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## Static Versus Dynamic Imagery

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The distinction between static and dynamic imagery is familiar to us all at the commonsense level in so far as we are able to imagine not only stationary objects but also action scenes in which objects are in motion or in the process of being rotated or otherwise transformed. This chapter examines the distinction and its implications at several levels. First, we review the general contrast between static and dynamic representations and processes, including imagery. Then we consider individual differences, including sex differences, on that dimension. Finally, we discuss possible mechanisms and causal factors that could explain the phenomena associated with the distinction.

### 7.1 Static versus Dynamic Processes

The static-dynamic imagery distinction is a special case of a more general distinction that has been drawn by many theorists without necessarily referring to imagery. Table 7.1 lists some of the variants of the general distinction. We elaborate briefly on each of these without trying to evaluate the different proposals in terms of their theoretical usefulness or validity.

William James (1890) expressed the distinction in terms of the substantive part as compared to the transitive part of the stream of thought. He illustrated the distinction metaphorically as an alternation of perchings and flights in a bird's life. He viewed the perchings as places in the stream of thought that are usually occupied by sensorial imaginations of some sort whereas the flights are filled

with thoughts of static or dynamic relations that move us to another substantive thought.

Table 7.1. Variants of the Static-Dynamic Process Distinction

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W. James:	substantive and transitive parts of thought
K. Lewin:	regions and goals vs locomotion in life space
Tolman:	S <sub>1</sub> R <sub>1</sub> S <sub>2</sub> (expectancy)
Skinner:	discriminative and manipulative covert responses
Berlyne:	situational and transformational thoughts
Piaget & Inhelder:	static images vs images of movement and transformation
Paivio (1971):	static vs dynamic functions of symbolic systems.

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Note: all implicate motor processes in dynamic thought processes.

The distinction takes on another metaphorical form in Kurt Lewin's cognitive "life-space" theory (e.g., see Cartwright, 1959). The static or situational cognitive states of the life space were conceptualized as psychological regions and goals. The dynamic transformational processes were captured in the concept of locomotion, which refers to symbolic movement, as when the symbolized person changes regions within the life space.

A comparable distinction also appears in different versions of behaviorism. Tolman's original S-S unit, or expectancy, explicitly included static situational components and implied a dynamic, transformational process that connects the situational elements (cf. MacCorquodale & Meehl, 1954). Although the static components of the

construct, sign and significate, were specified, the dynamic behavioral component was initially left implicit. Tolman's (1959) final statement of the theory explicitly introduced dynamic, transformational processes into the system. The central cognitive construct became S<sub>1</sub>R<sub>1</sub>S<sub>2</sub>, where the S<sub>1</sub> component referred to the internal representation of the eliciting stimulus, R<sub>1</sub> to an intermediary covert response, and S<sub>2</sub> to the expected significate that is contingent on R<sub>1</sub>. MacCorquodale and Meehl suggested that the central process develops as the result of perceptual experience with objects in the environment and also as the result of responding in relation to those objects. In terms of the present topic, the sign and significate are static components of an expectancy whereas the internal response is the transformational or dynamic component.

Skinner (1953) drew a similar distinction in the context of his discussion of the events involved in private problem solving; which he illustrated using the cube visualization problem. Recall that the problem is to think of a cube the surfaces of which are painted a particular color, say red. Now, divide the cube by making two horizontal cuts, two vertical cuts perpendicular to the front plane, and two vertical cuts parallel to the front plane. How many of the resulting 27 cubes will have three faces painted red, how many two, how many one, and how many none? Skinner's analysis of the problem distinguished between discriminative and manipulative covert responses. The discriminative responses consist of such covert events as seeing the faces of the cube whereas the manipulative responses include the covert acts of slicing the cube into smaller parts, separating the parts, and so on. Further discriminative responses consist of seeing the results of each covert action on the cube.

Berlyne (1965) reviewed various historical antecedents to this general distinction, which he then addressed himself in terms of the contrast between situational and transformational thoughts, drawing particularly on aspects of Piaget's theory. The Piagetian analysis that is most relevant here was presented with Inhelder in their 1966 book on the mental image. There, they distinguished between static images and images of movement and transformation. Their data suggested that imagery prior to age 7 or so has a static quality and any movement

is represented by images of successive stages of an act. Later imagery is represented by images of movements and transformations, and is characterized especially by its anticipatory quality. The earlier imagery, they suggested, may be based on passive perception whereas later imagery is based on internalized imitation. That is, mature imagery incorporates the implicit motor components of imitative acts in its capacity to symbolize movements and transformations. The reference to motor components deserves special emphasis because every version of the static-dynamic distinction either implies or refers explicitly to motor involvement in the transitive, transformational, or dynamic cognitive processes.

