Journal of Experimental Psychology:
Human Perception and Performance
1985, Vol. 11, No. 3, 317–328

0096-1523/85/$00.75

Can Mental Images Be Ambiguous?

Deborah Chambers and Daniel Reisberg
New School for Social Research

Although much recent research has emphasized the equivalence between imagery and perception, there are critical differences between these activities: Perception, initiated by an external stimulus, is to a large extent concerned with the interpretation of that stimulus. Images, in contrast, are created as symbols of something and hence need no interpretive process. Without a construal process, images do not allow reconstrual. In support of this argument, we ask whether subjects can reverse an ambiguous figure in mental imagery. In three experiments, no subject was ever able to reverse a mental image. In contrast, all of the subjects were able, immediately after this failure, to draw a picture from their mental image and then reconstrue the figure in their own drawing. This failure to reverse images occurs despite hints to the subject, some coaching, and a moderate amount of training in figural reversal.

A great deal of recent research has focused on the "equivalence" of mental imagery and of perception. In addition to the obvious phenomenal similarities between imaging and perceiving, these activities share a number of functional properties. When asked to scan across an image or rotate one or zoom in on one (to inspect detail) or zoom back from one (to make gross comparisons), subjects' response times are all as one would expect if subjects were inspecting an image that was in many ways picturelike, and, in particular, that preserved the metric properties of space. (For reviews of this large literature, see Kosslyn, 1980; Shepard & Cooper, 1983.)

In the same vein, the aftereffects of inspecting images seem comparable to those of inspecting visually present scenes. Finke and Schmidt (1977) obtained color aftereffects from inspection of images; Finke (1979) reported motor aftereffects from imaged "prism adaptation." If we attribute these effects to phenomena in the visual system (such as some sort of recalibration or fatigue), these demonstrations appear to be a strong argument that visual imagery draws on the same mental processes and structures as does visual perception.

This claim of shared mental resources is further strengthened by findings of interference between perceptual activity and imagination. In an extension of Perky's work (1910), Segal and Fusella (1970) showed that imaging interferes with the detection of near-threshold stimuli. Likewise, Brooks (1968) demonstrated that imaging interferes with visually guided responses but leaves verbal responses unimpaired, indicating that the act of imaging and the demands of visual perception draw on common mental structures.

Despite these (and other) demonstrations of commonality between imaging and perceiving, there is good reason to set bounds on this apparent functional equivalence. The Perky effect notwithstanding, we have in general little trouble distinguishing images and percepts phenomenally, a fact that suggests that there must be important differences between these activities. (See Kolers, 1983; Neisser, 1978; and, for an extensive phenomenological discussion of imagination, Casey, 1976.) In addition, visual images do not seem uniformly to respect laws of optical occlusion, so that "hidden" objects in an image seem to be part of the image. (For evidence that

This study emerged from discussions in a seminar on mental imagery that was made possible by a grant from the Exxon Foundation for the support of jointly taught graduate courses.

We want to thank the participants in that seminar, especially Jerome Bruner and Veronique Foti. Friderike Heuer, David Smith, Robert Melara, Carol Staszewski, and Peter Monk all made helpful comments on earlier drafts. We also thank Lynn Winters for her help in running Experiment 3, and Kriss Grisham for photographing the stimuli.

Requests for reprints should be sent to Daniel Reisberg, Department of Psychology, New School for Social Research, 65 Fifth Avenue, New York, New York 10003.

images can behave in this fashion, see Kerr & Neisser, 1983; Neisser & Kerr, 1973. For evidence that images do not always behave in this way, see Keenan, 1983; Keenan & Moore, 1979.) Finally, images are sometimes indeterminate on properties that cannot be unspecified in a visual stimulus, such as the exact number of stripes on an imaged striped tiger. (See Dennett, 1981a, 1981b.)

One important source of these differences between images and percepts lies in the way each of these comes into being. Perception, initiated by stimulation from an external object, is largely concerned with the interpretation of that object. Percepts are thus shaped and constrained by a stimulus; the perceiver might decide to reinterpret some ambiguous aspect of the stimulus but cannot will the stimulus to be other than it is.

Images, in contrast, are constructed as an image of some particular thing or scene. We do not mean to suggest that images are always deliberately constructed; obviously images can be evoked by external causes or can arise unbidden. The claim is that, whether or not an image was intentional in the ordinary sense of the term, it is intentional in the sense described by Brentano (1874/1973, p. 88): "Every mental phenomenon is characterized . . . by what we might call . . . reference to a content, direction toward an object. . . ." If a loud noise, for example, summons forth an image of someone falling, that image comes into being as an image of someone falling, not (to borrow an argument from Fodor, 1981) as an image of someone diving forward to grab something on the floor. Pictures of these two scenes might be indistinguishable, but the image is, for the imager, unmistakably one and not the other.

Kolers (1983) makes essentially the same point from a different perspective. Despite the misleading tendency in the literature to contrast *images* and *symbols*, images are symbolic. As such, images refer, not by some resemblance relation (which might be ambiguous), but by the conventions of the creator of the symbol, namely the imaginer. Therefore, the interpretation of the image is essentially transparent to the imaginer, who created the image to symbolize some particular thing.

These kinds of considerations led Fodor (1981) to argue that mental images are "images under description." There is no issue of "reading" or "interpreting" an image. The image is created as a symbol of some particular thing, and so the interpretation is there at the outset. As one consequence of this view, Fodor notes, one's image need not closely resemble what is being imagined: One's image of a tiger does not need to look much like a tiger; by the fact that the imager understands it as a tiger image, it is one. As another consequence, images, unlike the stimuli that give rise to perception, cannot be reinterpreted. Images can certainly be willed to be different, or can be replaced, but without a construal process, there is no possibility for reconstrual. Casey (1976), working within a very different philosophical tradition, shares this conclusion with Fodor: One regard in which images are *not* picturelike is that there is no such thing as an ambiguous image. "To imagine something differently is to imagine something different" (Casey, 1976, p. 159).

