same is true for percepts. The percepts associated with the Necker cube are not indeterminate about depth, they specify one configuration or another. Likewise for the Rubin vase/face: If one perceives the vase, the perceived stimulus has a particular depth arrangement, the ground is "completed" so that it continues behind the figure, and so on. Hence the perceived vase has different properties from the face; it also evokes different memories (including a different label). Most important, subjects will deny ever having seen the face before if, on some prior occasion, the figure was organized as the vase. By any of these indices, the vase and face are simply two different percepts, each by itself unambiguous.

There clearly is ambiguity in the vase/face, but it is in the stimulus, not in the percepts derived from it. This in fact allows us to deal with an earlier loose end: When subjects in our early experiments imaged the duck/rabbit, they reliably failed to discover both interpretations of the form. But when subjects are perceiving the duck/rabbit, they routinely reinterpret the shape. This contrast, we believe, comes directly from the presence of a stimulus in perception, i.e. an input which is independent of our understanding of it. Hence it is possible to set our understanding aside and return to this "raw material," potentially allowing us to arrive at a different percept. Imagery lacks this equipotential stimulus, making images (in this regard) more rigid, more inflexible than percepts.

This draws us to an important concluding point. While we have emphasized the commonalities between images and percepts, we also need to note the important differences between imagery and perception. Perception begins with a stimulus, and is largely occupied with the understanding or identification of that stimulus. At the end of this process is the percept, a mental representation, and hence all that is entailed by being a mental representation. It is thus the products of imagery and perception which are similar, but the processes leading to each are clearly different. The image, quite unlike the percept, is not the result of some interpretive process, because, as we have argued throughout, there is nothing to be interpreted. Thus, images and percepts are parallel representations with, we believe, virtually non-overlapping histories.

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