The static-dynamic distinction has also been important in clinical psychology, in particular with respect to the interpretation of Rorschach inkblots and similar projective tests. Movement scores on the Rorschach have been related theoretically to introversion and other personality dimensions, including such cognitive constructs as intelligence, field dependence, and creativity. Consistent with Piagetian claims about imagery development, Rorschach movement responses increase with age (Ford, 1946/74; Levitt & Truunmaa, 1972). Using another projective test, which involved drawing pictures given incomplete line patterns, Franck and Rosen (1949) found that the drawings differed for males and females. Among other differences, male drawings were more likely to include "dynamic objects (those that move under their own power)," whereas female drawings were more likely to include "static objects (movable by an external force only)" if at all (Franck & Rosen, 1949, p. 251).

One of us (Paivio, 1971) incorporated the essence of the conceptual distinction just reviewed into a theoretical discussion of static and dynamic functions of imagery and verbal processes. We are concerned here only with the distinction as it applies to imagery. Motor processes were viewed as essential to the dynamic functions of imagery, which were defined in terms of the symbolic representation of movements and transformations. These motor properties were used to analyze and interpret various phenomena in the research literature. The following are some of the more salient examples (the parenthetical page numbers indicate where relevant discussions can be found in Paivio, 1971): (a)

perception of movement in pictured objects that have a dynamic quality, such as a running mouse, as compared to ones with a static quality, such as a sitting mouse (pp. 105-107); (b) the facilitative effect of verb connectives as compared to conjunctions or prepositions on the learning of noun pairs in sentence contexts (388); the superiority of instructions to generate interactive images over noninteractive imagery instructions in associative learning (388; note that a motor interpretation would not necessarily apply to integrative imagery in which objects are imaged in a meaningful but static relationship); and (c) individual differences on spatial ability tests that do or do not require transformation of figural information (pp. 490-491). Later on, we summarize research that implicates motor processes in sex differences on the static-dynamic dimension.

## 7.2 Individual Differences in Static versus Dynamic Processes

Individual differences in cognitive skills that serve relatively static imagery functions can be measured by spatial tests that require one to generate and use untransformed spatial information, such as the appearances and spatial arrangements of familiar objects, comparisons of objects on some static attribute, and so on. Guilford's (1967) structure-of-intellect model includes potentially relevant factors pertaining to static figural ability, such as cognition of visual units and cognition of visual-figural systems, but some of the tests that define those factors (e.g., Thurstone's space tests) are "impure" in that they include transformational components as well as static ones. Guilford's figural transformation factors appear to include clearer tests of the more dynamic abilities. For example, cognition of figural transformations is defined as transformations in visual information, including changes in sensory qualities and quantities, in location (movement), and in arrangement of parts. The defining tests include familiar ones such as Flags, the Minnesota Paper Form Board, and the block visualization task already described (identified in Guilford's battery as Spatial Visualization II).

A number of tests specifically designed to measure imagery ability can be interpreted as measuring either static or dynamic imagery. Tests of imagery vividness based on Galton's original questionnaire (e.g., Betts, 1909; Marks, 1973; Sheehan, 1967) generally require the responder to generate static representations of objects and situations, and to rate the vividness of the resulting images. A notable exception are the questions and scales that refer to the vividness of kinesthetic imagery. This will be especially relevant to our later discussion of sex differences in static and dynamic imagery. Different aspects of dynamic imagery are tapped by Gordon's (1949) questionnaire test of voluntary control of concrete imagery, and by various mental rotation tests based on the experimental work of Shepard and his collaborators. The relevance of these and other tests are discussed in the following section.

### 7.3 Sex Differences in Static and Dynamic Imagery

Our interest in sex differences began with an incidental observation that emerged from factor analyses of the IDQ, a questionnaire designed to measure individual differences in imagery and verbal habits and skills (Harshman & Paivio, 1987; Paivio & Harshman, 1983). The analyses revealed a general imagery and a general verbal factor, along with four other more specific factors. We also observed systematic sex differences in responses to the imagery items so that, relative to the other sex, females more often endorsed items that refer to the preferred use and vividness of static images, whereas males more often endorsed items that implicate more dynamic imagery skills in the sense that the items imply or refer to movement, transformation, or re-organization of imaged information. A sample of the two classes of items and their endorsement frequencies by each sex are shown in Table 7.2.

Table 7.2. Examples of IDQ Sex Difference Items (from Harshman & Paivio, 1987)

Higher Male Endorsement	Higher Female Endorsement
I can easily picture moving objects in my mind.	I often remember work I have studied by imagining the page on which it is written.
By using mental pictures of the elements of a problem, I am often able to arrive at a solution.	When reading fiction I usually form a mental picture of a scene or room that has been described.

A review of the literature revealed other findings consistent with the static-dynamic distinction, although not always interpreted in that fashion. Table 7.3 lists the studies that we have found so far. Using his shortened version of the Betts imagery vividness questionnaire, Sheehan (1967) found that women reported more vivid images than men on all imagery modalities except kinesthetic imagery. These findings are pertinent here because, in modalities other than the kinesthetic, the questionnaire items generally refer to objects or situations that do not require generation of dynamic images. McKelvie (1986) also found that females reported more vivid imagery than males on the Marks (1973) Vividness of Visual Imagery Questionnaire, in which the items primarily refer to static situations. The study by Linn and Peterson (1985) showed, conversely, that the commonly-observed

Table 7.3. Studies implicating Sex Differences on "Static" and "Dynamic" Imagery Tasks.