However, some observations suggest that these views may be overdrawn. First, these arguments seem odd in the face of imagery reports of fluid, changing images (including Casey's own in his phenomenological study). Second, in many of the mental rotation procedures, one must rotate an imagined stimulus in order to decide whether that stimulus is a letter or a mirror reversal of a letter (Shepard & Cooper, 1983). In these studies, one seems first to have the image and only later to discover how to construe that image, contrary to Fodor or to Casey. Slee (1980) also presented evidence that suggests subjects can reinterpret mental images, or, more precisely, can interpret images in a way that differs from that intended when the image was constructed. Employing a procedure developed by Reed (1974; also Reed & Johnson, 1975), Slee briefly presented subjects with a pattern that was perceived as two adjacent Roman numeral 10s, enclosing a diamond-shaped space. In a later cued-recall test, subjects with vivid mental imagery (assessed by Slee's Visual Elaboration Scale, or VES) were able to reconstruct the figure around either one of the Roman numeral 10s or a parallelogram (which was embedded, but not perceived, in the original figure). Reed's (1974) and Reed and Johnson's (1975) subjects were also able to do this and comparable tasks. Although error rates were quite high in their studies, their subjects were above chance performance in detecting the parts of imaged stimuli. (Judging from Slee's data, the high error rates presumably reflect the inclusion in these earlier procedures of subjects with low imagery vividness.) Apparently, then, subjects (with the aid of a cue) are able to reorganize their memory image of the initial stimulus. Finally, we suspect that many readers of this article can easily reverse a mental image of a Necker cube or another ambiguous figure, a likelihood that again suggests the possibility of reconstruing images. In all of these cases, contrary to Casey or Fodor, images appear to share with percepts a construal process and, in addition, a possibility for reconstrual.

There are a number of ways one might reconcile these findings and the claim that images lack a construal process (and hence the possibility of reconstrual). In most of these cases, the "new" construal of an image involves the discovery of a familiar form—a letter, a previously cued shape, or the familiar view of the alternative perspective on a Necker cube. Thus, it is possible that the imager has simply *replaced* one image with another, has (in Casey's words) imagined something different rather than imagined something differently. This distinction does have an empirical consequence: In order to replace an image, one must know either with what to replace it or how specifically to alter the current image. Thus, the critical test of whether images can be reconstrued hinges on whether subjects can *discover* an unanticipated, uncued shape in an image. To find out if this is possible, subjects in the present experiments were asked to imagine an ambiguous figure (the duck/rabbit) and then asked to inspect their image for an interpretation of the figure other than that they had initially seen. We ask whether subjects can discover the alternative construal by inspecting the image, that is, whether the *first* reversal of this figure occurs while they are inspecting the image.

We chose the duck/rabbit (Figure 1A) for our test stimulus for three reasons. First, we expected that this simple outline drawing would be quite easy to image. In this way, any failures to reverse the figure could not be attributed to difficulties in creating or maintaining the mental image. (This expectation appears to have been correct: Our subjects, informally polled, indicated that they had no difficulty in forming an image of the figure.) Second, this figure seems less well known than some other ambiguous figures, making it easier, we hoped, to find subjects who were attempting to reverse it for the first time. (Note that our subjects do not need to be completely naive to ambiguous figures but only to the test figure.) Third, in order to maximize our chances of observing figural reversals, we wanted our instructions to be as explicit as possible. In particular, we wanted to acquaint subjects with an exemplar that would ensure that they understood exactly what was requested of them. There is such a parallel exemplar for the duck/rabbit, namely the chef/dog figure (Figure 1B). Both figures are simple line-drawings, both depend on orientation, and both are heavily influenced by the subjects' visual fixation. The procedure exploits these similarities to instruct subjects and thus to facilitate reconstruals of the mental image.

The logic of our procedure requires that subjects do not reconstrue the figure during the initial exposure of the stimulus, so that reversals of the imaged stimulus (if they occur) will be first reversals for that figure. With this in mind, we presented the stimulus to subjects for a brief (5 s) exposure. Pilot data indicated that this was ample time to encode these simple figures yet not enough time for naive subjects to find the reconstrual.[1] Subjects' performance in the reported experiments confirms both of these claims.

Experiment 1

Method

Subjects. Fifteen subjects were recruited from various universities in the New York area. Psychology students were excluded from the subject pool (for this and all of the procedures reported), because we feared they would be familiar with our test stimuli. None of the subjects we used indicated that they had seen ambiguous figures

[1] This is, of course, consistent with much evidence in the ambiguous figures literature. Although reversals subsequent to the first happen quickly, the first reorganization often requires more than 5 s. See, among others, Girgus, Rock, and Egatz, 1977; Reisberg and O'Shaughnessy, 1984.

before, nor did any, in our training or instruction, give any indication that they were familiar with the figures.

Stimuli and materials. Slee's Visual Elaboration Scale (VES; Slee, 1980) was employed to assess subjects' imagery vividness. Instructions for this scale urge subjects to think about certain objects (e.g., an animal skin hanging on a wall); subjects are then probed to determine how much they had spontaneously elaborated the image ("Was the skin a particular distance off the floor, or hadn't you thought about that?"). Subjects received one point for each of the elaborations they included; scores on the VES ranged from 0 to 16.

Subjects saw both test and training stimuli in this (and the subsequent) procedures; the training stimuli were designed to acquaint subjects with figural reversal. All stimuli were drawn in black on white paper, then photographed. During the procedure, subjects used a hand-held slide viewer to see the stimuli, all of which were on 1″ × 1″ transparencies. In the first experiment, our ambiguous test figure was the duck/rabbit; our training figures were the chef/dog, the Necker cube, Mach's "book," and the vase/face.