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McKelvie (1986):	F > M on reported vividness of imagery
Linn & Peterson (1985):	meta-analysis of 172 studies of spatial ability: large M > F only on mental rotation
Harshman, Hampson, & Berenbaum (1987):	M > F on 11/12 spatial ability tests especially mental rotation and shape transformation (except MPFB); F > = M on visual (picture) memory, mental size & clock comparisons
Price (1988):	recognition of point-light displays: M > F on biological motion displays; M = F on static displays; LVF > RVF on both tasks
Eriksen (1955):	scene construction with toys boys: used more moving-object toys; girls used more static-object toys
Hall & van de Castle (1966):	content analysis of dreams - activities category: M > F on physical activity; F > M on verbal activity.

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male superiority in spatial ability emerges most clearly with tests that require manipulation or transformation of spatial information. They performed a meta-analysis of 172 studies of spatial ability that had been published during an 8-year period following Maccoby and Jacklin's (1974) review of the area. The notable results were that large sex differences favoring males occurred only on measures of mental rotation, and that smaller differences were found on measures of spatial perception that do not require transformation. In addition, when sex differences were found, they could be detected across the life

span, suggesting that the issue that we are addressing here has very general significance.

Other studies simultaneously show both the male superiority on dynamic imagery tasks and female superiority or an absence of sex differences on more static ones. Harshman, Hampson, and Berenbaum (1983) studied sex and handedness differences in cognitive abilities in relation to brain organization. They found that males surpassed females on Space Relations, Mental Rotations, Surface Development (which involves imaging the outcome of 3-dimensional folding of a pattern), Gestalt/Harshman closure, Hidden Patterns (a disembedding test), copying (involving connecting dots to form a copy of an abstract pattern), and on the total Space Component Score. The Minnesota Paper Form Board was the only exception among the spatial tests in that it showed no sex difference. Females exceeded males significantly on a visual memory test (picture recognition memory), and on a paper and pencil test of symbolic size comparisons involving pairs of words as stimuli. Males and females performed equivalently on symbolic clock comparisons in which the subject is presented with pairs of digital times and is required to decide in which pair the hands of an analog clock would form the larger or smaller angle. The tests on which females surpassed or were equal to males generally can be interpreted as relatively more static tasks, whereas those in which males exceeded females are more dynamic in that they require transformations of the cognitive information.

Relevant evidence also comes from a Master's thesis by Brenda Price completed at the University of Western Ontario in 1988 under the supervision of Mel Goodale. Price presented Johansson (1973) point-light displays to the right or left visual field. The typical Johansson displays involve recognition of holistic movement patterns, such as a person walking, when all that can be seen are a few lights located at such strategic places as the limb joints of people who are photographed with a motion picture camera in the dark. Price used both static displays and ones showing biological motion. She found that males and females performed equivalently on the static displays whereas males were significantly more accurate than females on perception of biological motion. These findings are relevant here

because the perceptual task presumably entails imagery in the sense that the information about the original objects must be activated from long term memory by minimal cues. Thus, the results once again show the male superiority in dynamic imagery and an absence of a sex difference in the case of static imagery.

Some earlier observations of children's play activities and dream reports of adults are also consistent with the hypothesized sex differences on the static-dynamic dimension. E. H. Eriksen (1951) asked 11 to 13 year old boys and girls to construct scenes using toys. He reported that girls tended to build quiet scenes of everyday life, preferably within a home or in school, whereas boys preferred street and outdoor scenes, especially ones with wild animals, Indians, or automobile accidents. Eriksen generalized that boys prefer toys that move or represent motion, consistent with other evidence that vehicles are more popular toys for boys than girls (Richardson & Simpson, 1982; Rubin, 1977).

In regard to dreams, Eriksen reported an unpublished study by Colby of dream reports by 100 men and 100 women patients from Western Europe and the United States. Colby tentatively reported, for men, a preponderance of sudden and fast-moving events such as vehicular traffic, especially train engines; of guns and machines; hitting out, and so on. For women, he found a relative preponderance of stationary situations of houses, doors, windows, clothes, food, children, and the like. Hall and van de Castle (1966) noted in their book on the content analysis of dreams that the most striking sex differences in dream activities were on verbal and physical activity, with females exceeding males on reports of dreams involving verbal content and males exceeding females on reports of dreams involving physical activity.

Projective tests also provide information about the differential movement qualities of male and female fantasies, but the potential of this source is somewhat obscured because of measurement and conceptual difficulties. For example, inkblot scoring schemes for movement sometimes lump together static and dynamic "movement," are biased by theoretical clinical concerns, and may be confounded with response length. At least some studies do report results consistent

with the present hypothesis and perhaps especially for children. That is, boys tend to report more movement than girls and to report movement at an earlier age (e.g., Ames, Metraux, Rodell, & Walker, 1974; Ford, 1946/74; Holtzman, Diaz-Guerrero, & Swartz, 1975; Krall, Sachs, Lazar, Rayson, Grove, Novar, & O'Connell, 1983; but see Exner, & Weiner, 1982; and Lockwood, Roll, & Matthews, 1981). Less consistent results have been reported with older subjects (e.g., Ames, Metraux, & Walker, 1971; Ames, Metraux, Rodell, & Walker, 1973). Cognitive analyses of the imaginal-to-verbal referential processes involved in projective tests (e.g., Gold, 1987) may help to clarify these inconsistent results.

The various results we have just described are interesting in their own right because they qualify a commonly-held view that males excel in spatial ability and imagery skills. More generally, they may provide a theoretically-important window on qualitative differences in imagery that can be studied objectively and eventually related to causal variables. However, the suggestive observations need to be confirmed with more direct measures and manipulations of the static-dynamic imagery dimension. Toward this end, in collaboration with Trudy Bons, we have conducted a series of studies in which we measured sex differences in reaction time to generate static or dynamic images. We had already investigated factors that determined the speed of generating mental images to stimulus nouns (Paivio, Clark, Digdon, & Bons, 1989). Here, we extended the earlier procedure to the static-dynamic problem by varying the nature of the stimulus materials as well as experimental instructions.

The initial experiments used stimulus words that vary in the degree to which they suggest activity. Our reasoning was that the higher the rated activity level of the words, the more likely they are to evoke dynamic imagery. Moreover, men might be faster than women in imaging to such words but not necessarily the more static ones. The activity ratings were obtained from groups of subjects who rated both nouns and verbs on a 7-point activity scale. Table 7.4 shows examples of words that varied in their activity level, together with the overall means for the 78 nouns and 78 verbs in our total sample. Note that the average activity rating was considerably higher for verbs than nouns.

Accordingly, we expected an appropriate interaction effect on reaction time of subject sex by word class, as well as between sex and the rated activity level of words within a class.

Table 7.4. Examples of Concrete Words and Mean Activity Ratings Together with Overall Mean for Total Word Sample

Nouns		Verbs	
rocket	5.25	run	6.39
leopard	4.75	attack	5.94
mixer	4.36	skate	5.64
bird	4.31	build	5.28
eye	3.61	skip	4.97
factory	3.50	mince	2.83
scissors	2.75	sip	2.53
moon	2.03	soak	2.33
key	1.50	hear	1.86
vase	1.03	hire	1.83
Total Sample			
Means	2.63		3.75
N	78		78

The general procedure required subjects to generate visual images to each of a series of words presented one at a time on a computer screen, indicating when they had done so by pressing a key. To provide some validation of our activity ratings, we subsequently asked the subjects to rate the activity level of the images they had generated to each word during the reaction time phase. These post-experimental

ratings confirmed our normative results in that the verbs generally evoked relatively dynamic images for both sexes whereas nouns varied more widely, from static to dynamic.

The reaction time results were generally weak and somewhat inconsistent across several experiments. The first experiment showed a significant interaction of subject gender by word class that conformed to expectations in that men were faster than women on imaging to verbs but not nouns. The interaction emerged only as a nonsignificant trend in subsequent experiments and we didn't pursue the verb-noun effect thereafter.

In the subsequent experiments, we categorized our noun stimuli as static or dynamic according to scores above or below the mean of activity ratings. We also used a stronger behavioral criterion than in the initial experiment in that the subjects were required to describe or sketch their images after pressing the key. That aspect of the procedure is consistent with our previous imagery reaction time experiments. We found no systematic differences between the effects of sketching and describing, so we pooled the two conditions in the analyses of effects.

The first experiment using these changes yielded a significant interaction between sex of subject and the static-dynamic variable, so that men were faster in imaging to dynamic than static nouns whereas women showed a trend in the opposite direction. A regression analysis with mean latency scores for each item as a dependent variable, and mean activity ratings and other word attributes as predictors, confirmed the interaction in that it revealed a significant negative relation between activity scores and latencies for males and a nonsignificant trend in the opposite direction for females. Relations with the other noun attributes provided clear evidence that sex differences in imagery latencies were uniquely related to the activity attribute of the nouns. Thus, noun imagery values correlated significantly negatively with reaction times, as would be expected, but in this case the direction of the correlation was negative and equivalent for both sexes. Pleasantness values and gender relatedness of the nouns were unrelated to imagery latencies.

In our final experiment, we manipulated imagery by means of instructions. Some subjects were simply asked to image, whereas others were specifically asked to generate either static images or dynamic images to nouns that varied in activity level. Although noun activity level tended to interact with gender in the predicted manner, the trend was not significant. The most striking result was the crossover interaction, shown in Table 7.5, of subjects' sex with the static versus dynamic imagery instructions. Here we see that men generated dynamic images faster than static images, whereas women generated static images faster than dynamic ones. Moreover, the sex differences were appropriately reversed, so that females surpassed males in speed of static imagery whereas males surpassed females in speed of dynamic imagery. The interaction provides the clearest support to date for our original hypothesis, and is consistent with other suggestive findings in these studies and in the research reviewed earlier.