Procedure. All subjects were run individually. The procedure consisted of six steps. First, the VES was administered. Second, subjects were shown the Necker cube, the Mach book, and the vase/face slides to acquaint them with ambiguous figures and to ensure that each subject was able to reverse these test figures. In both the practice and the test trials, the subjects were instructed to announce when they had discovered the alternate view of the figure; they were then required to describe both construals to ensure that the reversal had in fact occurred. Third, subjects were shown the duck/rabbit slide, our test stimulus, for 5 s and were explicitly instructed to form a "mental picture" of this slide so that they would be able to draw it later. Although the slide was presented for only 5 s, subjects were given as much time as they needed to complete their mental picture. Fourth, subjects were shown the chef/dog figure, which, like our test stimulus, depends for its interpretations on orientation. Subjects were explicitly given the hint that shifting their visual fixation from the lower left corner of the figure to the upper right corner might help them to find the alternative construal. We hoped that the presentation of this figure, together with our hint, would instruct subjects in how best to look for a new construal of the duck/rabbit image.

Fifth, after the subjects had successfully found both construals of the chef/dog figure (all did), they were asked to inspect their image of the previous slide (duck/rabbit). Subjects were given as much time as they needed to form the image; all subjects reported having the image in a few seconds. The subjects had all seen either the duck or the rabbit initially; they were now asked to identify the alternate view. To aid subjects in reconstruing the image, they were given a standardized series of prompts. They were first asked if they had a "clear mental picture of the previous slide," then whether they could find an alternative interpretation "in the same way that [they] did for the chef/dog." If subjects still could not reverse the figure, they were again asked whether they "still had a clear picture of the figure" and were urged to look at the "east corner of the figure." When the subjects had shifted their mental fixations, they were asked what the figure "most resembled"; this was then repeated with the "west" corner. (These are in fact the fixations that facilitate reinterpretation with a perceptually given stimulus.) This entire series of prompts was repeated three times for each subject so that the entire imagery portion of the experiment took approximately 3 to 4 min.

Finally, in the last step of the procedure, subjects were asked to draw a picture of the imaged stimulus and to inspect their drawing until they found the alternate

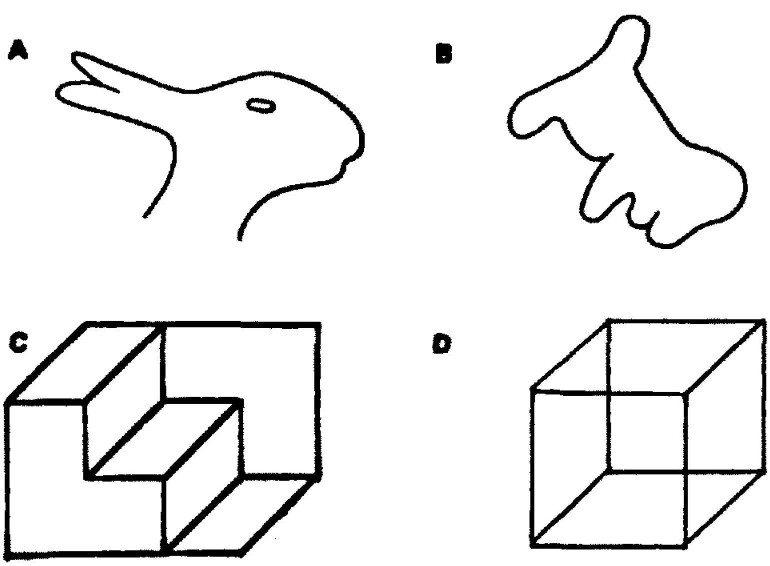

Figure 1. Stimulus A was our test stimulus for Experiments 1 and 2; Stimulus B was used to acquaint subjects with reversal; Stimuli C and D were used as test stimuli in Experiment 4.

construal. If they did not spontaneously report both construals, they were coached in the same fashion as they had been with the mental image.

Results

The results are summarized in Table 1. Our subjects spanned a range of imagery vividness, with a mean VES score of 8.23 (*SD* = 2.87) and a range from 2 to 13.

Despite the inclusion of several "high vividness" imagers, none of the 15 subjects tested was able to reconstrue the imaged stimulus, despite the familiarization with ambiguous figures in general and the chef/dog in particular and despite our hint about fixation. In sharp contrast, all 15 of the subjects were able to find the alternate construal in their own drawings. This makes clear that subjects did have an adequate memory of the duck/rabbit figure and that they understood our reconstrual task.

Although we did not time subjects in drawing, all subjects drew the figure immediately and fluidly. That is, subjects did not construct their drawings in a piece-meal fashion but typically drew the outline without lifting their pencil from the paper.

It is at least possible that subjects' memory images were biased by their original interpretation of the figure, making reconstrual of the image much more difficult. We know from Bartlett (1932) and Carmichael, Hogan, and Walters (1932) that these biasing effects are quite strong: Images are distorted in a way that makes them more consistent with our construals of them. To rule out the possibility that this accounts for our negative result, Experiment 2 is designed to minimize this possible memory distortion and hence to maximize our chances of detecting an ambiguous image.

Table 1
Summary of Results

Experiment and test stimulus	*N*	Number of reversals: From image	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

Experiment 2

The second experiment is identical to the first except for one important change in the instructions. Prior to the presentation of the duck/rabbit figure, Bartlett's experimental results (and accompanying figures) showing memory distortions of images were explained to subjects. Subjects were explicitly asked to avoid these types of errors when encoding their image and were instructed to create an "unbiased" literal copy of the slide. (Given the power of memory distortion, this manipulation may not be completely effective. However, the third experiment will provide a means of assessing the fidelity of our subjects' memories.)