Table 7.5. Interaction of Subject Gender and Imagery Instructions on Imagery Reaction Time in Sec ( $p = .01$ ).

	Imagery Instructions			
	Static	Dynamic		
	M	SD	M	SD
Males	3.49	(4.03)	2.28	(4.82)
Females	1.77	(2.46)	4.11	(4.26)

## 7.4 Underlying Mechanisms and Antecedents

We conclude with a discussion of possible explanations for the apparent relation between subject's sex and the static-dynamic imagery dimension, including brain and other correlates, experiential or other causes of the sex differences, and some tentative ideas about the different mechanisms involved in static and dynamic imagery.

In regard to brain correlates, there appears to be no clear evidence linking the critical effects to functional differences in the two hemispheres or regions within each hemisphere (for a review of relevant evidence, see Pavio, 1986, ch. 12). Studies of people with focal lesions suggest that the right hemisphere might be especially favoured in such spatial tasks as mental rotation and closure, which implicate dynamic imagery, whereas both hemispheres are equally proficient in mental size comparisons, which implicates static imagery. However, recognition memory for faces and nonsense patterns, which apparently depend on static memory images, is better in the right than in the left hemisphere.

On the basis of this kind of evidence, we could conclude that mental rotations and other spatial tasks that implicate dynamic imagery processes are reliably associated with right hemisphere superiority, whereas static imagery tasks show a mixed pattern consisting mainly of right hemisphere superiority and occasional hemispheric equipotentiality.

Even that tentative conclusion may need to be tempered by the following observations. Price and Goodale (1989), using the Johansson point-light displays, showed that both static poses and whole body movements were recognized relatively better when presented to the left visual field, hence the right hemisphere, whereas displays of skilled movements of the hand and limb resulted in no lateral asymmetry. This pattern was consistent with Price and Goodale's analysis of the possible role of the left hemisphere in the production and perceptual recognition of skilled movements. Their findings alert us to the conceptual and methodological complexities in this problem area. A more definitive statement must await further

neuropsychological research and a more complete psychological understanding of the cognitive structures and processes that distinguish static and dynamic imagery.

The Price and Goodale findings are also relevant in regard to the possible role of motor processes in static and dynamic imagery. We mentioned at the outset that all theorists who have discussed the static-dynamic distinction in its various forms have referred explicitly or implicitly to motor processes in cognition of movements and transformations. Various findings support a unique contribution of motor processes in the case of imagery. The studies entail the familiar distinction between motor or kinesthetic imagery on the one hand and visual imagery on the other. One example is modality-specific interference, so that motor tasks selectively interfere with tasks that implicate kinesthetic or motoric imagery (e.g., Engelkamp, 1988; Saltz & Nolan, 1981; see also Engelkamp, this volume). Another concerns the role of kinesthetic imagery when imagery rehearsal is used to improve motor skills (e.g., Denis, 1985; Hall, 1985). However, sex differences in static and dynamic imagery have not been investigated from that perspective. This could be done by appropriately modifying the imagery reaction time task and its controlling variables. Thus, we should be able to select dynamic items that strongly implicate transformations or motor movements on the part of the responding subject, as compared to items that refer to objects that move automatically. Experimentally, we could instruct subjects to image themselves performing activities suggested by stimulus words, or image movements done by the referent object. Finally, we could introduce tests of individual differences in motor imagery skills, as measured, for example, by Hall's Movement Imagery Questionnaire (see Hall, 1985). Such approaches could sharpen our understanding of the static-dynamic imagery distinction generally, as well as sex differences related to it.

A related question concerns the origins of static and dynamic imagery skills and sex differences in relation to them. Experiential and biological factors are implicated in this case as they are in other cognitive abilities. Biochemical factors, specifically hormonal influences, could also be involved in sex differences as well as

variations within sexes in relevant abilities. For example, higher levels of estrogen and progesterone are associated with poorer performance on spatial tasks (cf. Hampson & Kimura, 1988; Nyborg, 1983).

Our preferred research strategy would be to begin by exploring possible experiential determinants of the static-dynamic distinction, particularly as suggested by dual coding theory. The theory states that experiential factors determine the modality-specific properties of mental representations and processes. Thus, the differences in static and dynamic imagery could result from differences in the frequency of experience with different kinds of toys, games, sports, and other activities, along with the static or dynamic objects associated with them. We have already mentioned some relevant sex differences in play activities. Experiential differences could be further investigated by correlating data from a retrospective questionnaire with reaction times for dynamic and static imagery obtained from the same subjects. Alternatively, the effects of imagery training on subsequent reaction times could be determined.

Some relevant research exists on the relation of spatial ability to reported spatial activities and spatial training (e.g., Baenninger & Newcombe, 1989; Newcombe, Bandura, & Taylor, 1983; Olson & Eliot, 1986), but this research has not differentiated dynamic activities and abilities from static ones. Baenninger and Newcombe's meta-analysis indicated small effects for reported spatial activities and larger effects for training. Although not significant, there was suggestive evidence that prior spatial activities correlated less with spatial perception than with visualization and mental rotation. The latter tasks may be relatively more likely to involve dynamic imagery. Moreover, there is evidence that spatial activities classified as masculine may be better predictors of later spatial ability scores for both sexes than feminine and neutral spatial activities (Signorella, Jamison, & Krupa, 1989). Perhaps masculine spatial activities are particularly dynamic, consistent with the tendency for masculine toys to involve motor activity (Eaton, von Barger, & Keats, 1981) and for fathers' play to involve physical activity (Ross & Taylor, 1989).

It will be especially interesting to see to what extent any correlations obtained between imagery RT and retrospective reports of activities support an experiential account of individual differences in static and dynamic imagery, and of sex differences along that dimension. A variant of this correlational approach would be to measure static and dynamic imagery RT of groups that are known to differ in relevant experiences and skills, such as female athletes versus nonathletic women, or individuals who differ markedly on a relevant ability test (e.g., the Movement Imagery Questionnaire; see Hall, 1985).

We are left with the question of the underlying mechanisms that distinguish static and dynamic imagery. According to a strong analogue view of imagery, transformation of an image entails successive activation of spatially contiguous mental representations that are isomorphic to corresponding perceptual events. Such spatially organized spreading activation possibly involves processes that would not be involved in static imagery. For example, dynamic imagery necessitates some mechanism to control the directionality and order of the spreading activation so as to result in the appropriate transformation (e.g., lateral displacement versus expansion). Effective dynamic imagery may also require inhibition of immediately preceding representations whose continuing activation would blur the image. Contemporary research on the physiology of perceptual and motor movement provides strong evidence for the role of analogue mental processes (Georgopoulos, Lurito, Petrides, Schwartz, & Massey, 1989) and for the contribution of inhibitory mechanisms (Poggio & Koch, 1987). It remains to be seen whether and how such molecular mechanisms can account for the higher order constructs with which cognitive psychologists typically deal (i.e., decision and executive processes).

The preceding analysis implicates, in an interesting way, one fundamental distinction that has been made between the imagery and verbal systems, namely sequential versus parallel (or synchronous) processes (Paivio, 1971, 1986). That is, dynamic imagery, like nonverbal motor processes, may entail sequential processes (e.g., successive activation) that are not typically associated with static

imagery. A deeper understanding of the mechanisms that underlie performance of static and dynamic imagery tasks should permit construction of more sensitive imagery tasks, and stronger tests of the biological and experiential factors involved in the apparent sex differences in static and dynamic imagery.

## References

- Ames, L. B., Metraux, R. W., & Walker, R. N. (1971). *Adolescent Rorschach responses: Developmental trends from ten to sixteen years*. New York: Brunner/Mazel.
- Ames, L. B., Metraux, R. W., Rodell, J. L., & Walker, R. N. (1973). *Rorschach responses in old age*. New York: Brunner/Mazel.
- Ames, L. B., Metraux, R. W., Rodell, J. L., & Walker, R. N. (1974). *Child Rorschach responses: Developmental trends from two to ten years (2nd ed.)*. New York: Brunner/Mazel.
- Baenninger, M., & Newcombe, N. (1989). The role of experience in spatial test performance: A meta-analysis. *Sex roles, 20*, 327-344.
- Berlyne, D. E. (1965). *Structure and direction in thinking*. New York: Wiley.
- Betts, G. H. (1909). *The distribution and functions of mental imagery*. New York: Teacher's College, Columbia University.
- Cartwright, D. (1959). Lewinian theory as a contemporary systematic framework. In S. Koch (Ed.), *Psychology: A study of a science (Vol. 2)*. New York: McGraw-Hill.
- Denis, M. (1985). Visual imagery and the use of mental practice in the development of motor skills. *Canadian Journal of Applied Sports Sciences, 10*, 44S-16S.

- Eaton, W. O., von Bargen, D., & Keats, J. G. (1981). Gender understanding and dimensions of preschooler toy choice: Sex stereotype versus activity level. *Canadian Journal of Behavioral Science, 13*, 203-209.
- Engelkamp, J. (1988). Images and actions in verbal learning. In M. Denis, J. Engelkamp, & J. T. E. Richardson (Eds.), *Cognitive and neuropsychological approaches to mental imagery*. Amsterdam, Martinus Nijhoff.
- Eriksen, E. H. (1951). Sex differences in the play configurations of preadolescents. *The American Journal of Orthopsychiatry, 21*, 667-692.
- Exner, J. E., & Weiner, I. B. (1982). *The Rorschach: A comprehensive system (Vol. 3)* Assessment of children and adolescents. New York: Wiley.
- Ford, M. (1946/74). *The application of the Rorschach test to young children*. Westport, CT: Greenwood Press.
- Franck, K., & Rosen, E. (1949). A projective test of masculinity-femininity. *Journal of Consulting Psychology, 13*, 247-256.
- Georgopoulos, A. P., Lurito, J. T., Petrides, M., Schwartz, A. B., & Massey, J. T. (1989). Mental rotation of the neuronal population vector. *Science, 243*, 234-236.
- Gold, J. M. (1987). The role of verbalization in the Rorschach response process: A review. *Journal of Personality Assessment, 51*, 489-505.
- Gordon, R. (1949). An investigation into some of the factors that favour the formation of stereotyped images. *British Journal of Psychology, 39*, 156-167.