Method

Subjects. Ten new subjects were recruited from a community college in New Jersey. As before, psychology students were excluded; all subjects indicated that they had never seen the ambiguous figures. None gave any indication during the procedure of familiarity with the figures.

Procedure. With the exception of the instructions, the procedure was identical to that of the first experiment. Before subjects were shown the duck/rabbit slide (and after they had seen the practice ambiguous figures), subjects were told that people have a strong tendency to remember biased versions of these figures and were shown drawn examples (the famous eyeglass/barbell figure) of how these bias effects are manifested. Subjects were encouraged to remember the slide exactly as it appeared so that they would later be able to draw a literal copy.

Results

Our subjects' VES scores ranged from 1 to 15, with a mean of 8.87 (*SD* = 2.92).

None of the 10 subjects was able to find more than one construal of their image; all of the 10 subjects were able to find the alternate construal, a few moments later, in their own drawing. As in the first experiment, all subjects drew the figure fluidly and quickly.

Experiment 3

Were our instructions to subjects to form an unbiased, literal picture of the stimulus successful? One way to ask this is by asking whether subjects' drawings of the figure were in fact ambiguous, that is, could support both construals. In the third experiment, we take the drawings produced by our Experiment 2 subjects, show them to a new group of subjects, and ask them to find both construals of the figure.

Method

Subjects. Thirty subjects were recruited for this experiment; as before, the subjects were all naive to the test figures.

Stimuli and procedure. The practice stimuli in this procedure were the same as those used earlier; our test stimuli were the drawings produced by the Experiment 2 subjects. The procedure is identical to that of Experiments 1 and 2 except for four changes—we omit the VES and the procedural step in which subjects were first asked to encode the image; we substitute the drawing in place of an image of the duck/rabbit; and we omit the requirement to draw the figure. As before, subjects were shown the practice figures: the Necker cube, the vase/face, the Mach book and the chef/dog. Each subject was then shown a drawing produced by one of the Experiment 2 subjects. Because each subject in the current procedure saw only one of these drawings, our 30 subjects allowed us to show each drawing to 3 new subjects. If subjects did not spontaneously note both construals of the drawing, they were coached in the same way as the earlier subjects, and, in particular, were instructed to try fixating different corners of the figure. As before, once subjects announced the discovery of both construals, they were required to describe both views of the figure.

Results

The results indicate that our earlier subjects did encode a reasonably unbiased version of the stimulus, as the majority of their drawings supported both construals for new viewers. Four of the drawings are shown in Figure 2. (We include the three "best" drawings and the "worst," as judged by both the authors and as reflected in the Experiment 3 results.) Of the 10 drawings, 8 were reversed by at least one subject, 6 by at least 2 subjects, and 5 by all 3 of the subjects who viewed them. In this procedure, we accepted responses of *bird* or *chicken* as equivalent to *duck.* We also accepted *goat* and *giraffe* as substitutes for *rabbit,* because subjects were able to identify the animals' ears, nose, eye, and neck—all features shared with the rabbit construal. (These alternate labels were used by only 2 of the 30 subjects; the modal response was, as expected, *rabbit.*) We did not, by this logic, accept the *whale* or *foot* responses, each offered by 1 subject.

It should be noted that these data, although instructive, necessarily provide a weak test of whether the information in our subjects' *image* was an unbiased rendition of the test stimulus. Even though 8 subjects succeeded in creating ambiguous drawings, we have no guarantee that these drawings were "from their image."[2] Nonetheless, the third experiment provides an additional line of argument for two critical claims, first, that subjects in Experiment 2 adequately encoded the test figures, and, second, that they did, in fact, discover the alternative construal in their own drawings.

Experiment 4

Although the results so far seem to argue that images are not subject to reconstrual, one might challenge this conclusion on any of three grounds. First, it is conceivable that our population of subjects does not include an adequate number of "vivid imagers." This is, of course, tantamount to denying the validity of the VES assessment. This criticism seems unlikely, because our subjects included several artists and architects, members of professions likely to select systematically people with rich mental imagery. Nonetheless, the final procedure addresses this possible problem.

Second, our results may be peculiar to the use of the duck/rabbit figure, which may simply be difficult to reconstrue. Third, it is conceivable that we have not given subjects sufficient familiarization with figural reversal, again making it overly difficult to reconstrue the test stimulus. The last experiment answers these possible criticisms.

[2] There are many reasons why the other 2 subjects might have produced a drawing that is ambiguous for the drawer but unambiguous for some other observer. A drawer might realize, for example, that parts of the figure were drawn with less confidence, or with a different scale, and might compensate for this in inspecting his/her own drawing; a new observer would have no way of making this compensation. Alternatively, what is an adequate representation for one person may not be adequate for another, so that a drawing that "works" for its creator might be insufficient for another person. This is certainly consistent with the fact that some of the drawings were ambiguous for only some of the subjects in Experiment 3. Whether these speculations or some others turn out to be correct, however, is not relevant to our overall argument.

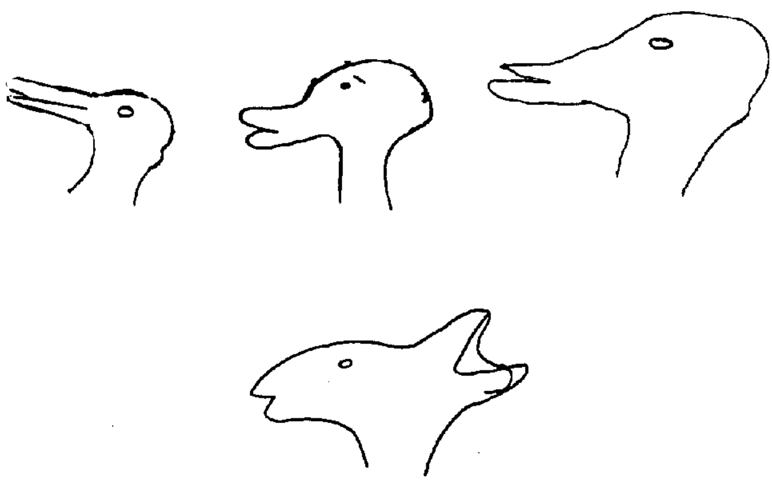

Figure 2. Four of the drawings produced by subjects in Experiment 2. (All of these drawings except the one on the bottom were ambiguous for all of the subjects who viewed them in Experiment 3.)

Method

Subjects. Ten new subjects were recruited from various New York area campuses; again, none was a psychology student and all were naive to ambiguous figures.

Stimuli and materials. In addition to the materials already described, the fourth experiment employed an additional imagery vividness measure, the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1972).

All stimuli were presented as before, via the hand-held slide viewer. We employ three test figures: the duck/rabbit from the first two experiments, a slide of the Necker cube, and a slide of the Schroder staircase. In addition, we employed 10 additional training figures, all line drawings of geometrically reversible figures.

Procedure. The procedure followed that for Experiment 2, including the instruction about forming literal images, with the following changes. Subjects were asked to inspect, image, and then draw each of our three test figures in turn. (The order of presentation for the test figures was randomly varied.) In each case, the inspection period (as before) was 5 s; subjects were encouraged to find the alternate construal of their image and, failing that, were asked to draw the figure and find the alternate construal of their drawing. As in the first two procedures, subjects announced when they had discovered the second construal and were then required to describe both views.

Results

The mean VES score was 8.83 (SD = 2.96); the scores ranged from 1 to 15. The mean VVIQ score was 33.3 (SD = 18.95), with a range of 20–70. These two imagery measures were correlated significantly ($r = -.86$, $p < .01$). (The negative correlation is due to the way the VVIQ is scored—"high" imagery on this test yields a low score.) There is thus no basis in our data for arguing that we have an inadequate sample of vivid imagers. There is likewise no basis for distrusting the VES scores; this argues that our earlier procedures also had an adequate group of vivid imagers.

Once again, none of the 10 subjects reported a reconstrual of an image, despite the presence of three opportunities for each subject. All subjects were able to draw and then reconstrue both the duck/rabbit and the Necker cube stimuli. Six of our 10 subjects were able to draw and then reconstrue the Schroder staircase. The other 4 subjects had difficulty in drawing the staircase and reported that their drawing did not accurately represent their image of this figure. The results are summarized in Table 1.

General Discussion

According to our results, images are not ambiguous. None of our 35 subjects reported a single reversal on any of the test trials. Our subject population contained many with vivid imagery (by the standardized self-report measures), including both artists and architects, so that there is no basis for claiming that our subjects were weak in imagery skills. Most impressive, our subjects were uniformly able to create an ambiguous picture from an unambiguous image, a finding that emphasizes the difference between images and percepts.

Could our negative results be due to some procedural insensitivity? One might claim that subjects had failed to encode the test stimuli adequately or had not adequately understood what a figural reversal was. These possibilities are, of course, ruled out by subjects' success in reversing their own drawing. Alternatively, it is possible that reversals from images are difficult simply because one cannot perceptually explore the figure, cannot shift one's gaze. However, the same is true for the afterimages of briefly flashed, brightly lit stimuli, and we know that such afterimages of ambiguous figures reverse quite readily (Magnussen, 1970; Piggins, 1979). Third, one might argue that our subjects were able to image our stimuli only part by part, so that, without opportunity to confront the entire figure, subjects were blocked from reversing the figure. This seems unlikely, given both the simplicity of the figures and subjects' informal self-reports (which, for our high-imagery subjects, indicated the presence of a complete and vivid image). Moreover, it is not obvious that one needs to see an entire figure to discover a reconstrual. Hochberg (1970) showed subjects ambiguous figures moving behind a narrow slit, so that only a narrow strip of the figure was visible at any given time. Subjects were still able to reverse the figures under these viewing circumstances.

Some early readers of this manuscript have suggested that the demand characteristics of our procedure blocked subjects from reporting a figural reconstrual. This claim seems dubious. For one thing, our subjects showed signs of considerable frustration when unable to discover the alternative view of the image, particularly since they had easily reversed the practice figures a few moments earlier. The subjects also expressed puzzlement at their failure when they subsequently quickly reversed their own drawings. This seems not at all like subjects who, because of experimenter demand, are initimidated into denying the figural reversal. Furthermore, all overt aspects of the procedure—our instructions to report the alternative view as soon as it was discovered and our coaching and hints about fixation—communicated to the subject that a reversal of the imaged stimulus was, in fact, possible. (Indeed, it was our expectation, prior to seeing our own results, that such reversals were possible!) Likewise, it is difficult to conceive of experimenter demand strong enough to have produced our entirely univocal results: One would expect at least 1 recalcitrant subject to resist this pressure.

Finally, one might argue that our subjects simply were not forming mental images but were instead thinking of some verbal or propositional code. In the extreme, a subject muttering "duck, duck" is unlikely to have the label *rabbit* come to mind. By the same token, one could argue that subjects were creating their drawings from some memory representation other than a mental image. A number of considerations, however, argue against this view. For one, our instructions for both the main task and for the VVIQ explicitly and repeatedly mention the creation of a mental picture. Likewise, our hints to subjects to try moving their "mental gaze" across the figure or to look at a particular corner presume a spatially laid-out representation of some sort; subjects indicated no confusion about this instruction. It is unclear how this instruction (or, for that matter, our request to find a reconstrual) could be understood without reference to a mental image. Finally, aspects of subjects' behavior all seem to indicate the use of mental imagery: Subjects would often close their eyes during the test or shift their gaze to some blank surface. Subjects also used the kinds of "visual language" that one associates with imagery, talking about "looking at" or "seeing" the figure or what a portion of the figure "looks like." In short, there seems to be no basis for arguing that our subjects failed to generate mental images in this procedure.