Guilford, J. P. (1967).

*The nature of human intelligence.* New York: McGraw-Hill.

Hall, C. R. (1985).

The role of mental practice and imagery ability in motor skill performance. *Canadian Journal of Applied Sport Sciences*, 10, 4 17S-21S.

Hall, C. S., & Van de Castle, R. L. (1966).

*The content analysis of dreams.* New York: Appleton Century Crofts.

Hampson, E., & Kimura, D. (1988).

Reciprocal effects of hormonal fluctuations on human motor and perceptual-spatial skills. *Behavioral Neuroscience*, 102, 456-459.

Harshman, R. A., Hampson, E., & Berenbaum, S. A. (1983).

Individual differences in cognitive abilities and brain organization, Part I: Sex and handedness differences in ability. *Canadian Journal of Psychology*, 37, 144-192.

Harshman, R. A., & Paivio, A. (1987).

"Paradoxical" sex differences in self-reported imagery. *Canadian Journal of Psychology*, 41, 287-302.

Holtzman, W. H., Diaz-Guerrero, R., & Swartz, J. D. (1975).

*Personality development in two cultures: A cross-cultural longitudinal study of school children in Mexico and the United States.* Austin: University of Texas Press.

James, W. (1890).

*Principles of psychology*, New York: Holt. (Reprinted by Dover, 1950).

Johansson, G. (1973).

Visual perception of biological motion and a model for its analysis. *Perception and Psychophysics*, 14, 202-211.

Krall, V., Sachs, H., Lazar, B., Rayson, B., Growe, G., Novar, L., & O'Connell, L. (1983).

Rorschach norms for inner city children. *Journal of Personality Assessment*, 47, 155-157.

Levitt, E. E., & Truunmaa, A. (1972).

*The Rorschach technique with children and adolescents: Applications and norms.* New York: Grune & Stratton.

Linn, M. C., & Peterson, A. C. (1985).

Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development*, 56, 1479-1498.

Lockwood, J. L., Roll, S., & Matthews, D. B. (1981).

Two studies of the movement responses in young children: New and highly discrepant norms. *Journal of Personality Assessment*, 45, 250-255.

Maccoby, E. E., & Jacklin, C. N. (1974).

*The psychology of sex differences.* Stanford, CA: Stanford University Press.

MacCorquodale, K., & Meehl, P. E. (1954).

Edward C. Tolman. In W. K. Estes, S. Koch, K. MacCorquodale, P. E. Meehl, C. G. Mueller, W. N. Schoenfeld, & W. S. Verplanck (Eds.), *Modern learning theory.* New York: Appleton-Century-Crofts.

Marks, D. F. (1973).

Visual imagery differences in the recall of pictures. *British Journal of Psychology*, 64, 17-24.

McKelvie, S. J. (1986).

Effects of format of the vividness of visual imagery questionnaire on content validity, split-half reliability, and the role of memory in test-retest reliability. *British Journal of Psychology*, 77, 229-236.

- Newcombe, N., Bandura, M. M., & Taylor, D. G. (1983). Sex differences in spatial ability and spatial activities. *Sex Roles, 9*, 377-386.
- Nyborg, H. (1983). Spatial ability in men and women: review and new theory. *Advances in Behavioral Research Therapy, 5*, 89-140.
- Olson, D. M., & Elliot, J. (1986). Relationships between experiences, processing style, and sex-related differences in performance on spatial tests. *Perceptual and Motor Skills, 62*, 447-460.
- Paivio, A. (1971). *Imagery and verbal processes*. New York: Holt, Rinehart, & Winston. (Reprinted 1979, Hillsdale, NJ: Lawrence Erlbaum Associates).
- Paivio, A. (1986). *Mental Representations: A dual-coding approach*. New York: Oxford University Press.
- Paivio, A., Clark, J. M., Digidon, N., & Bons, T. (1989). Referential processing: Reciprocity and correlates of naming and imaging. *Memory & Cognition, 17*, 163-174.
- Paivio, A., & Harshman, R. A. (1983). Factor analysis of a questionnaire on imagery and verbal habits and skills. *Canadian Journal of Psychology, 37*, 461-483.
- Piaget, J., & Inhelder, B. (1966). *L'image mentale chez l'enfant*. Paris: Presses Universitaires de France. (English translation published 1971 *Mental imagery in the child: A study of the development of imaginal representations*. London: Routledge & Kegan Paul).
- Poggio, T., & Koch, C. (1987). Synapses that compute motion. *Scientific American, 256*, 46-52.