There is, of course, a word of caution needed here. For obvious reasons, there is no way to assess directly what information subjects' images do or do not contain or whether the images provide an accurate facsimile of the test stimuli. As we noted earlier, although subjects' drawings are ambiguous, we have no guarantee that these drawings come "from imagery." Likewise, although we have provided a series of converging indications that subjects were imaging, there is no way to verify that subjects did indeed have a visual form in mind. In the same vein, subjects' self-reports of a vivid, complete image may be inaccurate. In short, we are confronted by what may be an intractable methodological problem: There is no way to prove that subjects do have an image and that their image "has a particular shape." These problems are not unique to this study but pervade the mental imagery literature (and beyond). The best we can provide is a pattern of converging argument for our claims about these phenomena, and that is what we have done here.

If we thus set aside these alternative accounts of our data, the results strongly support the arguments offered by Casey, Kolers, and Fodor that images cannot be reconstrued because images are not construed. Images are not quasi-pictorial in the sense of needing some interpretation. Instead, an image's referent is specified by the imaginer. Thus although an image might in some fashion resemble more than one content (e.g., a duck or a rabbit, someone falling or someone diving forward), this does not result in ambiguity because it is not by resemblance that images refer.

These results also support our earlier claims about tasks like Slee's or Reed's. Our argument here is simply that these tasks can be performed without reconstrual. Thus although one could describe these tasks in terms of reinterpreting images, there is nothing to compel us to adopt such an account. Given this, given the philosophical arguments against construal, and given our results, these earlier tasks cannot constitute evidence that images can be reconstrued.

How might one perform the imagery embedded-figures task without reconstrual, for example, how might one decide whether an imaged parallelogram could be embedded in a Roman numeral 20? All one needs to do, first, is replace one image with another (i.e., replace the imaged parallelogram with one that simply adds or deletes specific parts). By a succession of such replacements, one may come across a form isomorphic to the target figure. Second, one must be able to recognize this isomorphism between the imagined figure and the target. The imaginer understands the imagined parallelogram with added line segments as being just that, and not a Roman numeral 20, and hence no reconstrual has occurred. At the same time the imaginer can detect that these two distinct figures have a common form. Finally, once this isomorphism is discovered, subjects should be able at will to exchange the two images, the embellished parallelogram and the Roman numeral, and may in this way confirm the correspondences.[3]

Contrast this with the present procedure. Our subjects could have in principle detected the isomorphism between imaged duck and imaged rabbit, but this detection presumes both representations are already available for comparison. Hence sensitivity to this isomorphism is of no use in discovering the alternate interpretation of the image. Likewise our subjects could have freely replaced their duck image, perhaps with a rotated duck or an embellished duck, but these replacements are all still imaged ducks and are no more isomorphic to the rabbit than was the original figure. Hence the process we are describing for the imagery embedded-figures task will not succeed in a task like ours.

That a judgment of isomorphism is possible in imagery is itself interesting and leads us to an important point. Intending to image some X does not imply that one knows what the image will look like. In our study, subjects created an image to be an image of a duck (or of a rabbit) but may have been surprised by the size of the image, the color of the background, and so forth. These and other particulars of the image may be determined by the relative ease of imagining one version or another of the imagined object, certain conventions arising from experience, the specifics of some canonical representation (cf. Kennedy, 1983), or, significantly, properties of the imagery medium, and so on. In short,

---

[3] Two things should be noted about this account. First, it is by no means unique to pictorial stimuli. If one imagines hearing the phrase "the right wright," one is fully aware that it is this phrase (and not some homophonous one) being imagined. This knowledge of propositional content, however, does not preclude detecting the homophone.

Second, one can easily find variants of our account of the embedded-figures task. For example, rather than imagining a succession of embellished parallelograms, one might imagine just one corner of the shape and then consider the target figure, seeking an isomorphic corner. We have no stake in specifying which variant is correct. What is critical is merely that one does not need reconstrual for this task. Because of this, subjects succeed in the embedded-figures task but fail in ours.

the fact that an image is created as a symbol of some particular thing (and hence requires no construal) does not imply that all of the particulars of an image are anticipated. Beyond these unanticipated particulars, one can also be surprised by relations inside of an image. One might decide to imagine one object next to another yet still be surprised by aspects of the juxtaposition.

In all of these ways, one can image without knowing in advance what an image will look like. Thus, even though one does not need to inspect an image to learn what the image represents, one does need to inspect the image to learn how it appears. This plays an important role in our account of Slee's or Reed's data. It is also consistent with the informal observation that one is often surprised by one's images (see also the numerous anecdotal reports of problem solutions prompted by a mental image). Some experimental evidence makes the same general point: Finke and Kosslyn (1980), in a study of imagery "two-point acuity," reported that subjects can apparently learn from inspecting an image whether two points can or cannot be seen as separate at a given retinal eccentricity. Pinker and Finke (1980) reported that subjects can discover "emergent two-dimensional patterns" in imaged three-dimensional configurations. These observations are in no way inconsistent with the view we have been developing in this article, for the reasons just discussed.

Finally, the present results begin to set limits on just what are the "functional equivalences" of images and percepts (after Finke, 1980). Beyond this, however, our results bear on how the question about equivalence should be cast. Images might be seen as entering the stream of visual information processing events, and so images and percepts have a common final path. On this view, images and percepts would share properties arising subsequent to this entry but would not share properties arising earlier in the processing sequence. Additionally, not all of the information in images needs to activate visual mechanisms but might be carried along in parallel with the processing mechanisms of perception. (Cf. Finke, 1980, pp. 130–131.) We believe that this view (at least in the simple version just described) is not consistent with the present results. On the one hand, one might try to argue that reconstrual of ambiguous figures occurs early in the stream of visual processing (prior to the entry of images) and hence is a property of perception but not imagination. Such a claim seems implausible in light of current "cognitive" views of figural reversal. (See Girgus, Rock, & Egatz, 1977; Hochberg, 1970; Reisberg, 1983; Reisberg & O'Shaughnessy, 1984; Rock, 1983; and others.) On the other hand, one could claim that the mechanisms for interpreting a visual stimulus are among those not activated by imagery. In this way, the understanding or interpretation of an image is one of the properties maintained apart from the sequence of visual processing. The defect in this suggestion is that this sequence of visual processing is, presumably, largely concerned with just such problems as figural construal. If images do not enter this interpretive process, it is difficult to characterize what common final path for images and percepts this leaves.

Our results can thus be taken as arguing against the claim that imagery and perception share a common processing path. This argument is all the more pressing given the questions recently raised about the empirical base of the common path claim. (See Broerse & Crassini, 1980, 1981; Harris, 1982; Intons-Peterson & White, 1981; Kolers, 1983; Kunen & May, 1981; Neisser, 1978). Nonetheless, the fact remains that, as we noted at the outset of this article, there is considerable commonality between perceiving and imagining. An alternative account of this commonality, one consistent with our data, is readily available. As Neisser (1978) notes, a popular view of perceiving treats it as a kind of information processing and emphasizes a sequence of "bottom-up" events. This conception is implicit in the common processing path claim; these bottom-up processes are (to some extent) shared by imagery and perceiving (cf. Kolers, 1983). In contrast, consider conceptions of perception emphasizing "top-down" or "cyclic" processes (e.g., Gregory, 1970; Hochberg, 1970; Neisser, 1976; Rock, 1983). These conceptions, all of which involve an "interpretive," "constructive," or "anticipatory" aspect of perception, provide an obvious basis for the properties shared by imaging and perceiving. Imaging is, or at least draws heavily on, the top-down or anticipatory aspects of perceiving. Neisser (1978) has explicitly described one way this view might be developed: Perception, on Neisser's view, involves a "cyclic interaction" with the world, a critical part of which is "anticipation." Imagination is simply this anticipation in the absence of the stimulus. In short, to image is to get ready to see.

A closely related view can be derived from the work of Rock (1983), who has argued that form perception is a process of achieving a "non-verbal description" of the stimulus, a description that includes specification of what is figure, what ground, that defines the proper orientation of the figure, and that identifies axes of symmetry. The description also specifies the depth arrangement of the figure, so that two-dimensional drawings are assigned a three-dimensional interpretation. Thus for Rock, percepts are in no sense "copies" or mere transcriptions of the input; they are, at the least, interpreted representations or labeled copies. This notion of percept-as-description obviously resembles our claim that images are, to use Fodor's (1981) language, "images under description." Given Rock's description of the deliberative, intelligent, thoughtlike nature of this process, it would not be surprising if the process could be initiated by the imaginer, and not only by the presence of some stimulus. Hence, our suggestion, following Neisser's lead, is that this description, occurring in the absence of stimulus information, is what we call a mental image.

Thus imagery and perception will not share a number of aspects, including those associated with bottom-up processes or those resulting from the interaction of top-down and bottom-up events. (Construal, the process of finding what a stimulus is, presumably is one such interactive process.) At the same time, imagining will share at least some of the top-down processes and will reflect the properties of those processes. This provides a ready means of accounting for the phenomenal similarity between images and percepts. It is also easy to see how the activity of imaging can both interfere with perceiving (Segal & Fusella, 1970) or, under different circumstances, pave the way for perceiving (Posner, 1978). This view is also consistent with findings that imagery and perception seem to share a mode of representation, a mode that respects the metric properties of space. Finally, images should resemble percepts in how they interact with higher mental processes. If we adopt Rock's view of percepts as descriptions, then both images and percepts carry with them a retrieval set, so to speak, that governs how they interact with memory. Our imagery results, in fact, echo some of Rock's perceptual data concerning orientation or figure/ground organization. How a stimulus is internally described governs what prior figures are evoked from memory. Thus a familiar shape (e.g., an outline drawing of Africa) will not be recognized if it is assigned a "top" other than the northern edge (Rock, 1973, 1983). This obviously parallels our findings in which subjects, having assigned one interpretation, fail to discover (or evoke) a second.

This view of imagery forces on us a question that we earlier set aside. Regardless of the "language" of this internal representation—analog or proposition, "description" or "anticipation" (Kosslyn, 1981; Pylyshyn, 1981; Kolers, 1983)—we need to ask what is *included* in this representation. As already noted, Rock (1983) argues for some of the aspects that must be included in percepts—specification of figure and ground, orientation, depth relations; surely these same minimal aspects must be included in images as well. The more difficult problem lies in asking what else is included, and, additionally, whether the specification of images is equivalent in form to that of percepts. These are clearly problems for further work, both on empirical and philosophical fronts.

References

Bartlett, F. (1932). *Remembering: A study in experimental and social psychology.* Cambridge: Cambridge University Press.

Brentano, F. (1973). *Psychology from an empirical standpoint* (A. Rancurello, B. Terrell, & L. McAlister, Trans.). London: Routledge & Kegan Paul. (Original work published 1874)

Broerse, J., & Crassini, B. (1980). The influence of imagery ability on color aftereffects produced by physically present and imagined induction stimuli. *Perception & Psychophysics, 28,* 560–568.

Broerse, J., & Crassini, B. (1981). Misinterpretations of imagery-induced McCollough effects: A reply to Finke. *Perception & Psychophysics, 30,* 96–98.

Brooks, L. (1968). Spatial and verbal components of the act of recall. *Canadian Journal of Psychology, 22,* 349–368.

Carmichael, L., Hogan, H., & Walters, A. (1932). An experimental study of the effect of language on the reproduction of visually perceived form. *Journal of Experimental Psychology, 15,* 73–86.