- Price, B. (1988). *Asymmetries in the perception of biological motion*. Unpublished master's thesis, University of Western Ontario, London, Canada.
- Price, B. M., and Goodale, M. A. (1989). *Asymmetries in the perception of biological motion*. Unpublished manuscript, University of Western Ontario, London, Canada.
- Richardson, J. G., & Simpson, C. H. (1982). Children, gender, and social structure: An analysis of the content of letters to Santa Claus. *Child Development, 53*, 429-436.
- Ross, H., & Taylor, H. (1989). Do boys prefer daddy or his physical style of play? *Sex Roles, 20*, 23-33.
- Rubin, K. H. (1977). The social and cognitive value of preschool toys and activities. *Canadian Journal of Behavioral Science, 9*, 382-385.
- Saltz, E., & Nolan, S. D. (1981). Does motoric imagery facilitate memory for sentences? A selective interference test. *Journal of Verbal Learning and Verbal Behavior, 20*, 322-332.
- Sheehan, P. W. (1967). A shortened form of Betts' questionnaire upon mental imagery. *Journal of Clinical Psychology, 23*, 386-389.
- Signorella, M. L., Jamison, W., & Drupa, M. H. (1989). Predicting spatial performance from gender stereotyping in activity preferences and in self-concept. *Developmental Psychology, 25*, 89-95.
- Skinner, B. F. (1953). *Science and human behavior*. New York: Macmillan.
- Tolman, E. C. (1959). Principles of purposive behavior. In S. Koch (Ed.), *Psychology: A study of a science*. (Vol. 2). New York: McGraw-Hill.

- Newcombe, N., Bandura, M. M., & Taylor, D. G. (1983). Sex differences in spatial ability and spatial activities. *Sex Roles, 9*, 377-386.
- Nyborg, H. (1983). Spatial ability in men and women: review and new theory. *Advances in Behavioral Research Therapy, 5*, 89-140.
- Olson, D. M., & Elliot, J. (1986). Relationships between experiences, processing style, and sex-related differences in performance on spatial tests. *Perceptual and Motor Skills, 62*, 447-460.
- Paivio, A. (1971). *Imagery and verbal processes*. New York: Holt, Rinehart, & Winston. (Reprinted 1979, Hillsdale, NJ: Lawrence Erlbaum Associates).
- Paivio, A. (1986). *Mental Representations: A dual-coding approach*. New York: Oxford University Press.
- Paivio, A., Clark, J. M., Digidon, N., & Bons, T. (1989). Referential processing: Reciprocity and correlates of naming and imaging. *Memory & Cognition, 17*, 163-174.
- Paivio, A., & Harshman, R. A. (1983). Factor analysis of a questionnaire on imagery and verbal habits and skills. *Canadian Journal of Psychology, 37*, 461-483.
- Piaget, J., & Inhelder, B. (1966). *L'image mentale chez l'enfant*. Paris: Presses Universitaires de France. (English translation published 1971 *Mental imagery in the child: A study of the development of imaginal representations*. London: Routledge & Kegan Paul).
- Poggio, T., & Koch, C. (1987). Synapses that compute motion. *Scientific American, 256*, 46-52.

- Price, B. (1988). *Asymmetries in the perception of biological motion*. Unpublished master's thesis, University of Western Ontario, London, Canada.
- Price, B. M., and Goodale, M. A. (1989). *Asymmetries in the perception of biological motion*. Unpublished manuscript, University of Western Ontario, London, Canada.
- Richardson, J. G., & Simpson, C. H. (1982). Children, gender, and social structure: An analysis of the content of letters to Santa Claus. *Child Development, 53*, 429-436.
- Ross, H., & Taylor, H. (1989). Do boys prefer daddy or his physical style of play? *Sex Roles, 20*, 23-33.
- Rubin, K. H. (1977). The social and cognitive value of preschool toys and activities. *Canadian Journal of Behavioral Science, 9*, 382-385.
- Saltz, E., & Nolan, S. D. (1981). Does motoric imagery facilitate memory for sentences? A selective interference test. *Journal of Verbal Learning and Verbal Behavior, 20*, 322-332.
- Sheehan, P. W. (1967). A shortened form of Betts' questionnaire upon mental imagery. *Journal of Clinical Psychology, 23*, 386-389.
- Signorella, M. L., Jamison, W., & Drupa, M. H. (1989). Predicting spatial performance from gender stereotyping in activity preferences and in self-concept. *Developmental Psychology, 25*, 89-95.
- Skinner, B. F. (1953). *Science and human behavior*. New York: Macmillan.
- Tolman, E. C. (1959). Principles of purposive behavior. In S. Koch (Ed.), *Psychology: A study of a science*. (Vol. 2). New York: McGraw-Hill.