Casey, E. (1976). *Imagining: A phenomenological study.* Bloomington, IN: Indiana University Press.

Dennett, D. (1981a). The nature of images and the introspective trap. In N. Block (Ed.), *Imagery* (pp. 51–61). Cambridge, MA: MIT Press.

Dennett, D. (1981b). Two approaches to mental images. In N. Block (Ed.), *Imagery* (pp. 87–107). Cambridge, MA: MIT Press.

Finke, R. (1979). The functional equivalence of mental images and errors of movement. *Cognitive Psychology, 11,* 235–264.

Finke, R. (1980). Levels of equivalence in imagery and perception. *Psychological Review, 87,* 113–132.

Finke, R., & Kosslyn, S. (1980). Mental imagery acuity in the peripheral visual field. *Journal of Experimental Psychology: Human Perception and Performance, 6,* 126–139.

Finke, R., & Schmidt, M. (1977). Orientation specific color aftereffects following imagination. *Journal of Experimental Psychology: Human Perception and Performance, 3,* 599–606.

Fodor, J. (1981). Imagistic representation. In N. Block (Ed.), *Imagery* (pp. 63–86). Cambridge, MA: MIT Press.

Girgus, J., Rock, I., & Egatz, R. (1977). The effect of knowledge of reversibility on the reversibility of ambiguous figures. *Perception & Psychophysics, 22,* 550–556.

Gregory, R. (1970). *The intelligent eye.* London: Weidenfeld and Nicholson.

Harris, J. (1982). The VVIQ and imagery-produced McCollough effects: An alternative analysis. *Perception & Psychophysics, 32,* 290–292.

Hochberg, J. (1970). Attention, organization and consciousness. In D. Mostofsky (Ed.), *Attention: Contemporary theory and analysis* (pp. 99–124). NY: Appleton-Century-Crofts.

Intons-Peterson, M., & White, A. (1981). Experimenter naivete and imaginal judgments. *Journal of Experimental Psychology: Human Perception and Performance, 7,* 833:843.

Keenan, J. (1983). Qualifications and clarifications of images of concealed objects. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9,* 222–230.

Keenan, J., & Moore, R. (1979). Memory of images of concealed objects: A reexamination of Neisser and Kerr. *Journal of Experimental Psychology: Human Learning and Memory, 5,* 374–385.

Kennedy, J. (1983). What can we learn about pictures from the blind? *American Scientist, 71,* 19–26.

Kerr, N., & Neisser, U. (1983). Mental images of concealed objects: New evidence. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9,* 212–221.

Kolers, P. (1983). Perception and representation. *Annual Review of Psychology, 34,* 129–166.

Kosslyn, S. (1980). *Image and mind.* Cambridge, MA: Harvard University Press.

Kosslyn, S. (1981). The medium and the message in mental imagery: A theory. In N. Block (Ed.), *Imagery* (pp. 207–244). Cambridge, MA: MIT Press.

Kunen, S., & May, J. (1981). Imagery-induced McCollough effects: Real or imagined? *Perception & Psychophysics, 30,* 99–100.

Magnussen, S. (1970). Reversibility of perspective in normal and stabilized viewing. *Scandinavian Journal of Psychology, 11,* 153–156.

Marks, D. (1972). Individual differences in the vividness of visual imagery and their effect on function. In P. Sheehan (Ed.), *The function and nature of imagery* (pp. 83–108). NY: Academic Press.

Neisser, U. (1976). *Cognition and reality.* San Francisco: Freeman.

Neisser, U. (1978). Perceiving, anticipating and imagining. In W. Savage (Ed.), *Perception and cognition: Issues in the foundations of psychology* (pp. 89–105) Minneapolis: University of Minnesota Press.

Neisser, U., & Kerr, N. (1973). Spatial and mnemonic properties of visual imagery. *Cognitive Psychology, 5,* 138–150.

Perky, C. (1910). An experimental study of imagination. *American Journal of Psychology, 21,* 422–452.

Piggins, D. (1979). The influence of line reduction and image-stabilization on Necker cube reversal. *Perception, 8,* 719–720.

Pinker, S., & Finke, R. (1980). Emergent two-dimensional patterns in images rotated in depth. *Journal of Experimental Psychology: Human Perception and Performance, 6,* 244–264.

Posner, M. (1978). *Chronometric explorations of mind.* Hillsdale, NJ: Erlbaum.

Pylyshyn, Z. (1981). The imagery debate: Analog media versus tacit knowledge. In N. Block (Ed.), *Imagery* (pp. 151–206). Cambridge, MA: MIT Press.

Reed, S. (1974). Structural descriptions and the limitations of visual images. *Memory & Cognition, 2,* 329–336.

Reed, S., & Johnson, J. (1975). Detection of parts in patterns and images. *Memory & Cognition, 3,* 569–575.

Reisberg, D. (1983). General mental resources and perceptual judgments. *Journal of Experimental Psychology: Human Perception and Performance, 9,* 966–979.

Reisberg, D., & O'Shaughnessy, M. (1984). Diverting subjects' concentration slows figural reversals. *Perception, 13,* 461–468.

Rock, I. (1973). *Orientation and form.* New York: Academic Press.

Rock, I. (1983). *The logic of perception.* Cambridge, MA: MIT Press.

Segal, S., & Fusella, V. (1970). Influence of imaged pictures and sounds on detection of visual and auditory signals. *Journal of Experimental Psychology, 83,* 458–464.

Shepard, R., & Cooper, L. (1983). *Mental images and their transformations.* Cambridge, MA: MIT Press.

Slee, J. (1980). Individual differences in visual imagery ability and the retrieval of visual appearances. *Journal of Mental Imagery, 4,* 93–113.

Received March 20, 1984
Revision received December 19, 1984 ■